

Best Practices in Dam and Levee Safety Risk Analysis

III-1. Consequences (Introduction)

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RECLAMATION
Managing Water in the West



US Army Corps of Engineers
BUILDING STRONG®



Building the Case

$$\text{Risk} = \sum \left[\begin{array}{l} \text{Probability} \\ \text{of the Loading} \end{array} \right] \left[\begin{array}{l} \text{Probability of Failure} \\ \text{Given the Loading} \end{array} \right] \left[\begin{array}{l} \text{Consequences} \\ \text{Given Failure} \end{array} \right]$$

Teams must build the case for consequences as rigorously as done for potential failure modes.

What are the essential elements of building the case for the consequence estimate?



Essential Elements of Building the Case

- Initial distribution of people
- Redistribution of people (evacuation effectiveness)
- Flood characteristics
- Shelter provided by final location



Initial Distribution of People

- Primary impact areas:
 - Communities, state or county
 - Residential, commercial, or industrial
- Estimated population at risk
- Distance downstream from dam
- Spatial location and population density



Redistribution of People (Evacuation Effectiveness)

- Warning: flood forecast or breach detection, communication lag, warning issuance time (relative to breach initiation), initial non-breach warning (double-warning scenario), warning dissemination system (EAS, sirens, reverse 911 and effectiveness but also improvements by word-of-mouth due to dense urban environment, sheriff door-to-door or drive-by announcement).



Redistribution of People (Evacuation Effectiveness)

- Response (mobilization): clarity of warning message; similar warnings or experiences in past; physically unable; kids, pets, live stock, valuables, etc.; desire to protect home and property; nowhere to go; evacuation plan, etc.
- Evacuation potential (ability to get to safety before water arrives): distance to clear inundation limits, special evacuation assistance facilities, available road network or routes, traffic density and jams, etc.



Flood and Shelter Characteristics

- Flood characteristics (from hydraulic model):
 - Flood wave arrival time, depth, and velocity.
- Shelter provided by final location:
 - Potential for vertical evacuation and shelter in-place: number of stories
 - Survivability: structure damage, human stability, and vehicle stability



Impact Areas and Exposure

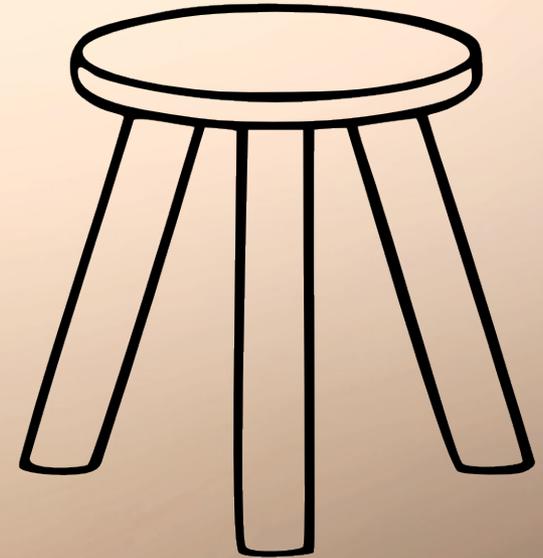
- Discuss population centers, impact areas, counties (EMAs), or river reaches early (i.e., during the PFMA).
 - Report consequences and flood risk spatially.
 - Helps communicate flood risk to decision-makers, reviewers, stakeholders, local officials, and public.
- Discuss exposure scenarios for temporal distribution of PAR during PFMA.
 - Time of day, day of week, season of year, etc.



Consequence Management

Three-legged stool:

- Evacuation planning
- Community awareness
- Flood warning effectiveness



Consequence management is a shared responsibility: federal/local agencies, stakeholders, and public



Evacuation Planning

- Does the threatened community have an evacuation plan?
 - Is it current and routinely updated?
 - Does it contain detailed information related to evacuation routes and procedures for dam/flood-specific scenarios or just general information related to evacuation procedures?
- Any recent successful evacuations?



Evacuation Planning

- Good understanding of likely inundation zones/scenarios
- Predefined triggers, integrated with EAP
- Predetermined routes with ability to adjust
- Predetermined shelters



Community Awareness

- Is the community aware that it is in the reservoir area or downstream of the dam?
- Is the community aware of the dam's role in flood risk management and generally understands that it is vulnerable to breach and non-breach flooding?



Flood Warning Effectiveness

- Does the community's EMA maintain a flood warning system (e.g., reverse 911, sirens) and routinely updated EAP?
- Does the EAP describe flood warning procedures in case of emergency?
 - Do the procedures rely on emergency responders to spread the warning?
 - Are the procedures updated and practiced at regular intervals?



General Guidance

- Collectively review as a team inundation mapping, breach assumptions, and life loss estimates and assumptions.
 - Discuss appropriateness for the PFMs identified.
 - Discuss and document site-specific conditions which make the life loss estimate better or worse than the life loss estimates and assumptions.
- Treat important inputs like other inputs to risk assessment.
 - Talk to local experts (emergency ops, responders, managers)
 - Consider sensitivity analysis for key parameters.
 - Additional modeling or estimates may be required.



Summary

- Numerical estimates are challenging.
 - Process forces participants to think through aspects that could contribute to life loss during a flood event.
 - What drives the result? Be honest about uncertainty.
- Build the case as rigorously as failure likelihood.
 - Order-of-magnitude estimate and understanding are often more important than discrete values.
 - Who is expected to lose their life, why, and why that makes sense?

