From:	Miller, Ed
To:	"RILEY, Jim"
Subject:	FAQ Files from Feb 21 2013 Meeting
Date:	Friday, February 22, 2013 1:55:00 PM
Attachments:	FAQ 011 - Seismic, Rev 0.docx FAQ 013 - Sunny Day Dam Failure Evaluation Rev 1.doc FAQ 015 Dam Breach Formulation, Rev 0.doc

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Jim,
Attached are the FAQs, including comments, from the February 21, 2013, public meeting. Please let me know if you have any questions. Thanks.

Ed Miller
301-415-2481

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A. TOPIC: **Criteria for Seismic Dam Stability Analyses**

Source document: ANS 2.8-1992 and NUREG/CR-7046 Section: 6.2 & 9.2.1.2 and Appendix H

B. DESCRIPTION:

ANS 2.8-1992, Section 6.2 titled "Seismic Dam Failures" provides guidance on evaluating the consequences of dam failures due to seismic events and points the user to Section 9, Combined Events Criteria for the specific details on combinations to be evaluated. NUREG/CR-7046 repeats the same load cases in Appendix H, Combined-Effect Floods. These documents are listed as current criteria for the use of flood hazard re-evaluations in the 10CFR50.54(f) letter in Enclosure 2, Recommendation 2.1: Flooding. The criteria for seismic dam failures (ANS 2.8-1992, Section 9.2.1.2) is as follows:

- Alternative I
    - 25-yr flood
    - Dam failure caused by the safe shutdown earthquake (SSE) coincident with the peak of the flood
    - 2-yr wind speed applied in the critical direction
- Alternative II
    - One-half probable maximum flood (PMF) or 500-yr flood, whichever is less
    - Dam failure caused by the operating basis earthquake (OBE) coincident with the peak of the flood
    - 2-yr wind speed applied in the critical direction

The use of the terms SSE and OBE imply deterministic earthquakes since these terms are not used within new plant licensing. The use of a deterministic earthquake for evaluation of dams does not align with current practice within the technical communities (nuclear power or dam safety). Therefore, there is a need to define criteria for use of a probabilistic earthquake for the evaluation of combined events due to seismic dam failures.

C. Initiator:

Name: Penny Selman Phone:_______
Date: 2/4/13 E-Mail: pbselman@tva.gov

D. RESOLUTION: (Include additional pages if necessary. Total pages: ___________)

Inquiry number:____________ Priority: H

The intent of the ANS 2.8-1992 combined events seismic is to evaluate an earthquake that produces higher ground accelerations, presumably with a high return period, with a flood of shorter return periods and under the second alternative, evaluate an earthquake that produces ground accelerations on the

order of half those of the SSE with a flood with a higher return period flood. The flooding of those two alternatives have the potential to produce floods of differing durations and magnitude as well as differing timing of the flood wave to the nuclear power plant, so both alternatives require consideration unless a bounding evaluation is completed[1]. To maintain the intent of ANS 2.8-1992, the following alternatives are proposed:

- Alternative I
  - 25-yr flood
  - Dam failure caused by 1E-4 ground motions coincident with the peak of the flood
  - 2-yr wind speed applied in the critical direction
- Alternative II
  - One-half probable maximum flood (PMF) or 500-yr flood, whichever is less
  - Dam failure caused by one-half the 1E-4 ground motions coincident with the peak of the flood
  - 2-yr wind speed applied in the critical direction

The 1E-4 ground motions shall be determined at the dam site. The following methods are acceptable for determination of the 1E-4 ground motions or 1E-4 uniform hazard response spectra (UHRS):

- Use Central and Eastern United States Seismic Source Characterization (CEUS-SSC) for Nuclear Facilities (NUREG-2115) and associated attenuation model to develop the mean seismic hazard curves and UHRS at the dam site for 1 Hz, 5 Hz, 10 Hz, 25 Hz and peak ground acceleration (PGA). Either EPRI 2004/2006 attenuation models or the updated EPRI 2004/2006 attenuation model (available in May 2013) may be used for development of the 1E-4 UHRS.
- Use United States Geological Survey (USGS) (2008) to determine the mean seismic hazard curves for 1 Hz, 5 Hz, 10 Hz and PGA. Apply one of five EPRI mean amplification functions to the mean rock seismic hazard curves based on the known geologic conditions at the dam site. EPRI mean amplification functions can be found in EPRI (1993). From the site-adjusted mean hazard curves, develop the 1E-4 UHRS.

After determining the 1E-4 UHRS, the evaluation of the dam's structural stability may be completed. This evaluation shall include the concrete and earthen sections of the dam as well as a structural evaluation or assessment of the dams appurtenances, e.g., spillway gates, navigation locks, etc. The headwater and tailwater used for the evaluation shall be the 25-year flood design values. The methods of completing this evaluation are those described by the criteria established by the agency having jurisdiction (e.g., FERC, USACE, Bureau of Reclamation, etc.). The applicable factors of safety per the dam regulator's criteria must be met to demonstrate that the dam will remain stable under the combined seismic and flood loading condition.

The above method shall be completed again for one-half the 1e-4 UHRS combined with headwater and

Comment [g1]: NRC Comment: Recommend align with 2.1 Seismic.

Comment [g2]: NRC Comment: Recommend reference to ISG instead or show consistency with ISG.

tailwater for the 500-year flood or one-half PMF, whichever is less.

These evaluations shall be completed for each dam within the watershed that is desired to demonstrate stability during these loading conditions. It is permissible to make conservative assumptions of failure within these analyses.

[1]The bounding evaluation would use conservative assumptions and require justification as the bounding condition.

Revision: 0 Date: 2/4/13

E. NRC Review:

Not Necessary________ Necessary X

Explanation:____

F. Industry Approval:

Documentation Method:________________________________ Date:______________

Comment [g3]: NRC Comment: Recommend address consideration of tail water effects.

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A. TOPIC: Dam Failure Evaluations: Sunny-Day Failures

Source document: JLD ISG-2013-xx Section: NA

B. DESCRIPTION:

The Interim Staff Guidance for dam failure evaluations describes a "sunny-day failure" but does not provide sufficient guidance on attributes of such an evaluation or how it might be performed.

C. Initiator:

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D. RESOLUTION: (Include additional pages if necessary. Total pages: 1)

Inquiry number: 013 Priority: H

A 'sunny-day' dam failure is not associated or concurrent with an initiating event (such as an extreme flood or earthquake) and may result from, for example, a structural, geotechnical, or operational deficiency. Sunny-day failures are typically associated with short warning times. Because of their nature, a sunny-day failure need not be considered for more than one dam at a time but the potential cascading effect of an upstream sunny-day dam failure on downstream dams must be considered. As with other dam failure analyses, the sunny day dam-failure analysis must consider not only dams upstream of the site, but also dams on tributaries that confluence with the river downstream of the site, which may affect the site due to backwater caused by the dam failure flood wave.

A hierarchical hazard assessment (HHA) approach as described in NUREG/CR 7046 should be applied to the sunny-day dam failure analysis. Simplified but conservative methods should be employed to identify the critical dam whose individual sunny-day failure may result in a flood hazard that exceeds the current flooding design basis for the site. For the critical dam (or cascading sequence of dams), the analysis should be refined progressively using site-specific data until one of the following criteria is satisfied:

1. The current flooding design basis for the site unambiguously bounds the critical sunny-day dam failure scenario results, or
2. The results from another flood causing mechanism considered in the flood hazard reevaluation unambiguously bound the critical sunny-day dam failure scenario results, or
3. No further site-specific refinement of the critical sunny-day dam failure scenario is possible or practical in accordance with the state of the practice, and the critical sunny-day dam failure scenario results unambiguously bound the current flooding design basis for the site. The critical sunny-day dam failure scenario results would become the revised flooding design basis for the site.

The attributes of a sunny-day dam failure analysis for the critical dam should include:

- Assume normal pool water level at the time of dam failure. This assumption applies to the initiating sunny-day dam failure as well as any downstream impoundments for analysis of cascading dam failures.

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- Assume no precipitation during the event or runoff into the critical reservoir other than normal baseflow conditions (which may be negligible). This assumption also applies to downstream impoundments in the cascading sequence (if applicable).
- Use conservative, but realistic, physics-based breach parameters that are appropriate to the type of dam(s) being evaluated.
- Assume warning times that are no greater than the time necessary to grow the breach from initiation to failure plus the time necessary for the flood water to reach the site.
- Develop information to appraise the probability of sunny-day failure of the critical dam or cascading series of dams.

Studies have shown that the overall probability of dam failure is in the range of 10^{-4} to 10^{-5} per year. For this reason, excluding a sunny-day failure from flooding reevaluations for riverine sites with critical upstream dams can be based on a probabilistic approach, rather than arguments that are based on satisfaction of applicable codes and standards during design or on meeting specified standards for dam operation or surveillance. The NRC has stated that a sunny day failure can be shown to not occur by proving that the probability of a sunny day failure for the specific dam under consideration is less than:

- 10^{-7} per year or
- 10^{-6} per year with additional justification

The information below may be helpful as additional justification:

- Ongoing monitoring and inspection programs that are able to detect problems prior to leakage
- Structural dimensions,
- Construction records,
- Records from installed monitoring instrumentation and/or piezometer wells,
- Field surveys,
- On-site inspection reports,
- Maintenance records,
- Risk tolerance of operating agency,
- Durable operation, maintenance, and corrective action procedures and agreement,
- Information from the dam owner, developed or approved by a state or federal agency.

Revision: 1 Date: 2/5/13

E. NRC Review:

Not Necessary________ Necessary____X______

Explanation:____

F. Industry Approval:

Documentation Method:________________________________ Date:_______________

Comment [g1]: NRC Comment: recommend delete.

Comment [g2]: NRC Comment: Warning time should be estimated and needs justification Clearly define what you mean by warning time.

Comment [g3]: NRC Comment: Additional discussion necessary on this topic at later public meeting.

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A. TOPIC:

Source document: NUREG CR/7046 Section: NA

B. DESCRIPTION: An essential part of the dam failure modeling process is formulating and characterizing the dam breach. NUREG CR/7046 does not provide specific guidance on dam failure analysis including breach parameter determination. What are key attributes that should be considered in the development of breach parameters?

C. Initiator:

Name: Dean Hubbard Phone:
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D. RESOLUTION: (Include additional pages if necessary. Total pages: ___________)

Inquiry number: XX Priority: _____________

Dam breach determination should be based on realistic but conservative assumptions. Key parameters, such as location, formation time, and size, can have a significant effect on the estimated outflow from a breach. Breach characteristics can be estimated using several approaches such as: comparative analysis, empirical methods using regression equations, and physically based models. Empirical methods and physically-based models are the two approaches most often used for estimating breach parameters and are discussed further below.

1. Embankment Dams

Breach Analysis Methods

Empirically-Based (Regression) Estimation - Empirically-based methods for breach parameter and peak outflow estimation are based on regression equations, generated using observed flows from actual breach events. Simple regression equations that rely on an assumed hydrograph shape with a known volume of water can be useful as a screening tool, or for sensitivity analysis to check the reasonability of other methods. The most realistic breach equations include multiple parameters, such as the primary geometric parameters with additional control variables (e.g. dam type, failure mode, and dam erodibility). Original technical papers or documentation should be reviewed prior to using these equations to understand their limitations and applicability. The most credible and appropriate technical papers include validation of the breach parameter assumptions and equations with documented dam failure data for dams of similar size, design, materials, and construction to the dam being evaluated. For example if the given regression equation was developed primarily with data from small dam failures (less than 15 meters), the method may not provide a realistic representation for large dams. Since estimates of breach parameters can vary significantly, it is recommended that that more than one method be used to establish a range of breach parameters, giving due consideration to the dam's design characteristics.

Wahl (1998) and Pierce (2010) identified and evaluated regression equations for peak outflow as a function of dam and/or reservoir properties. Other notable and more recent reviews of breach parameter prediction methods (and peak-flow prediction equations and related dam-failure modeling guidance) include Washington State (2007), Gee (2008), Wahl (2010), and Colorado Department of

Natural Resources (2010).

Physically-Based Breach Methods -The use of a physically-based breach model requires more dam specific information than empirical methods. Dam and reservoir details must be specified, alternatives for erosion calculations selected, and soil erodibility properties estimated or measured. Sensitivity analyses should be conducted to investigate the effects of variation of input parameters. The use of physically-based models is appropriate when more accurate results are needed and soil erodibility can be reasonably estimated and requires detailed documentation of the assumptions and inputs.

Breach Parameters

Failure Mode - The two primary failure modes for embankment dams are overtopping and piping failures. Breach formation and development time differ for overtopping versus piping failures. This is discussed under the section addressing breach formation time.

Failure Location – Breach location should be based on factors such as dam type, failure mode and the structural elements of the dam. Consideration for the history of the specific dam performance should included in the basis for breach location including seepage points, prior repair locations and known areas with lower margin. If the probable location cannot be determined based on design and history, the centerline of the breach should align with the centerline of the downstream main channel.

Breach Formation Time - The breach formation time is a variable that affects peak discharge and warning time for failure responses. The definition of breach formation time varies based on the methodology being used. However the breach formation time definition must be consistent with the breach formation methodology and analytical software being used to calculate the breach outflow and routing. Breach time is commonly characterized in two phases starting with breach initiation with a transition to breach formation if no action is taken to correct the developing abnormal condition.

Comment [g1]: NRC Comment: Consider addressing mixing use of different methods.

- **Breach initiation:** During the breach initiation phase, flow through the dam is minor and the dam is not considered to have failed. It may be possible to prevent a dam breach during this phase if flow is controlled.
- **Breach formation time:** The breach formation time is commonly defined as starting when flow through the dam has increased and is progressing to the point that erosion is significant, uncontrolled, and will result in the failure of the dam. The specific hydrologic or geologic failure mode must be considered when determining the starting point for the breach formation time.

  Overtopping failure breach formation time: The time from when the breach has eroded back to the upstream side of the top of the dam to when the breach is fully formed (i.e., significant erosion has stopped, not the time when the reservoir pool is emptied).

  Piping/Internal erosion failure breach formation time (hydrologic or geologic induced): The time from when a significant amount of flow and material are moving through the piping failure to when the breach is fully formed (i.e., significant erosion has

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stopped, not the time until the reservoir pool is emptied).

Breach Geometry - The final breach dimensions will vary based on the dam type, materials, and construction. The maximum size is reached when water velocities are low enough such that material transport drops to nominal levels. By using the breach parameter approach to dam break modeling, the analysis can exert control over the breach parameters in the dam break model taking into account specific site parameters.

The ultimate bottom elevation is the point at which erosion stops; usually either bedrock, or the bottom of the reservoir pool taking into consideration debris deposition and tailwater effects downstream of the breach. Due to the uncertainties associated with the breach predictions, sensitivity studies should be performed to support the final breach selection.

2. Concrete Dams

In general, the current approach to concrete dams is instantaneous failure. The analysis does not necessarily need to include failure of the entire dam based on the dam design and failure initiation event. For example, for a dam with large gates on the top, it may be reasonable to analyze a failure mode where only the gates fail, but that the concrete portion of the dam beneath and adjacent to the gates remains intact. For dams with distinct structural segments (e.g., buttress dams), limiting failure to one or more segments that are most prone to a deficiency may be justifiable. A technical justification will be required to provide the basis for a determination of partial failure based on an analysis of the dam design and construction.

3. Uncertainty

In general, uncertainty in formulating a dam failure should be evaluated by applying multiple methods and evaluating sensitivity to reasonable variations in input parameters. Methods and assumptions should be realistic but conservative. Justification for use of a particular method should be established based on an understanding of how the method was developed and its applicability to the dam in question. Examples of uncertainty information can be found in Froehlich (2008), Wahl (2004), and Xu and Zhang (2009).

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E. NRC Review:

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Explanation:____

F. Industry Approval:

Documentation Method:____ Date:________________