

# **John W. France, PE, D.GE, D.WRE**

## **Professional History**

Years with AECOM (Legacy URS): 25  
Years with other firms: 16

## **Academic Training**

MS, Civil Engineering, Cornell University, 1976  
BS, Civil Engineering, Cornell University, 1972

## **Areas of Expertise**

Dams and Dam Safety  
Geotechnical Engineering

## **Registration**

Professional Engineer: CO, OK, MA,  
NC

Mr. France has more than 41 years of experience in engineering consulting and design. Most of Mr. France's technical work for the past 33 years has focused on dams and water retention structures. This experience includes dam safety inspections and analyses, detailed geotechnical and geological field and laboratory investigations, hazard classification, seepage and static stability analyses and evaluations, seismic stability/seismic deformation analyses, conceptual and final designs of new structures, rehabilitation of existing structures, and consultation during construction. He has served on numerous senior technical review boards / panels for the U.S. Army Corps of Engineers (USACE); the U.S. Department of the Interior, Bureau of Reclamation; and BC Hydro. He is listed on the Federal Energy Regulatory Commission's (FERC's) lists of approved Independent Consultants and Potential Failure Modes Analysis (PFMA) facilitators. Mr. France has been a principal instructor for three presentations of a four-day Embankment Dam Design Course for the USACE and for seepage and stability analysis courses for the Association of State Dam Safety Officials (ASDSO) and for two presentations of a three-day course on Embankment Dam Seepage Remediation. In 2010, he received the prestigious President's Award from ASDSO for his contributions to dam safety in the United States.

## **Project Experience**

**Consultant Review Board, Horsetooth Dam, CO, U.S. Bureau of Reclamation:** Member of a three-person CRB that provided senior technical review of dam safety evaluations, dam modification designs, and construction for four large embankment dams located near Fort Collins, CO. The principal dam safety issues were seepage-related, including solutioning of limestone and gypsum foundation rock in the left abutment of one of the dams.

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**Principal-in-Charge, Carter Lake Dam New Outlet Works, CO, Northern Water:** Principal-in-charge and senior technical reviewer for design and construction phase engineering services for the new outlet works structure at Carter Lake Dam.

**Project Manager, Preliminary design of Chimney Hollow Dam, CO, Boyle Engineering and Northern Water:** Project manager for evaluation of foundation data and dam types and preliminary design of the proposed new Chimney Hollow Dam for the Windy Gap Firming Project.

**Risk Analysis Facilitator, Antero Dam, CO, Denver Water:** Served as an facilitator for a team that completed a potential failure mode analysis and qualitative dam safety risk assessment for Antero Dam, CO. The risk analysis addressed the full range of potential failure modes for an existing embankment dam.

**Risk Analysis Facilitator, Beaver Park Dam, CO, Colorado Department of Parks and Wildlife:** Served as an facilitator for a team that completed a potential failure mode analysis and qualitative dam safety risk assessment for Beaver Park Dam, CO. The risk analysis addressed seepage and internal potential failure modes and potential risk reduction actions for an existing embankment dam.

**Independent Consultant, Williams Fork Dam, CO, Denver Water:** Independent consultant for the FERC-required five-year safety inspection of Williams Fork Dam, CO.

**Independent Consultant, Dillon Dam, CO, Denver Water:** Independent consultant for the FERC-required five-year safety inspection of Dillon Dam, CO.

**Independent Consultant, Rampart Dam, CO, Colorado Springs Utilities:** Independent consultant for two FERC-required five-year safety inspections of Rampart Dam, CO.

**Board of Consultants, Chilhowee Dam, TN, Brookfield Renewable Energy.:** Member of a three-person FERC-mandated Board of Consultants for evaluation of seepage concerns for an existing sloping core rockfill embankment.

**Technical Advisory Panel, Wolf Creek Dam, KY, U.S. Army Corps of Engineers:** Served as chairman of a Technical Advisory Panel reviewing design and construction of major dam safety modifications for Wolf Creek Dam, which is a Dam Safety Action Class (DSAC) 1 facility – the class of highest dam safety concern for the Corps of Engineers. The modifications were completed to address seepage concerns in the karstic foundation of the embankment section of the dam. The implemented solution was a deep, concrete diaphragm seepage barrier wall. Activities also included serving as an estimator for quantitative risk analyses completed during construction and after completion of the project.

**Technical Advisory Panel, Center Hill Dam, TN, U.S. Army Corps of Engineers:** Served as chairman of a Technical Advisory Panel reviewing design and construction of major dam safety modifications for Center Hill Dam, which is a DSAC 1 facility. The modifications were completed to address seepage concerns in the karstic foundation of the embankment section of the dam. The implemented solution was a deep, concrete diaphragm seepage barrier wall.

**Independent Expert Panel, Isabella Dam, CA, U.S. Army Corps of Engineers:** Served on a team that completed an independent expert panel review of the 65 percent design of dam safety modifications for Isabella Dam, CA, which is a DSAC 1 facility. The modifications are being designed to address seismic stability and spillway capacity concerns for this existing facility.

**Risk Assessment Team, Success Dam, CA, U.S. Army Corps of Engineers:** Served as an estimator on a team that completed a qualitative dam safety risk assessment for Success Dam, CA, which at the time was a DSAC 2 facility. Potential dam safety concerns related to seismic stability, seepage and internal erosion, and spillway capacity.

**Risk Assessment Team and Facilitator, Herbert Hoover Dike, FL, U.S. Army Corps of Engineers:** Served as an estimator on a team that completed a potential failure mode analysis and qualitative dam safety risk assessment for Herbert Hoover Dike, FL, which is a DSAC 1 facility. In a later stage of this four-year long effort, Mr. France served as facilitator for one part of

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the risk analysis. Potential dam safety concerns for this 150 mile long embankment structure centered on seepage and internal erosion potential failure modes.

**Technical Advisory Panel, Martis Creek Dam, CA, U.S. Army Corps of Engineers:** Served on a four-member Technical Advisory Panel reviewing dam safety evaluations for Martis Creek Dam, which at the time was a DSAC 1 facility. Issues of concern were seepage and seismic performance.

**Technical Advisory Panel, Success Dam, CA, U.S. Army Corps of Engineers:** Served on a five-member Technical Advisory Panel reviewing design and construction of major dam safety modifications for Success Dam, which is a DSAC 2 facility.

**Consultant Review Board (CRB), Mormon Island Auxiliary Dam and Other Embankment Dams Associated With the Folsom Project, CA, U.S. Bureau of Reclamation:** Member of Consultant Review Boards providing senior technical review of dam safety evaluations, dam modification designs, and construction for one of the embankment dams that impound Folsom Lake, CA. The principal dam safety issues are embankment and foundation seepage and piping, seismic stability concerns and inadequate spillway capacity. Modifications may include a large fuse plug spillway.

**Consultant Review Board, Lauro Dam, CA, U.S. Bureau of Reclamation:** Serving on a three-person CRB providing senior technical review of dam safety evaluations and dam modification designs for an embankment dam in California. The principal dam safety issue is stability and deformation during an earthquake.

**Consultant Review Board, Horsetooth Dam, CO, U.S. Bureau of Reclamation:** Member of a three-person CRB that provided senior technical review of dam safety evaluations, dam modification designs, and construction for four large embankment dams located near Fort Collins, CO. The principal dam safety issues were seepage-related, including solutioning of limestone and gypsum foundation rock in the left abutment of one of the dams.

**Consultant Review Board, Keechelus Dam, WA, U.S. Bureau of Reclamation:** Member of a three-person CRB that provided senior technical review of dam safety evaluations, dam modification designs, and construction for an embankment dam located near Cle Elum, WA. The principal dam safety issues were embankment and foundation seepage and piping concerns.

**Consultant Review Board, Wasco Dam, OR, U.S. Bureau of Reclamation:** Served as a single reviewer providing senior technical review of dam safety evaluations and dam modification designs for an embankment dam in Oregon. The principal dam safety issues were embankment and foundation seepage and piping concerns.

**Consultant Review Board, Red Willow and Norton Dams, NE, U.S. Bureau of Reclamation:** Served as a single reviewer providing senior technical review of dam safety evaluations and dam modification designs for two embankment dams in Nebraska. The principal dam safety issues were embankment and foundation seepage and piping concerns.

**Consultant Review Board, Clear Lake Dam, CA, U.S. Bureau of Reclamation:** Member of a two-person CRB that provided senior technical review of dam safety evaluations, dam modification designs, and construction for an embankment dam located in northern, CA. The principal dam safety issues were embankment and foundation seepage and piping concerns. The embankment dam was replaced with a new roller compacted concrete dam.

**Advisory Board Member, BC Hydro:** Serving on an Advisory Board for review of BC Hydro's planned dam safety modifications of Strathcona Dam.

**Advisory Board Member, BC Hydro:** Serving on an Advisory Board for review of BC Hydro's planned dam safety modifications of Ruskin and Blind Slough Dams. A major part of modifications at Ruskin Dam were completed to address seepage issues.

**Potential Failure Modes Analysis Facilitator, Baker Project, WA, Puget Sound Energy:** Facilitator for FERC-mandated potential failure modes analysis for the Baker Project, which includes two concrete dams, two powerhouses, and two embankment dams.

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## **Potential Failure Modes Analysis Facilitator, Noxon Rapids Project, MT, Avista Corporation:**

Facilitator for FERC-mandated potential failure modes analysis for the Noxon Rapids project, which includes a concrete gravity intake/powerhouse structure, a gated concrete gravity spillway structure, and two embankment dams.

## **Potential Failure Modes Analysis Facilitator, Blue Ridge Dam, AZ, Phelps Dodge Morenci, Inc.:**

Facilitator for FERC-mandated potential failure modes analysis for Blue Ridge Dam, a 170-foot high concrete thin-arch dam.

## **Potential Failure Modes Analysis Facilitator, Murray Hydroelectric Facility, AR, City of North Little Rock, AR.:**

Facilitator for FERC-mandated potential failure modes analysis for a hydro electric facility in Arkansas, located adjacent to a U.S. Army Corps of Engineers lock and dam.

## **Potential Failure Modes Analysis Facilitator, Ellis and Whillock Hydroelectric Facilities, AR, Arkansas Electric Cooperative Corporation.:**

Facilitator for FERC-mandated potential failure modes analysis for two hydro electric facilities in Arkansas, located adjacent to a U.S. Army Corps of Engineers lock and dam projects.

## **Potential Failure Modes Analysis Facilitator, Hydroelectric Station No. 2, AR, Arkansas Electric Cooperative Corporation.:**

Facilitator for FERC-mandated potential failure modes analysis for a hydroelectric facility in Arkansas, located adjacent to a U.S. Army Corps of Engineers lock and dam project.

## **Toker Dam, Eritrea, East Africa:**

Project manager for design and construction of a new, 210-foot-high RCC gravity dam, in Eritrea. The design included preparation of complete plans and specifications for solicitation of tenders from international construction firms. Dam construction was completed in the summer of 1999, at a cost of about \$20 million.

## **Project Manager, New Construction, Elmer Thomas, USFWS, OK:**

Managed field investigations and conceptual and final designs of dam safety actions for an existing 97-foot-high earthfill/rockfill dam. Completed final design of a new 113-foot-high RCC replacement dam.

## **Project Manager, Dam Safety Modifications, McKinney Lake Dam, USFWS, NC:**

Managed conceptual and final designs of dam safety modifications for an earthfill embankment dam and provided engineering services during construction. The modifications included RCC embankment overtopping protection.

## **Project Manager, Dam Safety Modifications, Umbarger Dam, USFWS, TX:**

Managed conceptual designs of dam safety modifications for an earthfill embankment dam. The preferred alternative included RCC embankment overtopping protection.

## **Project Manager and Facilitator, Workshop on Seepage Through Embankment Dams:**

Organized, managed, and facilitated a workshop sponsored by the Federal Emergency Management Agency and the Association of State Dam Safety Officials. The purposes of the workshop were to identify the state-of-the-practice for analysis, evaluation and design related to seepage through embankment dams and to develop prioritized lists of recommended research and development activities to improve the state-of-the-practice.

## **Project Manager and Facilitator, Workshop on Dam Outlet Works:**

Organized, managed, and facilitated a workshop sponsored by the Federal Emergency Management Agency. The purposes of the workshop were to identify the state-of-the-practice for analysis, evaluation and design related to seepage through embankment dams and to develop prioritized lists of recommended research and development activities to improve the state-of-the-practice.

## **Instructor, Potential Failure Modes Workshop:**

Instructor for a two-day workshop developed for the Colorado Dam Safety Office.

## **Advisor, Risk Prioritization Workshop:**

Advisor for a one-day workshop on development of a dam safety risk prioritization tool for the New Mexico Dam Safety Office.

## **Instructor, Internal Erosion Potential Failure Modes Workshop:**

Instructor for a one-day workshop presented at ASDSO's National Conference.

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**Instructor, Seepage Analysis for Embankment Dams Workshops:** Instructor for two one-day workshops presented at ASDSO's National Conference.

**Instructor, Seepage Analysis for Embankment Dams:** Instructor for a two-day course for ASDSO.

**Instructor, Slope Stability Analysis for Embankment Dams:** Instructor for a three-day course for ASDSO.

**Instructor, Embankment Dam Design:** Instructor for a four-day course for the U.S. Army Corps of Engineers.

**Instructor, Dam Seepage Rehabilitation:** Instructor for a three-day course for the U.S. Army Corps of Engineers.

# PETER A. DICKSON

**POSITION IN FIRM:** Vice President, Global Geotechnical Practice Leader, Geotechnical Risk Manager

**YEARS WITH FIRM:** 39

**TOTAL YEARS OF EXPERIENCE:** 44

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## KEY QUALIFICATIONS:

Dr. Peter Dickson has broad experience on a large variety of water resource projects in many parts of the world mostly involving dams for water supply and hydroelectric projects, spillways, power plants, penstocks, tunnels, caverns, and flood control structures. His 39 years with MWH has involved a particular emphasis on large hydropower and pumped storage projects. His experience includes project screening and ranking; design and supervision of geological and geotechnical investigations; siting of project features and developing layouts and arrangements; dam type selection, slope stability evaluations and slope design; foundation design for heavy civil works; criteria for planning, design and construction of dams, spillways, and underground works; detailed design and contract document preparation; hazard and risk analysis, including forensic investigations.

As Global Geotechnical Leader, his work involves coordination of work being done by geotechnical teams in offices around the globe, including implementation of consistent practices, and establishing consistent communications between offices. His responsibilities include assessment of technical risk on new pursuits, risk assessment on various projects during implementation using PFMA and FMEA methods, independent technical review, and constructability review.

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## EDUCATION:

PhD, Geology, University of Pittsburgh, 1977  
MSc, Geology, University of Manchester (UK), 1974  
BSc, Geology, University of Leeds (UK), 1971

## Professional Registration:

Professional Geologist, Georgia, 1990  
Professional Geologist, Virginia, 1984  
Professional Geologist, Wyoming, 1993  
Professional Geologist, Indiana, 1983

## SELECTED DAM AND HYDROELECTRIC PROJECT EXPERIENCE:

### Neelum-Jhelum Hydroelectric Project, Pakistan

*Client: WAPDA*

Currently serves as member of senior technical review team during detailed design and construction of 979-MW hydroelectric project scheme in Himalaya foothills, Pakistan. Responsible for site visits, value engineering and technical advice to design and construction teams, technical review of underground works (>56km tunnels, underground powerstation complex, 300-m-high surge shaft), and concrete gravity dam, de-sanding chambers; tunnel construction by drill-blast and TBM. Severe project challenges include major earthquake hazard, weak foundation materials, active fault crossings for tunnels, highly deformed and complex tunnel geology. Technical lead in evaluation of earthquake hazard and foundation design; development of seismic design parameters for final design including ground motion estimates, response spectra and time histories.

### Priest Rapids Dam, Washington

*Client: Grant County Public Utility District*

Independent Technical Reviewer of investigations and detailed design of remedial works under right side of embankment dam, where existing dam is founded on potentially liquefiable materials. Provided guidance to client and design team in selection of a preferred solution involving construction of a new dam downstream of the existing dam with a core tie-in by construction of a cutoff wall; presented findings and design solution to FERC.

#### **Wanapum Dam Spillway Remediation Project, Columbia River, Washington**

*Client: Grant County Public Utility District*

Independent Technical Reviewer for repairs and stability improvements to the Wanapum Dam Spillway following discovery of serious vertical and downstream movement in one of the 13 spillway monoliths. Provided independent review and oversight of study of the root cause of the movements, foundation analysis, finite element static and seismic stress analyses, and stability improvements to the entire spillway. Final solution included installation of 61 strand tendon post-tensioned anchors and 3" dia post-tensioned bar anchors in each spillway monolith.

#### **Panama Canal 3rd Set of Locks Project, Panama**

*Client: GRUPO and Autoridad del Canal de Panama (ACP)*

Dr. Dickson served on technical review board for the designers of the design-build team for construction of new locks expansion project. Responsible for review of all foundation and seismic aspects, geotechnical design criteria, design procedures and analytical approaches, risk assessment, and submittals. Following successful bid, continued in this role during construction in review of foundations and seismic aspects, including forensic examination of root cause of foundation problems occurring during construction. At Client request, and prior to bidding period, served as peer reviewer of seismic hazard and geologic data acquisition and interpretation, and advised client in approach to selection of seismic design criteria. During design and construction, reviewed foundations, RFIs, changed conditions issues, and submittals. Independent reviewer during preparation of design and drawings for repair of cracked lockhead structures; was involved in root cause analysis.

#### **Tekeze Dam, Ethiopia**

*Client: Ethiopian Electric Power Corporation*

Responsible for field inspection of project works and seismic hazard on 190-high thin-arch concrete dam under construction, responsible for identification of foundation and rock slope stability critical issues, rock mechanics evaluations (including 3-D rigid block and kinematic analyses, block theory, 2-D and 3-D FEM stress and deformation analysis). Responsible for rock reinforcement and anchor design, including thrust-block design and left abutment remedial works (abutment replacement), review of underground works (power tunnel system and powerhouse cavern); QA of site engineering.

#### **Iowa Hill Pumped-Storage Project, California**

*Client: SMUD (Sacramento Municipal Utilities District)*

Lead geological engineer in re-examination of project layouts and construction costs. Prepared new revised layouts for underground works including powerstation complex, high pressure and low pressure waterways, power shaft, and upper reservoir. Prepared risk assessment and conducted FMEA workshop. Participated in preparation of estimates of construction costs, constructability analysis, and scheduling. Advised on development of scope of additional site investigations. (Intermittent 1990 to 2013)

#### **John Hart Hydroelectric Project and Ruskin Hydroelectric Project, British Columbia, Canada**

*Client: BC Hydro*

Served on team providing a validation of replacement of the existing John Hart Project and Ruskin Project, both of which exhibited serious technical deficiencies. Role included evaluation of geological conditions at sites, foundation geotechnical assessment, potential seepage and piping issues, seismic hazard evaluation, and review of proposed engineering solutions to deficiencies. With client staff, conducted detailed risk assessment and facilitated failure modes workshops (FMEA).

#### **Shandong Taian Pumped-Storage Project, China**

*Client: Shandong Taian Pumped-Storage Power Station Co. Ltd*

Consultant responsible for checking review and technical advice on design and construction of upper reservoir CFRD dam and underground works. Responsible for assessment of site investigations, check of design criteria, tunnel design, independent analysis and assessment of stability of caverns and tunnels, and shafts; conducted numerical analysis, excavation and support design, overall review of design and construction methods; review and advise construction

design of underground works, including review construction procedures and specifications; check of project construction schedule, implementation plan, and construction cost estimates; responsible for technical advice and evaluation of geomembrane lining system for upper reservoir. (2001 – 2007)

### **Seneca Station Pumped-Storage Project, Pennsylvania**

*Client: First Energy*

Served on Risk Evaluation Team during facilitated Probable Failure Modes Analysis (PFMA) workshop for hydroelectric pumped storage project. The purpose was to evaluate risks associated with piping failure, slope stability, structural concerns, and operations of the project. A total of 27 potential failure modes were evaluated, including risk reduction measures; prepared report. Lead geological engineer and quality control engineer during emergency investigations, development of repair program, drawings and specifications, and implementation of repairs at lined upper reservoir of pumped storage project. Developed program to repair cracked asphaltic-concrete reservoir floor lining. Responsible for supervision and review of design components, Health and Safety Plan, QCIP, and field supervision.

### **International Panel of Experts, Iraq**

*Client: Ministry of Water and Energy Resources*

Expert in geological engineering, karst, and seismicity serving on International Panel of Experts (POE) for Minister of Water, to provide technical review, advice, and oversight of all dam projects in operation, under design, or investigation for planning and future development. For three years the main focus of the panel was on the management and safety of Mosul Dam, including subsurface and hydrogeological investigations, evaluation of alternatives, review of on-going grouting programs and instrumentation/monitoring. The POE provided a long-term solution to the Owners of this extreme risk project which they have now accepted and is in the process of being implemented.

### **San Pedro Hydroelectric Project, Chile**

*Client: Colbun*

Dr. Dickson served on Board of Consultants as technical expert on foundations and underground structures. Assignments involved review of a \$250-million 144-MW hydroelectric project in Chile with installed capacity of 144 MW. Review activities included site visits and detailed inspection of investigations and design with Owner and its design team. The project is in early stages of construction and opinions were provided regarding constructability, schedule, technical and construction risks.

### **Proyectos HidroAysen, Chile**

*Client: HidroAysen*

Served on Board of Consultants as technical expert on foundations and underground structures. Assignment involved review of five hydroelectric projects under various stages of development with total installed capacity of 2750 MW. Review activities included site visits and detailed inspection of investigations and design review with Owner and its design team. Helped in risk workshops using risk-informed decision-making processes (including development of event trees and fragility curves in risk-based models) to assist in determining design criteria for critical project components. Construction: On hold pending environmental studies financing. Project Cost: \$3.5B

### **Sanchung Pumped-Storage Project, Korea**

*Client: Hyundai Engineering Company, Ltd., Seoul, and Saman Engineering Co.*

Consulting geologist during construction of upper and lower reservoir dams and underground works. Responsible for evaluation of rock support system, geologic mapping and detailed geologic data collection in newly excavated works. Carried out stability and finite element analyses of stresses around PH cavern. Results used to check rock support provisions and recommend modifications in support system, underground construction methods, grouting and drainage. During planning and design phase, independent checking engineer responsible for assessment of site investigations, design oversight of all geotechnical features including power tunnel system, PH, and surge shaft, two concrete-faced rock fill dams, spillways, and material quarries; carried out numerical analysis of cavern and tunnels, recommended underground layout revisions, additional investigations, design details, prepared rock support system, and underground construction methods; dam foundation assessment, recommended additional investigations and grouting requirements.

### **Al Wehdah Dam, Jordan**

*Client: Jordan Valley Authority*

Lead engineering geologist for the \$400-million water supply dam project. Major structures include a 140-m-high, concrete-faced rockfill dam (CFRD), which was later re-designed as a roller-compacted concrete dam (RCC); 400-m-long chute spillway; penstocks; irrigation tunnels; and power plant. The dam site has sensitive foundations with karstic limestone, highly soluble altered rock, weak marls and clay layers. During final design and construction bid document preparation, responsible for site investigations, selection of geologic design parameters including foundation stability and treatment, evaluation of spillway foundation potential failure modes, earthquake hazard evaluation, and input to cost estimate. During construction, evaluated foundations, conducted stability assessments (including 3-D block analyses), rock mechanics analyses, proposed design and construction modifications, reviewed foundation treatment and grouting works. Resident engineer during construction of diversion tunnel; provided construction supervision for treatment of karst features in foundations; evaluated reservoir leakage potential and reservoir rim stability.

### **El Cajon Hydroelectric Project, Mexico**

*Client: CFE and CIISA*

Principal engineering geologist serving on Dispute Resolution Board retained by Owner (CFE) and contractor consortium (CIISA) to provide expert opinion and resolve financial disputes upon completion of construction of major hydroelectric project with high concrete-faced dam, underground powerstation complex. Activities included site visit, meetings with Owner and Contractor, review of technical and contract information, and development of opinion on validity of claims involving changed/unanticipated geologic conditions, scheduling interferences, cost impacts (2007)

### **Karahnjukar Hydroelectric Project, Iceland**

*Client: Landsvirkjun*

Lead geological engineer in review and finalization of seismic design for 200-m-high concrete-faced-rockfill dam in Iceland; QA review of geology, foundations, and grouting. Presented findings and recommendations to independent technical review Panel of Experts.

### **Diamer Basha Dam and Hydroelectric Project, Pakistan**

*Client: WAPDA*

Project involves a 270-m-high dam on the Indus River in highly seismic region of the Himalayas. Responsible for seismic hazard evaluation and preparation of seismic design parameters and criteria. Developed initial layouts and basic design of underground works, including two 6-unit powerhouses, transformer/GIS caverns, surge chambers, power tunnels, tailrace tunnels, and construction access tunnels. Provided technical review and input in geotechnical investigations, foundation design, and detail design requirements of underground structures. Responsible for detailed geotechnical and rock mechanics analyses including finite element modeling of caverns, rock support design excavation design, stability assessment of spillway plunge pool, tunnel lining design parameters, rock slope analysis and design, supervision of geotechnical design team, preparation and review of reports. Task leader in independent study of optimizing project arrangements, dam type selection and criteria.

### **Boyabat Dam Project, Turkey**

*Client: Doğu Construction and Trading Co.*

Lead geotechnical engineer during final design of project involving a 200-m high concrete gravity dam on Kizilirmak River in north-central Turkey. The 3-unit project has an installed capacity of 528 MW. Significant issues related to presence of faulted, karstic limestone in the foundation and abutments, and due to the proximity of the North Anatolian Fault, capable of M = 8.0 events. Responsible for site visits, directing a team of geologists and geotechnical engineers in final design including foundation evaluation and stability analysis, foundation excavation and treatment design, cofferdam design, instrumentation design, earthquake analysis, specifications and drawing preparation.

### **Bath County Pumped-Storage Project, Virginia**

*Client: Virginia Electric Power Company*

Field geologist responsible for foundation investigations (lower reservoir dam and spillway, upper dam), stability analysis of lower reservoir spillway foundation, detailed geologic mapping of excavations and power tunnels and site inspection during construction; member of grouting team during emergency repairs to power tunnel system, included review of geologic and grouting data in high-pressure tunnel and penstock areas; interpreted Thermal Infrared Imagery to enable detection and monitoring of leakage and springs.

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# **Curriculum Vitae - Stephen James Rigbey**

## **POSITION**

Director, Dam Safety, BC Hydro, British Columbia, Canada

President, SJR Consulting Inc., Vancouver, Canada



## **EDUCATION**

B.A.Sc., and M.A.Sc., Geological Engineering,

University of Windsor, Canada, 1975, 1980

## **PROFESSIONAL ASSOCIATIONS**

Association of Professional Engineers and Geoscientists of the Province of British Columbia

Professional Engineers of Ontario

Canadian Dam Association (CDA) – member Dam Safety Committee

International Congress on Large Dams (ICOLD) – Canadian representative on the Seismic Committee

## **SUMMARY OF EXPERIENCE**

Stephen joined Acres International (now Hatch) in 1979, where he rose to Principal Geotechnical Engineer and Project Manager. Through Acres, he gained extensive worldwide experience, working in more than 15 countries and following numerous projects through investigations, design, construction of underground complexes, concrete and earthfill dams, and long-term monitoring. Specialties include instrumentation and dam safety, seismicity assessments, and rock mechanics designs.

Stephen then joined BC Hydro in 2008, and is now the Director of Dam Safety, responsible for ensuring safe reservoir retention and passage through and around hydro facilities at 41 sites throughout the province of British Columbia, Canada. He is responsible for monitoring and surveillance, the identification and prioritization of all associated risks, initiating Investigation and Capital projects, and providing technical oversight to these projects, which will total \$CAN 1.9B over the current 10-yr Capital Plan. He has a staff of about 35 professionals, technologists and support staff.

Externally from BC Hydro, Stephen has been a member of Advisory Boards for the Lower Churchill Project in Newfoundland and for audits of dam safety programs for utilities in Sweden and Turkey. As a member of the CDA Dam Safety committee, Stephen was heavily involved with the 2013 review and updating of the Dam Safety Guidelines.

Stephen has been recently awarded the prestigious Inge Anderson Award by the Canadian Dam Association in recognition of his “significant contributions to the advancement of knowledge and practices related to dams in Canada”.

- **Operational Safety:** At BC Hydro, Stephen has initiated changes to spillway and reservoir operations in a number of cases as interim risk management measures. He has also initiated overall operational reviews of reservoirs and river systems in view of dam safety considerations. Current work involves the Campbell River System on Vancouver Island, where operations and input hydrographs have been stochastically modelled to better understand the consequences of a single random spillway gate failure to operate on demand. Results have indicated that changes to operational rules will greatly reduce overall downstream flooding risks while only marginally increasing upstream risks. Stephen is also one of the four sponsors responsible for initiating the work behind the recently published book *Operational Safety of Dams and Reservoirs* (Sept 2016, ICE Publishing).
- **Dam Safety Assessments:** Prior to joining BC Hydro, Stephen performed numerous dam safety assessments of various earth and concrete structures within Canada, including detailed foundation condition investigations, coordination of laboratory work, and assessment of rock/concrete shear strengths. A systematic approach to the evaluation of parameters for stability analyses was developed for this work, and is quoted in the Canadian Dam Association Guidelines. Internationally, Stephen has performed Dam Safety Reviews and seismic hazard assessments for high-risk dams in Iran, El Salvador and Panama.
- **Administration and Quality Control :** At BC Hydro, Stephen is responsible for initiating and reviewing all major projects involving water passages and dams. At Acres, he was responsible for the administration and technical coordination of all geotechnical work on hydro projects, including seismicity assessments. Stephen also has significant experience in quality control reviews, and has acted as Lender's Engineer in the review of designs and construction of dams in Panama and India.
- **Dam Investigations and Design :** Stephen has been the Project Manager for the design of a 35-m high, 500-m long embankment dam founded on sands and gravels, including a 65-m deep plastic concrete cutoff wall. He had previously managed an investigations and monitoring program for the original dam, which included an extensive remote automated instrumentation system, development of a detailed Emergency Preparedness and Response Plans, infilling of sinkholes, geophysical surveys, exploratory boreholes through the damaged core of the dam, and sonar surveys of the headpond. A methodology for precise sonar surveying of the sinkholes was developed under Stephen's supervision as part of the work for this project. Stephen has worked in karst environments for projects in both Iran and Indonesia.
- **Rock Mechanics and Geological Engineering :** Stephen has designed layouts and support for underground powerhouses and tunnels under various conditions, including extremely high horizontal in situ stresses and time dependent deformations. Design studies have included the development of specialty laboratory tests to investigate swelling rock pressures. He also has experience in the laboratory and field identification of alkali-aggregate reactions. Stephen spent 2 years on-site in India during the construction of a major underground power facility, and was also Resident Site Engineer during the construction of a 600-m long, 3.5-m dia adit and a 13.5 m dia trial excavation chamber in shales. He was involved onsite at the Karun III project in Iran during the construction of a 200-m concrete arch dam and underground powerhouse complex. He also worked for a number of years on the Niagara Diversion Tunnel project, a 10-km long, 14.4-m diameter rock TBM drive, including investigations, design, and the development of the project Geotechnical Baseline Report.

## CAREER CHRONOLOGY

### ***SJR Consulting Inc – Vancouver, 2013 to present***

- Advisory Board member, Muskrat Fall Hydroelectric Project, Newfoundland (Nalcor) : project involves RCC and embankment dams about 20 to 40 m high, and a unique abutment issue where a currently meta-stable landform must be transformed into a robust reservoir retaining structure.
- Audits of Dam Safety Programs: extensive audit of management and technical processes and procedures against ICOLD Bulletin B154 - Dam Safety Management: Operational Phase of the Dam Life Cycle, for Vattenfall Vattencraft (Sweden) and Enerjisa (Turkey), resulting in 40 to 50 specific recommendations for consideration in each case.

### ***BC Hydro – Vancouver : Manager (now Director) of Dam Safety, 2008 to present***

- Responsible for all aspects of safety involved with water retention and water passage structures at 41 separate hydroelectric sites, developing the appropriate scope and initiating all major studies, investigations and civil projects associated with dam safety, and for providing technical guidance throughout the execution of these projects.
- Reporting directly to the Deputy CEO, and to the Board of Directors on a quarterly basis

### ***Hatch Energy – Vancouver : Principal Geotechnical Engineer & Project Manager, 2006 to 2008***

- Comprehensive review of shear strength parameters for the Ruskin Dam, including investigations for basic resistance of the bedrock-concrete contact.
- Forrest Kerr Hydroelectric Project Feasibility Study —Responsible for geotechnical investigations and feasibility level designs for a 190 MW underground powerhouse scheme and 3.4 km tunnel in Northern British Columbia.
- Risk Study for Kemano Tunnel, including investigation of submersible inspection techniques. This partially-lined rock tunnel has a history of rock collapses, and is critical to the supply of power for Alcan's aluminum smelter at Kitimat. Various alternatives to reduce failure risk were compared on a Net Present Value Basis.
- Project Manager for various detailed sonar bathymetry studies for BC Hydro and TransAlta.
- Dam Safety Review Engineer for various large dams, including BC Hydro's extreme consequence category Mica Dam, a 240-m high earthfill structure, and the 120 m high Wood Creek Suncor tailings dams.
- External consultant to BC Hydro for an audit of monitoring and surveillance practices within the Dam Safety Group.

### ***Acres International (later Hatch Energy), Niagara Falls: Principal Geotechnical Engineer, 2001 to 2005***

Responsible for quality control of geotechnical work and mentoring/guidance of geotechnical staff within the hydro division. Continued in previous role as Department Head.

Development of the Geotechnical Baseline Report (GBR) for the Niagara Diversion tunnel project (14.4-m excavated dia., 10 km long). Participated in technical evaluation of the bids and contract negotiations.

Seismic hazard assessments and dam safety reviews for high-risk dams, including regional seismicity reviews, deterministic and probabilistic hazard analyses, selection of design events for:

- Dez dam, Iran
- four dams in El Salvador
- Fortuna dam, Panama.

Due diligence studies and site visits as Lender's Engineer for hydroelectric projects during construction:

- Estí project in Panama, a 120-MW scheme involving an earth dam, 6-km canal, 50-m high concrete-face rockfill dam, 4.8-km, 7-m dia tunnel and surface powerhouse
- Vishnuprayag project in India, involving 11-km, 4-m dia tunnel and 400-MW underground powerhouse.

Onsite review of abutment stability safety for a 140-m high, concrete gravity arch dam at the Chamera project, northern India, following a massive downstream landslide.

Project Manager for the design of the 35-m high, 500-m long Shikwamwka Replacement embankment dam, founded on sands and gravels, and incorporating a 65-m deep plastic concrete cutoff wall. Also acted as Project Manager for the monitoring and investigations program involving the original dam.

Numerous dam safety assessments of various earth and concrete structures in Ontario and New Brunswick, including detailed foundation condition investigations, coordination of laboratory work and assessment of rock/concrete shear strengths for the stability analyses. A systematic approach to the evaluation of parameters for stability analyses was developed for this work.

***Acres International, Niagara Falls, Geotechnical Department Head - 1996—2001***

Responsible for the administration and technical coordination of all geotechnical work on all projects involving geology, soil and rock mechanics, and seismicity. The department had a staff of 12-15 engineers and technologists.

Acting Geotechnical Site Engineer, Karun III hydroelectric project, Iran. Responsibilities included

- supervision of foundation preparation in a faulted area for a 205-m concrete arch dam
- providing advice on major ground movements experienced during excavation of the 26-m span underground powerhouse; review of all instrumentation results
- development of 3D numerical rock mechanics models for the underground complex
- development of 2D seepage models for the arch dam abutment

Project Manager responsible for a study to examine possible causes of, and to develop alternative remedial options for, significant leakage at the Old Mill Station subway tunnel portal, Toronto, Ontario. The study included geotechnical investigations, conditional surveys and a full-scale pump test.

Inspection and interpretation of monitoring data, detailed hydrogeological site assessment, and detailed analysis of groundwater chemistry for the Irving Paper aeration and stabilization basin. The basin containment dike is constructed on a soft marine clay deposit, Saint John, New Brunswick. Preparation of yearly monitoring reports are issued for the New Brunswick Ministry of the Environment.

Project Manager for potential rockfall studies on 48 highway rockcuts in eastern Ontario. Report included recommendations for remediation, cost estimates and benefits.

On-site consultation for remediation of a collapsed 3.5-m dia tunnel in overburden in Bolivia.

Design of remedial works for a 100+ m slope undergoing long-term creep in weathered rock over a water tunnel intake for the Cañon del Pato project in Peru. On-site consultations and construction reviews.

Provided on-site technical advice for the Second Power Reconstruction project, Bosnia and Herzegovina, in the planning for re-instrumentation of the Bocac and Trebinje dams following damage during the war. Developed specifications for international tendering through the World Bank. Instrumentation included precise survey equipment for geodetic monitoring, regional seismicity monitoring and local accelerometer networks, automatic weather stations, and various geotechnical instrumentation systems, including telependula, vibrating wire piezometers, strain gauges, tiltmeters, and ADAS systems.

Vibrating wire piezometer design and installation in boreholes in Welland, Ontario, to measure uplift pressures on tunnel portal structures for the Ministry of Transportation, Ontario. Readings were data logged and alarm software developed for notification via a remote communications link.

Pre-bid and final designs of underground excavations for the Western Beaches combined sewer outfall storage tunnel (3 m dia, 4 km long) in Toronto, Ontario. The project also included excavation of 30-m dia. shafts through rock to tunnel elevation. Ongoing site visits and consultation during construction.

Design of bar anchor and lining support for two 9-m dia. mine shafts in Wyoming for use as storage bins.

Coordination of tender preparation and pre-bid design of underground support, including large bar anchors and shotcrete for the Nam Ngum III project in Laos (involving a 440-MW underground powerhouse scheme and 10 km of 5-m dia. tunnels).

Project Manager for the Welland River shoreline rehabilitation project, involving the stability assessment of natural, concrete wall and other shoreline types along an unused ship canal and the development of remedial recommendations and cost estimates.

Tunnel inspections and stability reviews for two 4- to 6-m dia. power tunnels in northern Ontario. Review of existing bar anchor and shotcrete support and design of remedial measures.

***Acres International Senior Geological Engineer 1990—1996***

Design of layout and support for an underground powerhouse and water transfer tunnels for the Alto Cachapoal project, Chile, including excavation design and sequencing, bar anchor and shotcrete support design for both drill and blast and TBM excavation.

Site reconnaissance and project layout review for the Upper Marsyangdi hydroelectric project, Nepal.

Review of alkali-aggregate reactivity (AAR) in the concrete of three locks in the St. Lawrence Seaway system, including the preparation of instrumentation plans for long-term monitoring of concrete growth.

Assessment of rock/concrete shear strengths for the stability analyses of a number of concrete gravity structures in northern Ontario.

Review of conceptual plans for the underground storage of low-level radioactive waste in Ontario. Assisted in the preparation of tenders and contract awards.

Responsible for the long-term automation planning for geotechnical instrumentation at a number of hydroelectric plants in northern Ontario, and the design and installation of remote monitoring systems.

Project Engineer for the Malvern remedial project, involving site preparation for the sorting and storage facilities for 9000 m<sup>3</sup> of mildly radioactive contaminated soils. Responsible for detailed final designs, contract preparation, construction supervision and contract closeouts.

Resident Site Engineer during the Stage 3 geotechnical investigations for the Niagara River hydroelectric development. These investigations included the construction of a 600-m long, 3.5-m dia. adit and a 13.5-m dia. trial excavation chamber in the Queenston shale by means of roadheader. The site was affected by high in situ stresses, highly corrosive groundwaters and swelling rock conditions. The program also included various instrumented arrays, measurement of in situ stresses, borehole dilatometer and geophysics testing, and the development of special in situ and laboratory testing for rock swell.

Geotechnical coordination for the definition phase design of the generation facilities for the Niagara River hydroelectric development. These facilities included a proposed 26-m wide powerhouse cavern, transformer gallery, 12.5-m dia. penstock and tailrace tunnels, and associated access tunnels. Design studies included 3D boundary and finite element analyses of the underground complex, and preliminary support design. The work was superseded by the Niagara Diversion Tunnel project.

Coordination of geotechnical and geophysical field investigations for feasibility and final design of a proposed extension to the Owen Falls generating station, Uganda. Responsible for overall review of project seismicity. The project involves a 20-m deep cut in residual soils for a 1-km long power canal and an intake structure on very weak bedrock foundations.

Coordination of investigations for feasibility of siting a health center on an existing landfill in Toronto, Canada. Specific concerns included methane gas control and excavation/redisposal of solid wastes.

***Acres International Geological Engineer 1978—1990***

Resident geotechnical representative at the construction site of the 540-MW Chamera hydroelectric generating station in Himachal Pradesh for National Hydro Power Corporation of India. Work included

- supervision of rock excavation, rock support and quality control for 9.5-m dia, 6.5-km long power tunnel, underground powerhouse complex and tailrace tunnel. Installation of 10.5-m long, 52-mm high tensile hollow core bar anchors in crown, and 13-m long, 36-mm dia anchors in walls
- training and transfer of technology to a group of local engineers and geologists
- geotechnical instrumentation.

Planning and supervision of drilling, testing and instrumentation at the Mactaquac generating station, New Brunswick. Investigation of structures and their foundations included determination of concrete characteristics of, and defining the cause of movements within, a concrete gravity intake/spillway and powerhouse. Fieldwork involved a study of concrete cracking and construction joint conditions by borehole photography and ultrasonic methods. Instrumentation installations included tape and borehole extensometers, normal and inverted plumb lines, various deformation and strain gauges, pneumatic piezometers and thermocouples. Concrete tests included direct shear, strength and index properties, thermal properties and both standard and non-standard tests for potential AAR.

Involved in geological investigations for a major project in the Middle East including in situ stress measurements in deep boreholes and core orientation studies.

Development of stereographic projection, statistical analysis and other computer program packages for general use in interpretation of geological field data.

Feasibility site reconnaissance and geologic interpretation of general site conditions for the Sentani hydroelectric project in Irian Jaya, Indonesia. Project involved 4-m dia. tunnels through karstic limestone ridges and 20-m deep channel excavations in weak soils. Evaluation of bids for field explorations.

Detailed dam abutment geologic mapping and assessment for the proposed Granite Canyon hydroelectric development, Yukon.

Development of a computer aided borehole photography interpretation system for use in a foundation investigation program for the spillway at the Limestone generating station, Manitoba.

Prefeasibility site reconnaissance for the Yom-Nan diversion project in Thailand. Responsible for interpretation of general site conditions for determination of project feasibility. Project involved a 25-km long, 8-m dia. tunnel in rock and 48-km of canal excavation in residual soils.

Responsible for geological mapping, core logging, borehole photography and geological interpretation of site conditions for the Upper Salmon hydroelectric development, Newfoundland. Project involved excavations up to 25 m in vertically fissile rock, greater than 5 km of earth-fill dams and dikes up to 25 m high, and overburden excavation for diversion channels. Preparation of data for tenderers and technical specifications for contract purposes. Calculations of rock slope stability and support requirements on site during part of the construction period to review the rock excavations and performance of bar anchors. Responsible for installation of dam instrumentation and supervision of post-impounding monitoring program. Instrumentation included inclinometers, hydrostatic settlement profile gauge, tape extensometer and pneumatic piezometers.

Layout, field supervision and report on an exploratory drilling program related to the stability of a powerhouse rock intake tunnel near Wawa, Ontario.

Responsible for geological mapping, core logging and geological interpretation of site conditions during a major investigation program for a thermal power generating station at Atikokan, Ontario. Project involved dam rehabilitation, construction of rock tunnels, deep excavations in rock and overburden, and heavy structure foundations.

#### **TECHNICAL PAPERS AND MAJOR PRESENTATIONS**

Dam Safety Risk – Canadian and BC Hydro Perspectives, ICOLD-INCA Symposium on Dam Safety for the Americas, Mexico City, October 2016

Next Steps in BC Hydro's Risk Informed Decision Making, keynote presentation at ANCOLD Annual Conference, Brisbane, November 2015

BC Hydro Seismic Hazard Model, presentation at Emergency Preparedness and Business Continuity Conference, Vancouver, November 2014

Reframing Risk Informed Decision Making at BC Hydro, Canadian Dam Association Conference, October 2014 and keynote speech, 2013 HG Acres Seminar, Niagara Falls.

Why Every Owner Needs Risk Informed Decision Making, presentation at CEATI Dam Safety Interest Group meeting, Vancouver, October 2013

Assessment of Extreme Flood Hazard, Series of articles for CDA Newsletter, 2011-2013, that led to the 2013 revision of the CDA Guidelines

Assessment of Shear Resistance for Blasted Rock Foundations, Canadian Dam Association Conference, September 2007.

The Design and Construction of the Shikwamkwa Replacement Dam, Canadian Dam Association Conference, September 2007. (Coauthor)

Accounting for Time-Dependent Deformation in the Niagara Diversion Tunnel Design, Proc. 1<sup>st</sup> Canada-US Rock Mechanics Symposium, Vancouver, May 2007

Concepts of Shear Resistance and Practical Applications. Dam Engineering, Volume XVI, Issue 3, November 2005. (Coauthor)

Monitoring Sinkhole Development by Detailed Sonar Profiling. Proceedings; Association of State Dam Safety Officials Annual Conference, September 2005, and Proceedings; Canadian Dam Association Conference, October 2005. **Best Paper Award**

The Assessment of Sliding Resistance Beneath Concrete Structures. WaterPower XIII, July 2003. (Coauthor)

Grouting of a Karstic Arch Dam Foundation. 55th Canadian Geotechnical Society Conference, Niagara Falls, Ontario, October 2002. (Coauthor)

A Phased Approach to the Rehabilitation of an Aging Northern Dam. HydroVision 2000 Conference, August 2000. (Coauthor)

Exploratory Adit Program for the Niagara River Hydroelectric Development. 12th Annual Canadian Tunnelling Conference, Vancouver, BC, October 1994.

Design of Underground Powerhouse Complex, Niagara River Hydroelectric Development. 45th Canadian Geotechnical Conference, Toronto, Ontario, October, 1992.

Placement and Performance of Impervious Fill Blankets on Slopes. 44th Canadian Geotechnical Conference, Calgary, Alberta, 1991. (Coauthor)

Rock Support for a Large Underground Cavern at Chamera. All India Conference on Underground Engineering, Lucknow, India, February, 1989.

Engineering and Construction Options for the Management of Slow/Late Alkali-Aggregate Reactive Concrete. Proceedings, 16th International Congress on Large Dams, San Francisco, 1988. (Coauthor)

Laser Strain Measurement System. Paper presented at Annual Meeting, Association of Engineering Geologists, Hershey, Pennsylvania, 1978.

The Effect of Sodium Chloride on Water Sorption Characteristics of Rock Aggregate. Bulletin, Association of Engineering Geologists, Vol XIII, No. 3, 1976. (Coauthor)

## LANGUAGES

English

# Alvi Associates, Inc.

Irfan A. Alvi, P.E.  
President & Chief Engineer

## RESUME

### Education

B.S. (Honors), 1989, Civil Engineering  
University of Maryland

More than 70 credits of post-graduate coursework in engineering, risk analysis, geology, physics, chemistry, biology, and other topics

### Professional Registrations

1994, PE, MD, 20775  
1999, PE, VA, 033361  
2012, PE, DE, 18065  
2015, PE, WV, 021527  
2016, PE, PA, 084842

### Relevant Areas of Specialization

New Dam Design  
Dam Rehabilitation Design  
Dam Inspection  
Materials Testing  
Forensic Investigation  
Human Factors Investigation  
Reservoir Routing Analysis  
Open Channel Hydraulics  
Seepage and Stability Analysis  
Structural Engineering  
Geotechnical Engineering  
Risk Analysis  
Dam Removal Study  
Fluvial Geomorphology  
Construction Management

### Summary of Experience

Mr. Alvi has 28 years of experience in structural, water resources, geotechnical, and transportation engineering for dams and other infrastructure. His uniquely multi-specialist background is ideally suited to projects involving dams. In his role as Chief Engineer, he also regularly teaches mechanics of structures, fluids, soil, and rock to all of the engineers at Alvi Associates, at a conceptual depth beyond that offered in typical university courses and textbooks.

Mr. Alvi has completed many hundreds of projects involving inspection, materials testing, forensic investigation, studies, remedial design, and new design. Many of these projects have involved providing innovative solutions to meet challenging situations, with the result that many of his projects have received design awards during the past decade.

Mr. Alvi is a nationally-recognized expert in dam engineering. He served as technical leader for Alvi Associates' Prettyboy Dam project, which received the *2010 National Rehabilitation Project of the Year Award* from the Association of State Dam Safety Officials (ASDSO), which is among the most prestigious awards attainable in the dam engineering profession. The project also received three other awards in 2011, including an ASCE/MD Outstanding Civil Engineering Achievement Project award, ACEC/MD Engineering Excellence Outstanding Project Award, and ESB Outstanding Engineering Achievement Award.

More generally, Mr. Alvi has completed a diverse range of dam projects involving inspection, materials testing, forensic investigation, hydrologic and hydraulic analysis, reservoir routing and spillway capacity analysis, dam break modeling and inundation mapping, stream geomorphic study and restoration design, fish passage design, seepage and stability analysis, three-dimensional structural analysis, remedial design, design of new concrete and embankment dams, evaluation and design for dam removal, and construction management.

Mr. Alvi is also nationally-recognized as a pioneer and leader in the role of human factors in dam failure and safety. He has served on the ASDSO Dam Failures and Incidents Committee (DFIC) since 2010, leading the committee's work on human factors, making numerous presentations on human factors at ASDSO conferences (including a keynote address) and publishing several peer-reviewed papers. He also recently served as a Technical Advisor and Human Factors Expert for a FEMA project related to dam failures and incidents. In addition, at the request of ASDSO, in 2015 he presented a two-hour webinar ([link](#)) on human factors in dam failure and safety, as part of ASDSO's expert series of webinars. Several of his investigations of dam failures and the associated role of human factors are described below.

**Irfan A. Alvi, P.E.  
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**Examples of Dam Study and Design Projects**

**Prettyboy Dam in Baltimore, Maryland.** For this large high-hazard concrete gravity dam which is a key component in the water supply system for the City of Baltimore, performed review of extensive records related the dam's construction and history (including previous crack monitoring and investigations), abovewater and underwater inspection using an ROV in order to prepare detailed defect mapping, concrete coring and testing, forensic investigation of structural cracking using three-dimensional structural analysis (accounting for creep effects) and an innovative causes/effects matrix model, gatehouse stability analysis considering a wide range of potential failure surfaces, remedial design for a \$6 million post-tensioned anchorage system installed underwater in water depths up to more than 100 feet and consisting of 38 anchors drilled up to 70 feet into the dam (the first system of this type in the world), contractor prequalification, and extensive construction-phase services including development and evaluation of a preproduction anchor testing program. This 15-year project received four major design awards, as noted above.

**Mill Pond Dam in Cecil County, Maryland.** Performed alternatives studies and preliminary design for dam reconstruction to address breach in 1999 of an embankment dam dating to circa 1837. Alternatives included elements such as a new twin-cell box culvert outlet structure with a multi-stepped weir and a fish ladder, reconstruction of the failed embankment, embankment widening to allow a wider roadway, roadway reconstruction, a new sheet pile wall, riprap slope protection, and measures to control seepage, piping, and erosion within the new and reused portions of the embankment dam.

**Embankment Dam at I-695/Charles Street Interchange in Baltimore County, Maryland.** Performed hydrologic analysis, hydraulic analysis, and geotechnical studies for design of a new embankment dam, along with dam break and inundation modeling to assess risk to the adjacent interstate highway and perform hazard classification. Included installation of a geomembrane for seepage control.

**Seneca Crossing Dam in Montgomery County, Maryland.** Complete structural, geotechnical, and hydraulic design for a new concrete gravity dam flanked by embankment dams at each abutment. The concrete gravity dam was selected in order to minimize the dam footprint, and thus reduce the impact to wetlands. Due to adverse subsurface conditions involving highly compressible and permeable materials, an innovative design founding the dam on steel piles was developed and a sheet pile cutoff wall extending 18 feet deep was designed for seepage and uplift control. This design is estimated to have reduced construction costs by at least 40% relative to a conventional concrete dam.

**Bishopville Pond Dam in Bishopville, Maryland.** To address fish passage needs on a tidal waterway, performed inspection of an existing steel sheet pile dam, tidal hydrologic and hydraulic analysis using TR-20 and HEC-RAS to assess feasibility of dam removal and floodplain impacts (accounting for an existing bridge in the model), and design of a new offline pond isolated via an embankment in order to meet recreational needs of local residents.

## **Examples of Dam Forensic Investigations**

**Prettyboy Dam in Baltimore, Maryland.** In addition to the design aspects described above, extensive forensic investigation was performed for this high-hazard concrete gravity dam founded on micaceous schist. The dam is 150 feet high and 700 feet long.

By 1978, extensive cracking was observed in the gatehouse and the adjacent main body of the dam, along with substantial water leakage into the gatehouse stairwell. To respond to this concern, continuing until 1994, six investigations of the cracking were performed by five previous consultants, but with inconclusive and/or inconsistent findings.

We then became involved and performed a comprehensive multi-phase dam investigation involving many tasks: exhaustive review and summary of all available records, abovewater inspection, underwater inspection using divers and a remote-operated vehicle (ROV), precise mapping of defects throughout the exterior of the dam as well as inside the gatehouse, crack monitoring during gate testing operations, concrete coring and testing, analyses and evaluations, and preparation of a 300-page study report with recommendations.

We next performed a forensic structural/geotechnical investigation of the gatehouse cracking, eventually discerning that the cracks clustered into eight distinct groups, and likewise discerning three distinct general causes of the cracking, with each cause contributing in varying degrees to each crack group. In other words, we developed a “cause-effect matrix,” thus transcending the usual assumption of a simple one-to-one influence of cause to effect. The three identified causes of the cracking were vertical flexure of the dam, differential settlement between the gatehouse and main body of the dam, and deformation from the reactions of the bridge spans adjacent to the gatehouse. Our hypothesized causal matrix was quantitatively validated by analyses of stresses and deformations of the dam, gatehouse, and bedrock, and the resulting predictions were found to fit the observed cracking remarkably well.

The findings of the investigation were presented in a report for the client, a peer-reviewed paper in the ASDSO *Journal of Dam Safety* ([link](#)), and a presentation at the ASDSO national conference.

**Big Bay Dam in Mississippi.** This embankment dam was over 50 feet high and 2000 feet long, and failed in 2004, resulting in damage or destruction of more than 100 structures. Performed a comprehensive investigation of the failure, including review of many hundreds of pages of documents, including plans, calculations, construction records, deposition transcripts, engineering reports, etc. Focused on the human factors aspect of the failure, identifying the roles of the engineer, owner, state regulatory agency, maintenance personnel, and inspectors, as well as the complex interaction of human factors and physical factors during the two decades from the design until the failure. Findings of the investigation were presented in a peer-reviewed paper in the ASDSO *Journal of Dam Safety* ([link](#)), a dedicated ‘soapbox’ session at the ASDSO national conference, an ASCE invited speaker presentation, and Mr. Alvi’s 2015 webinar for ASDSO.

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**Sella Zerbino Secondary Dam in Italy.** The Sella Zerbino secondary dam was a concrete gravity dam about 46 feet high and 360 feet long. In 1935, a decade after construction, the dam failed catastrophically, resulting in at least 111 fatalities. Starting with the planning of the project four decades prior to the failure, a series of human and physical factors interacted and compounded, until a 1000-year storm was the final physical trigger for the failure. Additional physical factors included lack of a spillway for the secondary dam, instability and erodibility of the foundation rock at the secondary dam, and grossly inadequate discharge capacity for the reservoir, which was exacerbated by clogging of spillways and outlets. The human factors contributing to the failure included hasty design and construction of the secondary dam after a late decision to raise the height of the main dam, inadequate geologic investigation and missed warning signs related to the foundation of the secondary dam, and lack of rainfall data to adequately design spillways and outlets. This investigation involved an extensive literature review, mapped out the role of physical factors, and contributed new insights into the failure by identifying the role of human factors in the failure, using the framework pioneered by Mr. Alvi. Findings of this investigation were presented in a peer-reviewed paper ([link](#)) and presented at an ASDSO national conference.

**St. Francis Dam in California.** This arched concrete gravity dam near Los Angeles was nearly 200 feet high, and failed in 1928, about four years after construction began and a day after fully filling the reservoir for the first time, resulting in a flood which extended more than 50 miles and resulted in at least 400 fatalities, along with millions of dollars of property damage. The failure is considered by many to be the worst US civil engineering disaster of the 20<sup>th</sup> century. Performed a comprehensive investigation of the failure, including review of more than one hundred pages of documents, including plans, engineering analyses, other investigations, etc. Focused on the human factors aspect of the failure, identifying the roles of the chief engineer, other engineers working under the chief engineer, City of Los Angeles, and local citizens who reported warning signs, as well as the complex interaction of human factors and physical factors during the years preceding the failure. Findings of the investigation were presented in a peer-reviewed paper ([link](#)) and a presentation at the ASDSO national conference.

**Ka Loko Dam in Hawaii.** This embankment dam was 42 feet high and 770 feet long, and failed in 2006, resulting in flood depths of 10 to 30 feet, seven fatalities, extensive property and environmental damage, a criminal sentence for the owner, and a civil settlement of many millions of dollars. Performed a comprehensive investigation of the failure, including extensive literature review of many hundreds of pages of documents, including plans, calculations, engineering reports, other investigations, news reports, etc. Focused on the human factors aspect of the failure, identifying the roles of the owner, Corps of Engineers, a trust which owned a portion of the reservoir, the County and Mayor, state regulatory agency, federal regulatory agencies, maintenance personnel, and inspectors, as well as the complex interaction of human factors and physical factors during the century preceding the failure. Findings of the investigation were presented at an ASDSO national conference, a keynote address at an ASDSO conference ([link](#)), and Mr. Alvi's 2015 webinar for ASDSO.

**John Trojanowski, PE**

**President: Trojanowski Dam Engineering, Limited**  
Dam Engineering Consulting Services

**Work Experience:**

**Work Related to Hydraulic Jacking of Spillway Slabs and Failure Modes Related to Stagnation Pressures at Spillway Joints and Cracks**

- Replacement of Cold Springs Dam Spillway – Project Manager for the Bureau of Reclamation (Reclamation) in 1996 for the replacement of Cold Springs Dam spillway. The original spillway had numerous open joints and cracks, and it was determined that it could fail during low flow discharges due to hydraulic jacking. As project manager, I was responsible for the design and construction of a low-cost replacement spillway. The original concrete spillway was removed and replaced with a Roller Compacted Concrete (RCC) spillway having enough weight to resist hydraulic jacking for all design flow conditions up to the PMF.
- Emergency Modifications to Hyrum Dam Spillway and Long-Term Modification Planning – In the fall of 2003 I was asked by Reclamation's Dam Safety Office to inspect cracks in the Hyrum Dam spillway stilling basin. The stilling basin had been unwatered for the inspection. Upon arriving at the site, I noticed that foundation soil had been transported through the drainage system and had been deposited in the stilling basin. I determined that this was due to water flowing into open chute joints. I was designated the Project Manager for dam safety studies. In preparation for the 2004 flood season, I directed field staff to seal open joints and cracks in the spillway chute, and lower the reservoir to provide additional storage for spring runoff. After completing hydraulic analyses and performing a risk analysis I determined that the most vulnerable portion of the spillway was the steep section of the chute, where hydraulic jacking could easily fail chute slabs during high flows, resulting in a rapid headcut to the reservoir. I formed a team to design and construct an emergency modification that would be completed before the spring 2005 runoff. I was the Project Manager for long-term studies to replace the spillway. I later supervised these studies as the Manager of the Waterways and Concrete Dams Group at Reclamation.
- Papers, Articles, and Presentations Related to Spillway Failure Modes – As a Reclamation Dam Safety Advisory Team (DSAT) member and a Risk Facilitator I became aware that there was a lack of understanding of spillway failure modes both within Reclamation, and within the dam engineering community in general. As a result, I prepared two papers (“Assessing Failure Potential of Spillways on Soil Foundation,” ASDSO Dam Safety Conference in Phoenix, AZ, September 2004; and “Can Your Spillway Survive the Next Flood?” 26th Annual USSD 26th Annual Conference, San Antonio, TX, May 2006). I also wrote an article for Hydro Review (“Evaluating Spillway Condition,” Hydro Review, April 1, 2008). I also provided several technical update lectures for Reclamation and USACE staff. This was all to get the word out that spillways could fail in various ways, including from hydraulic jacking. I was also trying to alert engineers to the fact that their spillways may not have been designed to resist some of these failure modes.
- *Uplift and Crack Flow Resulting from High Velocity Discharges Over Open Offset Joints* – Based on my experience as the Project Manager for Hyrum Dam and my ongoing duties as a DSAT member and a Risk Facilitator at the Bureau of Reclamation, I requested funding from the Dam Safety Office to perform model studies that could act as a guide for prediction of potential uplift forming at offset joints and cracks in a spillway chute. I was the Project manager for these studies and peer reviewed the resulting report: Report DSO-07-07, *Uplift and Crack Flow Resulting from High Velocity Discharges Over Open Offset Joints*. This study also resulted in another paper that I coauthored (“Recent Advances in Predicting Uplift and Structural Collapse on Spillways with Open Offset Joints or Cracks,” Warren Frizell and John Trojanowski, 2008 USSD Annual Meeting and Conference, Portland, Oregon, on April 28-May 2, 2008.)
- Risk Analysis Facilitation – I was one of two risk analysis facilitators at Reclamation that could perform risk analyses related to spillway failure modes. In this capacity, I facilitated numerous risk analyses related to spillway failure modes, including hydraulic jacking and foundation erosion. I also trained several individuals to be future risk facilitators.
- US Army Corps of Engineers (USACE) Spillway Toolbox (2007-2008) – I was asked to participate in developing a toolbox for the USACE to assess various potential failure modes for spillways. I worked with an international team of experts to develop criteria to be used for assessing the failure potential for all types of spillways in the USACE inventory. The team relied heavily on by knowledge of foundation erosion and hydraulic jacking potential at joints and cracks in spillways.
- Bennett Dam Spillway – In 2011 I was contacted by BC Hydro in British Columbia, Canada to consult with them on Bennett Dam spillway. This request was based on papers and articles I had published related to hydraulic jacking failure modes. BC Hydro was planning a release of 150,000 cfs through there spillway. The spillway had no waterstops at critical joints. I showed them how to estimate the potential for chute slab instability due to hydraulic jacking, and helped them come prepare joint modification details to prevent jacking issues at critical joints in the spillway. With my help, they were also able to determine which joints did not need to be modified.
- Consultation and Peer Review Related to Spillway Failure Modes – While at Reclamation I became the resident expert and go-to person within the Technical Service Center related to spillway failure modes. I assisted on too many projects to list. Many of these projects involved identifying potential failure modes during the Comprehensive Review process.

I assisted Principal engineers from both the Civil Engineering and Geotechnical Engineering Divisions to understand and evaluate potential spillway failure modes related to the dams they were reviewing.

- Hydraulic Structures Workshop – I have participated in providing training related to spillway failure modes for the USACE, both as Reclamation employee and as an independent consultant. As part of the training I put the participants through an exercise to determine the potential hydraulic jacking forces and potential flow into a spillway joint and ask them to determine if the drains have adequate capacity, and if the chute slab can be jacked.
- Bluestone Dam – The USACE Bluestone Dam spillway has components that are vulnerable to hydraulic jacking failure. I was hired as a consultant to help them prepare a detailed risk analysis and to determine ways to modify the spillway to make it safe.

### **Trojanowski Dam Engineering, 2016**

Participation in a Value Engineering Study for Cherry Creek Dam in Colorado for the US Army Corps of Engineers (USACE), as a sub-contractor for AECOM.

Participation as an instructor for the USACE Hydraulic Structures Workshop, as a sub-contractor for AECOM.

Member of the Bluestone Dam Stilling Basin Design Expert Panel as a subconsultant for Stantec. Included review of the hydraulic model studies and foundation drainage and grouting designs.

#### **Previous Work Experience:**

**U.S. Department of the Interior, Bureau of Reclamation, Denver Colorado from 1978 to 2014 (Retired after 36.5 years)**

#### **General Manager/Civil Engineer – Waterways and Concrete Dams Group at the Bureau of Reclamation’s Technical Service Center (2010-2014)**

Managed 15 to 25 Civil Engineers as the General Manager (GM) for the Waterways and concrete Dams Group. Group work included design of new and modified concrete dams and appurtenant structures such as spillways, outlet works, bridges, powerplants, fish bypass, and other reinforced concrete structures. The group was responsible dam safety aspects of all concrete dams, spillways, and outlet works in the Bureau of Reclamation’s (Reclamation) inventory. This included conducting Comprehensive Reviews that included evaluation of structural (static and seismic) and hydrologic/hydraulic risk, making recommendations for engineering studies, conducting Issue Evaluations, Corrective Action Studies, final designs and specifications preparations, and engineering support during construction. This responsibility also extended to dams owned by other Department of the Interior (DOI) Bureaus. As GM I assigned work to Project Managers and design staff related to this work. I also was responsible for policy and quality of the work products. I hired and trained staff as needed to complete the workload. During my tenure as GM I peer reviewed a large percentage of the work prepared by my group, was an active member of Project Management Teams (PMT) for dam safety projects, participated as a Dam Safety Advisory Team (DSAT), and acted as a consultant for other government agencies such as the Corps of Engineers and National Park Service, and for outside organizations such as BC Hydro. My group was also responsible for updating Design Standards, maintaining and updating flood routing and water surface profile software, and standardizing and updating Dam Safety Best Practices used by both the DOI and Corps of Engineers. I also worked with other Technical Service Center (TSC) General Managers and the Dam Safety Office to develop and maintain annual workload planning schedules.

#### **Civil Engineer – Waterways and Concrete Dams Group at the Bureau of Reclamation’s Technical Service Center (1978-2010)**

#### **General Experience**

My time at the Bureau of Reclamation I worked in design groups specializing in concrete dams and waterways for dams. During this period my work experience includes design and analysis related studies, inspections, and construction support, for all civil engineering related aspects of concrete and embankment dams. This included operations studies (such as flood routings and reservoir evacuations), hydraulic analyses, sizing and design of various types of spillways and outlet works, structural analyses and design of various types of dams and waterways (including reinforced concrete structures), concrete dam foundation analyses and design, numerous risk analyses, cost analyses, and various other studies related to dams. I was certified as a risk facilitator for Reclamation and is a member of Reclamation’s DSAT. I have authored numerous technical papers, articles for publications, reports, and manuals, and was a team member on a joint project with the UCACE to prepare a spillway failure toolbox. I am also a current member of ASDSO and USSD.

#### **Specific Work Experience**

**Technical Expert:** As a technical expert I have participated in various projects for other organizations where I provided engineering reviews and participated in training as an instructor, participated as a technical representative at hearings, participated in risk analyses, and provided technical reviews. This work included Bennett Dam Spillway reviews for BC Hydro,

Bluestone Dam Risk Analysis for the USACE, participation as an instructor for the USACE's Risk Management Center for their first Hydraulic Structures Workshop and various other projects, reviewed issues related to the Gavins Point Dam Spillway for the USACE, participated in a failure mode analysis for the USACE's John Day Dam, reviewed technical proposals for the design of the San Vicente Dam Raise for the San Diego County Water Authority, reviewed and prepared reports for numerous projects for the government of Taiwan, participated in an emergency dam replacement for Kirby Dam for the US Forest Service, and acted as a technical advisor and hearing officer for the National Park Service for the historic Pawtucket Dam.

**Research Projects:** As a design engineer was actively involved in the planning of research projects that were both general in nature and specifically tailored to various dam projects. Of note was my work to initiate hydraulic laboratory studies to define hydraulic jacking parameters for evaluating spillway failures under various flow conditions. I expanded this study to include estimates for flow into open cracks and joints in concrete slabs for the purpose of estimating required foundation drainage capacity. I was the peer reviewer of the final report (DSO-07-07) from this study. My participation in this study resulted in me preparing criteria for these specific spillway potential failure modes in the Best Practices handbook, and my participation in preparing a Corps of Engineers toolbox for assessing spillway failure modes.

I participated in the early studies by Reclamation to define cavitation potential in spillway chutes. I worked with Dr. Hank Falve on this study. My responsibilities included computing water surface profiles and cavitation index for various high velocity spillways to determine when the computed index resulted in major, minor, or no damage. These results were used in the publication of Reclamation's Engineering Monograph No. 42. As a result of my participation in this study I became one of the Group's leading experts in cavitation damage prediction and the use of water surface profiles to predict cavitation potential. My subsequent work has resulted in changes in operating procedures for critical spillways in order to reduce or prevent cavitation damage without requiring structural modification.

**Comprehensive Reviews:** Senior Engineer for several including: Stony Gorge, American Falls, Grand Coulee, Hoover, Morrow Point, Crystal, Bartlett, Altus, Parker  
Peer Reviewer for several including: Pueblo, Stewart Mountain, Clear Creek, Crystal, Flaming Gorge  
Civil Engineer team member for many

**Issue Evaluations:** Project Manager for several including: Parker, Grand Coulee, Morrow Point, Flaming Gorge, Crystal, Minidoka, Hyrum, Gerber, Pueblo, Clear Creek, Navajo  
Team Member for many

**Risk Analysis:** Risk Facilitator for many dams

**Final Designs and Corrective Action Alternatives:** Project Manager for several including: Minidoka (new spillways and post-tensioned tendon stabilizations), Hyrum, Clear Creek, Pueblo, Glen Canyon, San Vicente Dam (TPEC to select the Design organization), Milltown Hill (Proposed New RCC Dam), Kirby Dam Reconstruction  
Team Member for several including: Brantley (new concrete dam), Stewart Mountain Dam Modifications, Spring Creek Debris Dam Raise, Cold Springs, Minidoka Powerplant, Theodore Roosevelt (Outlet Works Gate Shaft, Tunnel, and Control Structures)  
Engineer preparing designs and analyses on other projects including: Three Gorges Dam in China, Auburn Thin Arch and Concrete Gravity Dams, Stony Gorge Dam, McPhee Dam.

**Dam Safety Advisory Team Member:** This involves review of all kinds of dam safety studies, modifications, and new designs. Review of associated risk analyses and decision documents. Providing technical support for the Dam Safety Office, Region, and Area Offices within Reclamation and for others within the Department of the Interior.

**Education:** B.S.C.E. from the University of Colorado in Boulder, Colorado

**Registration:** Professional Engineer in the State of Colorado

**Publications:**

**Papers:**  
"Dam Safety Modifications for Clear Creek Dam," Manuscript for ASCE Hydraulics Division, 1993 National Conference on Hydraulic Engineering, July 1993, Author.

"Stabilization of Minidoka Dam Using Epoxy Coated Strand Rock Anchors," ASDSO Dam Safety Conference, Pittsburgh, PA, September 1997, Co-author.

"Risk Reduction Through Monitoring at Pueblo Dam," USCOLD 18th Annual Conference, 1998, Buffalo, NY, August 1998, Co-author.

“Stabilization of Pueblo Dam Using RCC,” ASDSO Dam Safety Conference, St. Louis, MO, October 1999, Author.

“Dam Safety Investigations and Modifications for Clear Creek Dam,” FEMA National Dam Safety Program Technical Workshop No. 8, Emmitsburg, MD, February 2001, Author.

“Grouted RCC Contraction Joints at Pueblo Dam,” ASDSO Dam Safety Conference, Snowbird, UT, September 2001, Co-author.

“Assessing Failure Potential of Spillways on Soil Foundation,” ASDSO Dam Safety Conference in Phoenix, AZ, September 2004, Author.

“Stabilizing the Spillway Foundation at Pueblo Dam,” ASCE Proceedings of the Biennial Denver Geotechnical Symposium, October 2004, Denver, CO, Co-author.

“Construction Methods for Roller-Compacted Concrete Spillways,” ASDSO Dam Safety Conference, Orlando, FL, September 2005, Co-author.

“Can Your Spillway Survive the Next Flood?” 26th Annual USSD 26th Annual Conference, San Antonio, TX, May 2006, Author.

“Recent Advances in Predicting Uplift and Structural Collapse on Spillways with Open Offset Joints or Cracks,” Warren Frizell and John Trojanowski, 2008 USSD Annual Meeting and Conference, Portland, Oregon, on April 28-May 2, 2008.

#### **Articles:**

“RCC Used to Stabilize Pueblo Dam,” USCOLD Newsletter, March 2000, Author.

“Methods of Construction,” International Water Power & Dam Construction, February 14, 2006, Co-author.

“Evaluating Spillway Condition,” Hydro Review, April 1, 2008, Author.

#### **Manuals:**

“Roller-Compacted Concrete, Design and Construction Considerations for Hydraulic Structures,” Bureau of Reclamation, Technical Service Center, 2006, Co-author.

#### **Research Reports:**

“Testing and Examination of Concrete Cores - Minidoka Dam Idaho,” GR-80-8, Concrete and Structural Branch, Division of Research, Engineering and Research Center, Denver, CO, December 1980, Co-author.

“Uplift and Crack Flow Resulting from High Velocity Discharges Over Open Offset Joints,” Report DSO-07-07, Dam Safety Technology Development Program, USBR, December 2007, Peer Reviewer.

## CURRICULUM VITAE RELATIVE TO SPILLWAYS

**Name:** Henry T. Falvey

**Nationality:** US citizen

**Profession:** Consultant in Hydraulic Engineering

### **Key Qualifications:**

- Wrote a book on labyrinth weirs that was published by ASCE.
- Consultant for Freese Nichols for the design of the labyrinth weir on the Brazos River at Waco TX. I proposed modifications to the design, participated in physical model study and inspected installed labyrinth.
- Analyzed the flow capacity for the Flamingo Dam labyrinth spillway at Las Vegas, NV.
- Analyzed labyrinth design methods to increase spillway capacity for Los Angeles District Corps of Engineers at Prado Dam. Included site visit to evaluate existing design, development of design parameters, and advised on model studies at the Waterways Experiment station.
- Independent Technical Reviewer for Sacramento District Corps of Engineers of Isabella Dam labyrinth spillway. Included site visit and observation of physical model study at the Water Research Laboratory of Utah State University.
- Prepared an engineering monograph for the analysis of cavitation problems of chutes and spillways for Bureau of Reclamation. The monograph includes recommendations for repair, surface tolerances, aeration, and several computer programs to analyze cavitation potential and aerator design.
- Evaluated cavitation performance and recommended remedial measures on Blue Mesa, Flaming Gorge, Glen Canyon, Hoover, Kortes, and Yellowtail Dams for Bureau of Reclamation and Seven Oaks Dam for the Corps of Engineers.
- Hydraulic consultant to Hydroplus on the use of fusegates to increase spillway and reservoir capacity.
- Analyzed cavitation potential for Manenggon Hills Dam spillway for Dames & Moore.
- Analyzed spillways of Tolt, Railroad, and Smith Lake Dams, as well as the outlet works of Twin Lakes Dam for Woodward Clyde. These included investigations of existing spillways and spillways proposed to increase capacity.
- Designed baffled apron drop to control saturation at Ralston Reservoir and analyzed Dillon Dam morning glory spillway for Denver Water Board.
- Independent Technical Reviewer for US Corps of Engineers on outlet works for Folsom, Seven Oaks and Coyote Dams, spillway of Kaweah Dam and auxiliary spillway for Folsom Dam, bypass structures for Guadalupe River in San Jose, field-testing of Warm Springs Dam, fish bypass for the Dalles Dam, and spillway for Folsom Dam.



- Independent Technical Reviewer for URS Australia on Burnett (now Paradise), Eildon, Dartmouth and Hinze Dam spillways.
- Consultant for HKM Consultants in Billings Montana on the spillway and outlet works upgrade for Bair, Ruby and Nevada Creek Dams.
- Analyzed allowable surface tolerances on spillway surface for Granite Construction Company at Prado Dam.
- Directed physical model study of the double curvature arch dam Eagle Nest Dam for overtopping in NM for URS.
- Analyzed erosive damage potential for spillway flow from Warragamba Dam in Australia.
- Member of review board to reduce total dissolved gas content from the spillways on Boundary Dam in the state of Washington and on Cabinet Gorge Dam in Idaho.
- Author of the following papers on hydraulics of spillways and outlet works.

### **Engineering monographs**

"Air-Water Flow in Hydraulic Structures," US Bureau of Reclamation Monograph No. 41, 143 pp., 1980.

"Cavitation in Chutes and Spillways," US Bureau of Reclamation Monograph No. 42, 143 pp., 1990.

### **Papers**

"Hydrodynamic Pressures in Conduits Downstream of Regulating Gates," *IAHR Congress*, Fort Collins, CO 1976.

"Mean Air Concentration of Self-Aerated Flows," ASCE *Journal of the Hydraulics Division*, Technical Note, Vol. 105, No. HY1, pp. 91-96, 1979.

"Predicting Cavitation in Tunnel Spillways," *International Water Power and Dam Construction*, pp. 13-15, Aug. 1982.

"Prevention of Cavitation on Chutes and Spillways," ASCE *Proceedings of the Conference on Frontiers in Hydraulic Engineering*, Cambridge, MA, pp. 432-437, Aug. 1983.

"Tests on Cavitation Inception from Cylindrical Holes in a Boundary," (Co-authored with B. Mefford), ASCE *Hydraulics Division Specialty Conference*, Coeur d'Alene, ID, Aug. 1984.

"Increasing Shongweni Dam Discharge Capacity with a Hydroplus Fusegate System," (Co-authored with E.F.A. Snell and J. Raussiguier), *Proceedings of the USCOLD Annual Meeting*, Phoenix, AZ, 1994.

"Hydraulics and Design of Fusegates," (Co-authored with Treille), ASCE *Journal of Hydraulic Engineering*, Vol. 121, No. 7, 1995.

"Case Study - Dillon Dam Trashrack Damage," (Coauthored with J.H. Weldon), 2002, ASCE *Journal of Hydraulic Engineering*, Vol. 128, No. 2. , pp. 144-150.

“Investigation and Repair of the Outlet Works Tunnel Slab Damage - Seven Oaks Dam, Santa Ana River, California,” *Poceedings of the IAHR International Symposium on Hydraulic Structures*, Ciudad Guayana, Venezuela, Oct. 2006 ( Co-authored with Burgi, P.H., Cozakas, D.P., Kwan, R., Sawka, M.J., Schlenker, S.J. and Waller, T.N.)

## **Book**

*Hydraulic Design of Labyrinth Spillways*, ASCE Press, 2002.

## **Membership**

Member of International Association for Hydraulic Research (IAHR),  
American Society of Civil Engineers (ASCE), United States Committee on Large Dams  
(USCOLD)

Associate editor for Journal of Hydraulic Engineering ASCE.

Member of Hydraulics Committee of USCOLD and Unsteady Flow in Hydraulic Machinery Work Group of IAHR..

Consulted or taught in Algeria, Australia, China, Egypt, France, Germany, India, Mexico, Pakistan, Romania, Switzerland, Taiwan, and Turkey.

## **Education:**

BSCE with Honor      Georgia Institute of Technology  
1953-1958            Atlanta, Georgia

MSCE                 California Institute of Technology  
1959-1960           Pasadena, California

Dr.-Ing.              Universität Karlsruhe  
1962-1964            Karlsruhe, Germany

## **Experience Record:**

1960-1962: Hydraulic Engineer, Division of Research, US Bureau of Reclamation, Denver, CO  
1962-1964: Student, Universität Karlsruhe Germany  
1964-1970: Hydraulic Engineer, Division of Research, US Bureau of Reclamation, Denver, CO  
1970-1972: Head, Hydraulic Research Section, Division of Research, US Bureau of Reclamation, Denver, CO  
1972-1974: Senior Research Officer, Ecole Polytechnique Federale de Lausanne, Switzerland.  
1974-1987: Technical Specialist, Division of Research, US Bureau of Reclamation  
1987-1991: Private Consultant and Faculty Affiliate, Colorado State University  
1991-present: President, Henry T. Falvey & Associates, Inc. and Faculty Affiliate, Colorado State University.

**Languages:**

	Speaking	Reading	Writing
English	Native	Native	Native
German	Excellent	Excellent	Good
French	Fair	Good	Poor

**Honors:**

- Bureau of Reclamation - Silver Medal for Meritorious Service.
- Nominated for the Denver Federal Executive Board Outstanding Scientist/Engineer Award.
- Denver Federal Center Professional Engineers Group - Engineering Achievement Award.
- American Society of Civil Engineers - Hydraulic Structures Medal.
- American Society of Civil Engineers - Best paper in Division of Irrigation and Drainage, 1993.
- Society for Technical Communication - Distinguished Technical Communication Award for *Air-Water Flow in Hydraulic Structures* (1981) and *Cavitation in Chutes and Spillways* (1991).
- International Television Association - Award of Excellence for Video *Cavitation - A Bursting Bubble*.
- College Awards - Chi Epsilon, Tau Beta Pi, Briarian Society, Distinguished Military Graduate.
- Holder of one patent and applied for another.
- Recognized as one of eleven eminent water resources engineers who have made a great contribution to the profession during their career at the 2004 American Academy of Water Resources Engineers meeting in Anchorage Alaska. Bestowed the Academy's highest honor of "Honorary Diplomate."