Simplified Inundation Maps for Emergency Action Plans
FACT SHEET[1]

The cost of dam breach inundation maps is a major impediment towards the goal of developing Emergency Action Plans for all high and significant hazard potential dams in the United States. Developing dam breach inundation maps is an inexact science dependent upon numerous assumptions and uncertainties. Conservative estimates of inundation limits should be used for emergency and evacuation planning purposes. Simplified inundation maps (SIMS) produce conservative inundation limits at a much lower cost than performing more detailed studies which may result in a more precise representation of potential flooding for a given set of assumptions, but not necessarily a more accurate representation of actual flooding should dam failure occur. A number of states routinely accept simplified inundation maps (SIMS) for use in EAPs, but not for classifying hazard potential or establishing inflow design floods. Commonly used methods for SIMS fall into two categories:

1. Simplified Engineering Analyses
2. Photo-Based Mapping

SIMS are most applicable for small and intermediate sized dams with a limited number of homes downstream and where local emergency management agree that adequate evacuation procedures can be developed without more detailed inundation mapping. More detailed surveying or modeling may be warranted for large dams, those with a large population in the evacuation area or with significant downstream hydraulic complexities such as major diversion structures, split flows or potential for cascading dam failures.

The following recommendations are provided to assist states and dam owners in developing reduced cost SIMS for EAPs. They are not a substitute for engineering judgment nor do they alleviate the need to comply with state or federal regulatory requirements.

Summary of Recommendations

1. A single inundation map assuming dam failure during fair weather conditions with the reservoir level at the top of dam, neglecting reservoir inflows and spillway outflows, is an acceptable alternative to showing different inundation areas for fair weather and flood conditions. Use of a single "top of dam" inundation map eliminates the need for expensive watershed and spillway studies and provides a reasonable upper limit estimate for warning and evacuation.

2. Whenever possible, major streets, railroads, and other well known features should be depicted on the maps. Maps should be prepared using terms accepted by local emergency agencies and residents who, for example, may prefer to use local flood crest levels, such as depth over a road, instead of water surface elevations to describe floods.

3. Information provided on flooding conditions at downstream locations might include:

    - Distance downstream
    - Arrival time of leading edge of flood wave
    - Peak flow depth, incremental rise, or water surface elevation (as appropriate)
    - Peak velocity

4. Flood wave arrival times may be estimated using the NWS "rule of thumb" of an average downstream speed of 3 to 4 miles per hour. In mountainous areas with steeper slopes and or little vegetation such as out west the speeds may be higher. The flood wave will attenuate in height and speed very quickly as it spreads across the floodplain.

5. Representative flow velocities may be estimated based on channel slope using values provided in the 2007 State of Washington[2] guidance document.

6. In selecting conservative breach parameters the average breach width should be in the upper portion of the range of reasonable values; the time to failure should be in the lower portion of the range; and the Manning's n-value should be in the upper portion of the range. Chapter 2 of the FERC's Engineering Guidelines[3] provides typical breach parameters for different dam types.

7. Depending on the size of reservoir and channel conditions, after travelling ten miles downstream the routed flows is usually reduced only ten to forty percent from the peak outflow at the dam (State of Washington, 2007). In such cases, a constant or "steady state" discharge for the potentially affected areas downstream equal to the peak outflow at the dam may be assumed. The steady state peak discharge is conservatively estimated using predictive equations and applied at each of the downstream cross sections.

8. The best existing topographic data should be used to route dam breach outflows downstream. Digital elevation model (DEM) topographic data is often available free of charge. DEM data can be used with a variety of (GIS)-based software packages to rapidly create downstream cross sections for flood routing. GIS-based data processing has made development of inundation mapping for EAPs easier than ever before. Field surveying of downstream cross sections is usually not required unless little or no topographic data exists.

9. Although unsteady routing models are becoming much more user-friendly, hydrologic routing models (HEC-HMS and HEC-1) and the NWS SMPDBK models provide useful results.

10. To account for debris bulking and other uncertainties, 0.5 to 2.0 feet should be added to computed flow depths at each cross section (with corresponding increases in width of inundation).

11. Photo-Based SIMS are generally applicable for two cases:

    a. A small or intermediate size dam with an easily-identified number of downstream structures for which local emergency management agree adequate evacuation procedures can be established.

    b. A small or intermediate size dam for which funding is not immediately available for engineering studies and the photo-based mapping is to be used in the interim until such funding can be arranged and the mapping updated.

12. Regardless of the SIMS method applied, a visual inspection of the potentially affected areas should also be performed to confirm the number and locations of residences, channel characteristics and the presence of alterations to the channel or floodplain.

Online Mapping Resources

- USGS National Map Seamless Server (http://seamless.usgs.gov/index.php)
- FEMA Mapping Service Center (http://msc.fema.gov)
- Google Earth® (http://earth.google.com)
- Google Maps® (http://maps.google.com)
- Mapquest® (http://www.mapquest.com)
- Terraserver–USA® (http://www.terraserverusa.com)
- Topo!® State Series (http://www.natgeomaps.com)
- Trails.com® – former Topozone (http://www.trails.com)
- Yahoo Maps® (http://maps.yahoo.com)

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[1] See *Simplified Inundation Maps for Emergency Action Plans* (NDSRB EAPWG, 2009) for a more complete discussion.

[2] Washington State Department of Ecology (2007), Dam Safety Guidelines – Technical Note No. 1 – Dam Break Inundation Analysis and Downstream Hazard Classification, http://www.ecy.wa.gov/programs/wr/dams/Emergency.html

[3] Federal Energy Regulatory Commission (1993), *Engineering Guidelines for the Evaluation of Hydropower Projects, Selecting and Accommodating Inflow Design Floods for Dams, Chapter 2,* http://www.ferc.gov/industries/hydropower/safety/guidelines/eng-guide.asp