RECLAMATION

Managing Water in the West

Event Trees

Dam Safety Risk Analysis Best Practices

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U.S. Department of the Interior
Bureau of Reclamation

Presentation Taken From One Developed for Reclamation Best Practices

- This is an abbreviated version and not meant to be a complete look at the Reclamation Best Practices
- The presentation is to provide an introduction to important concepts that Reclamation has developed over many years

Key Concepts

- An event tree is constructed using a series of nodes and branches
- Each node represents an uncertain event and each branch represents a possible outcome
- A well-defined failure mode is easily “decomposed” into a sequence of necessary events or potential states of nature
- All events in the sequence must take place to allow an uncontrolled reservoir release
- Event trees are very flexible and can be adapted to portray most any potential failure mode

Key Concepts (cont.)

- Event trees are typically constructed from left to right starting with an initiating event, typically a load
- Loads are partitioned into ranges which cover the full possibility of loading
- The probability for each outcome at each subsequent node (proceeding to the right) is estimated assuming the previous branch has already occurred
- The branch probabilities for a given node must sum to 1.0
- Branch probabilities are multiplied through the tree from left to right
- End branch probabilities which lead to failure are summed for annual failure probability

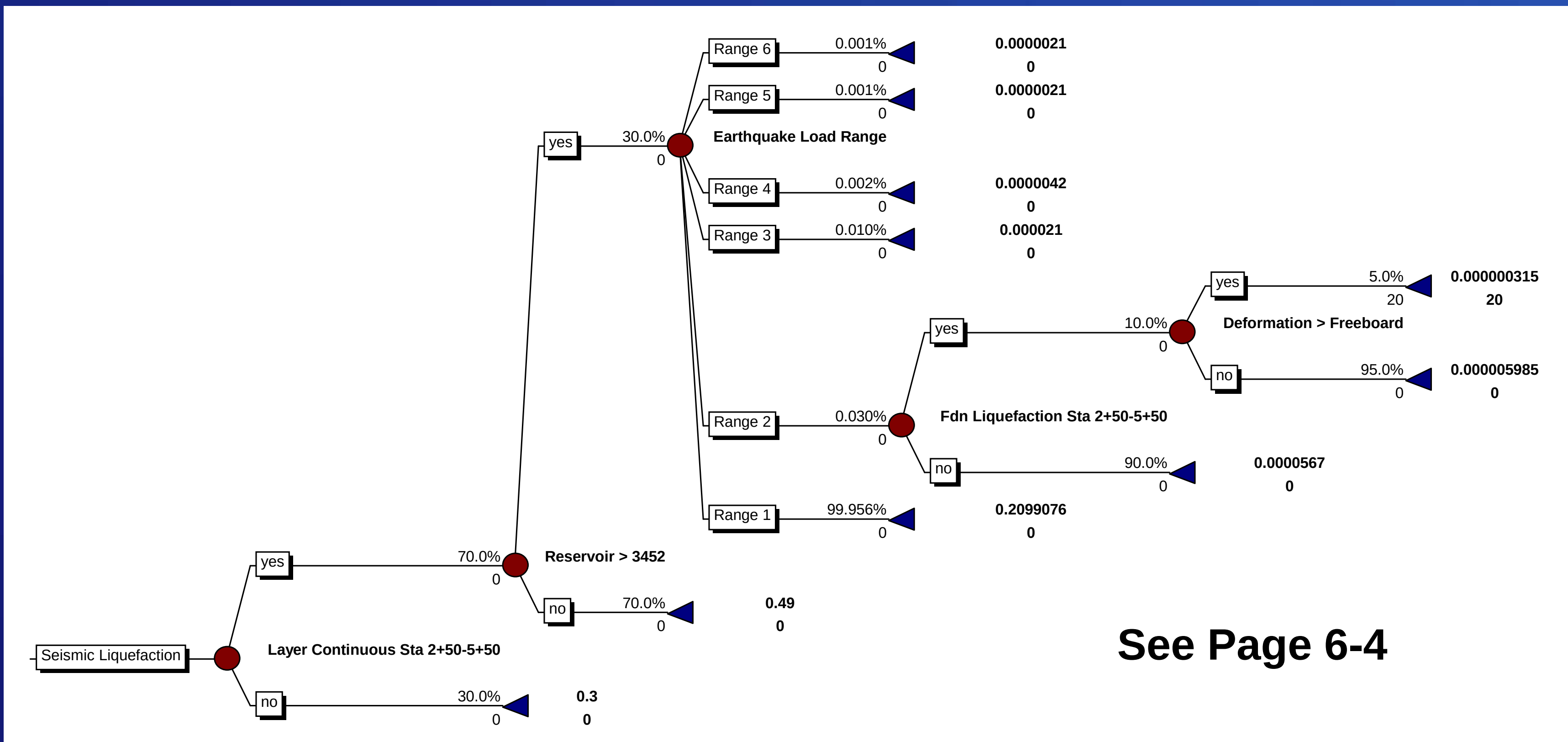
Key Concepts (cont.)

- Consequences are usually included at the end branches which result in failure
- The end-branch probability multiplied by its associated consequence is that branch's contribution to the annualized probability of that consequence (if life loss, then APLL)
- Contributions from each branch are summed in various ways
- Event trees shown are examples only. It is important to think about site specific conditions and adjust the event trees accordingly

Example Failure Mode Description No.1

- ***During a period of high reservoir, when the foundation becomes saturated (based on piezometric measurements), seismically- induced liquefaction of a loose and continuous foundation sand layer, identified in borings between Stations 2+50 and 5+50, leads to instability of the downstream slope of the dam, crest deformations greater than the available freeboard, and overtopping erosion breach of the dam.***

Example Event Tree No. 1



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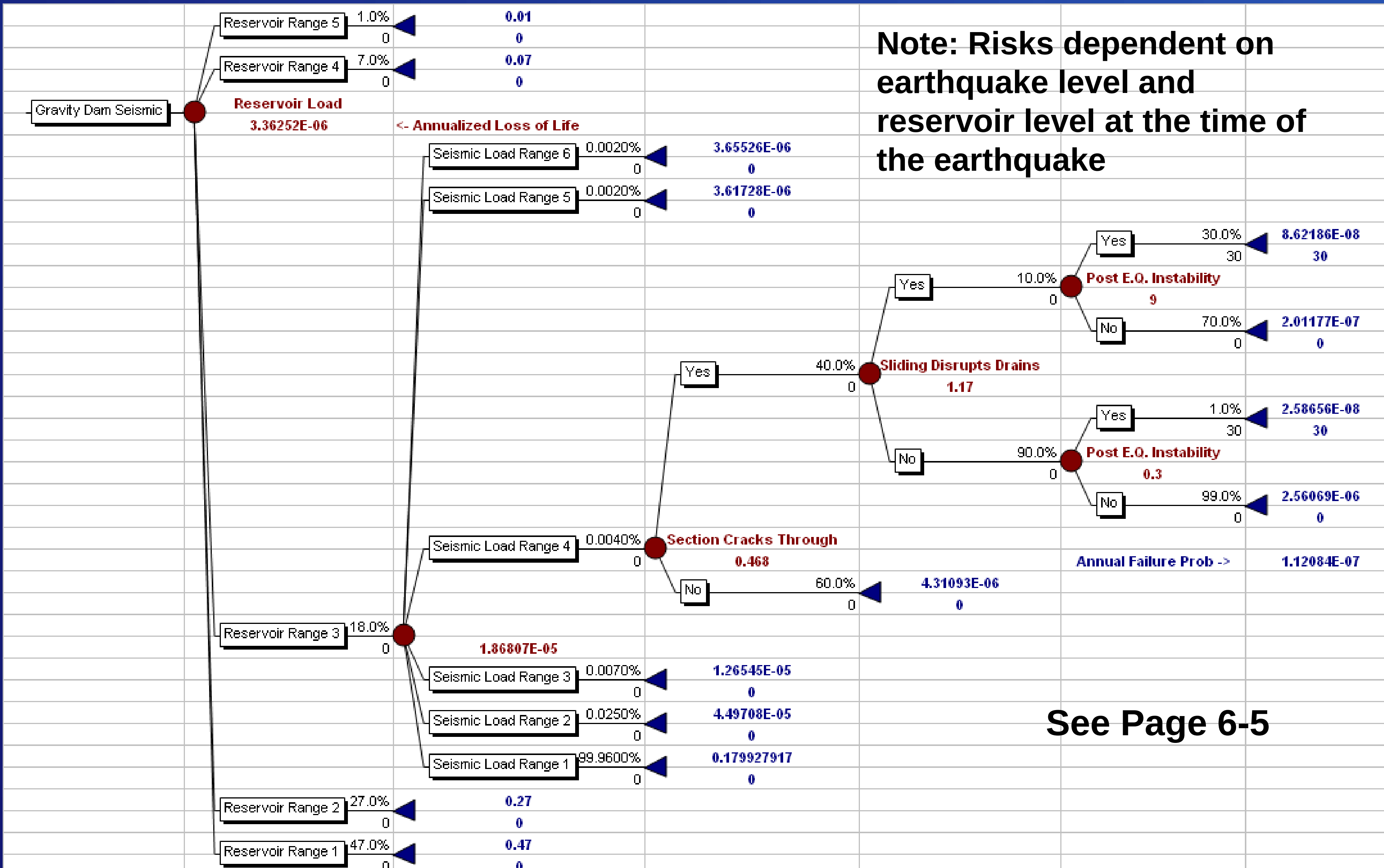
Example Failure Mode Description No. 2

- ***During strong earthquake shaking, the concrete gravity dam cracks completely through upstream to downstream over several monoliths along a lift joint at the change in slope on the downstream face at Elevation 1137. If sufficient earthquake-induced sliding displacements follow, the formed drains in the dam could become severed, increasing the uplift pressures on the cracked plane. Post-earthquake sliding instability of the cracked section results in dam breach and uncontrolled release of the reservoir.***

Example Event Tree No. 2

Note: Risks dependent on earthquake level and reservoir level at the time of the earthquake



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Load Ranges

- Threshold loading – below which risk contribution is considered negligible – very important, put some thought and study into it and how you will define what the threshold represents. This may require iterative analyses at smaller loads.
- Select enough load ranges such that changes in conditional response are smoothly captured. Interpolate analysis results if necessary (may require analyses at more than just 10k and 50k ground motions)
- There should not be a wide range in conditional response between the upper and lower end of a load range.

Load Ranges (cont.)

- Be aware that load range probability is dominated by most frequent load when estimating conditional response for the range
- Load range boundaries may be selected to correspond to loads where analysis results are available (consider weighting response estimates toward low end of range)
- Or, place corresponding analysis value within the range (consider placing it closer to the lower end)

Load Ranges (cont.)

- To obtain a mean load range probability, subtract the probability of the lower load from the probability of the upper load.