STATE OF CALIFORNIA – CALIFORNIA NATURAL RESOURCES AGENCY **GAVIN NEWSOM**, *Governor*

**DEPARTMENT OF WATER RESOURCES**
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

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Honorable Jim Nielsen, Senator, 4th District
State Capitol, Room 2068
Sacramento, California 95814

Honorable James Gallagher, Assembly Member, 3rd District
State Capitol, Room 2518
Sacramento, California 95814

I have received your March 11, 2019 letter with your questions regarding the "*Proposed Plan for Oroville Dam Complex Level 2 Risk Analysis.*" This plan was filed with the Federal Energy Regulatory Commission (FERC) on December 21, 2018, and was formally accepted by FERC in its January 8, 2019 letter to the Department of Water Resources (DWR). I appreciate the time you have spent reviewing this plan.

Your questions focus on "*...proposed enhancements to the existing PFMA and responsiveness to the IFT recommendations.*" The ongoing Level 2 Risk Analysis for Oroville Dam and its appurtenant facilities exceeds the current PFMA workshop process. The Independent Forensic Team (IFT) identified a set of sixteen recommendations to be considered for improving the PFMA process. These are listed in Section 10 of Appendix F3 of their report on the Oroville Dam Spillway Incident (see Pages F3-24 and F3-25). The majority of these recommendations have been implemented in the ongoing Level 2 Risk Analyses as described in the plan.

Additionally, as quoted in your letter, the IFT made a broader recommendation related to the PFMA process for the dam safety industry as a whole. While DWR supports the continued improvement of the dam safety industry, the recommendation to conduct a review of the PFMA process used by the industry as a whole is not one that DWR intends to pursue as part of the current Level 2 Risk Analysis and PFMA effort. Nor would it be appropriate for a single utility to unilaterally pursue an alternative approach.

However, in advance of such an industry-wide improvement to the PFMA process, the ongoing Level 2 Risk Analysis being conducted for Oroville Dam and its appurtenant facilities already goes beyond existing PFMA processes. It not only incorporates almost all of the recommendations offered by the IFT, but also incorporates a more complex risk evaluation together with improved and widened definitions of "*failure.*" Further, it involves an unprecedented number of national and international experts with expertise ranging across many engineering, geology, and risk disciplines. As the workshops extend for over ten weeks from January through August of 2019, it is unlikely that there have been many other existing dams, if any, subject to such an extensive risk evaluation process.

Responses to your specific questions are attached. Thank you for your continued engagement with DWR on these important efforts. I expect that we will continue our dialogue on this topic, including at future meetings of the Ad Hoc group.

Sincerely,

Joel Ledesma

Joel Ledesma
Deputy Director
State Water Project

Attachments

## ATTACHMENTS

**Question No.1: What risk assessment processes outside the 'dam industry' were evaluated to inform the presented PFMA modifications?**

Response: The Federal legislation that required the independent Level 2 Risk Analysis (L2RA) for Oroville Dam also specifically required that the L2RA be performed "consistent with Commission's guidelines" and that it would be used to inform the next Federal Energy Regulatory Commission (FERC) Part 12 safety review. In developing the Proposed Plan for the L2RA, the independent team relied upon existing FERC's Draft Level 2 Risk-Informed Decision Making (RIDM) Guidelines. In particular, the independent team relied upon the following draft document *FERC Risk-Informed Decision Making for Dam Safety, PERIODIC (LEVEL 2) RISK ANALYSIS PROCEDURES, DRAFT, Version 1.1, June 2018.*

Though the RIDM Guidelines have not been finalized by FERC; the Department of Water Resources (DWR) believes they are well developed and provide an appropriate methodology that is consistent with requirements of the federal legislation. FERC's RIDM guidelines and risk assessment process are also consistent with other Federal guidelines (*Federal Guidelines for Dam Safety Risk Management*, FEMA, January 2015) and Federal agency practice (*Best Practices in Dam and Levee Safety Risk Analysis*, U.S. Department of the Interior, Bureau of Reclamation and U.S. Army Corps of Engineers, July 2015).

Federal and dam safety industry risk practices were developed in consideration of probabilistic risk analysis methods employed by the nuclear, oil and gas, aerospace, and other agencies such as the United Kingdom's Health and Safety Executive. The publications entitled, *Risk and Uncertainty in Dam Safety* (2004) and, *Operational Safety of Dams and Reservoirs* (2016) provide informative summaries of the application of probabilistic risk analyses in dam safety and their commonalities to those of other industries.

While DWR did not perform an "evaluation" of risk assessment processes outside the dam safety industry, DWR believes the dam safety industry as a whole has commonly looked to other industries to improve dam safety risk assessment processes.

DWR believes the dam safety industry approach required by the Federal legislation, along with other improvements as noted in the L2RA plan, is the most logical and credible approach currently available. Major process improvements that the independent L2RA team is implementing that were not part of past traditional dam safety PFMA processes include:

1) An expanded definition of failure that includes potential failure modes (PFMs) that do not necessarily result in dam breach or life loss, but cause damage;

2) A focus on component and human interactions to better estimate the overall system response to loadings; and,

3) The use of fault trees (an approach used by the nuclear power and aerospace industries) to better understanding complex systems and their vulnerabilities.

In addition, the L2RA is considering non-failure operational events that result in inundation downstream when the project operates as intended for very large and remote hydrologic events that could lead to downstream damages and potential life loss. These types of events were not explored in PFMA workshops prior to 2017 as such scenarios did not incorporate "uncontrolled release" of the reservoir.

**Question 2: Was a comparison of the strengths/weakness of risk assessments across the industries completed? If yes, are the findings documented and available to the public?**

Response: To our knowledge, the dam safety industry and federal agencies have not recently performed a formal comparison, nor documented strengths and weakness of approaches used in other industries. The approach being undertaken by the L2RA includes numerous changes to PFMA processes, many of which were recommended by the Independent Forensic Team (IFT), but the processes must still comply with the guidelines of FERC's Level 2 RIDM guidelines – as mandated in the federal legislation.

**Question 3: IFT refers to 'complex systems.' What is DWR's definition of a 'complex system.'**

Response: DWR has not established a formal definition of a "complex system" for internal use. However, DWR considers the following description of a dam system, presented in *Operational Safety of Dams and Reservoirs* (2016) as a succinct definition that communicates our understanding of a complex dam system:

> "Dams are engineered systems that are set in a natural environment, and as such the dam system, comprising the dam and appurtenant structures, reservoir, foundation, abutments, etc. is an engineering altered natural system. These are not merely a collection of components but complexes of interacting parts, subject to a variety of disturbances, and operated by human agency."

DWR further recognizes that the human agency component includes the management policies, plans, procedures of the agency that operates and maintains the dam, the commitment and expertise of the agency's employees. The system also includes the regulatory agencies, the stakeholders that live downstream, the public that relies on the reservoir for water supply, recreational, and other benefits, and those that fund dam

operations, maintenance, and capital improvements. All of these human agents can influence the dam system.

**Question 4: What are the credentials, experience, and training of the individual(s) who developed the proposed PFMA modifications?**

Response: As required by the Federal legislation, DWR requested that United States Society of Dams (USSD) nominate qualified persons to prepare a L2RA for Oroville Dam and its appurtenant facilities. Upon receipt of USSD's list of nominees, DWR selected and contracted with individuals based on their qualifications, interest, and availability. Many of these individuals have significant experience from Federal agencies which have the most mature dam safety risk programs in the nation. In addition, many of the independent subject matter experts who will participate in the workshops and provide risk estimates have participated in numerous risk evaluations across the United States, and across the world (e.g. Professor Robin Fell of the University of New South Wales, Australia). Provided electronically along with this letter please find the resumes of the selected USSD nominees and the independent subject matter experts.

**Question 5: What validation techniques will be employed to demonstrate the proposed modifications will achieve the intended improvements?**

Response: As part of their plan, the L2RA team specifically requested technical oversight of the L2RA. This role has been filled by individuals with significant experience with the United States Army Corps of Engineers' (USACE's) risk program, namely Eric Halpin, former Chief of the Dam and Levee Safety Program for the USACE, and Steve Townsley of the USACE Risk Management Center. The process improvements (expanding the traditional definition of a dam safety PFM; focusing on component and human interactions to better estimate the overall system response; and the use of fault trees) are areas of specific interest of the technical oversight individuals and FERC. At the conclusion of each daily workshop session, the L2RA facilitation team, individuals providing technical oversight, FERC's risk expert, and DWR staff meet and hold discussions on the workshop's process to ensure it meets all parties' expectations. The process improvements receive particular attention. Guidance and feedback is provided to the L2RA facilitation team and adjustments to the L2RA PFMA format are made as needed. The L2RA team has also received input from the Part 12D Independent Consulting Board, Comprehensive Needs Assessment (CNA) Independent Review Board members, and Division of Safety of Dams (DSOD) and FERC participants.

Each dam is a unique and each PFMA or risk workshop is unique due to the expertise of the individuals involved, the documentation available, as well as other factors such as possible subtle variations on the definition of failure and time and resources available for the endeavor. In recognition that validation is of interest, FERC requires PFMA results be reviewed every five years during the Part 12D Safety Inspection process.

DWR has elected to conduct full PFMA workshops every five years for Oroville Dam as inevitability new important information, new studies, and updated analyses are generated in the interim that can result in new PFMs and changes in PFM classification that warrant re-visitation of risk reduction opportunities. The catalogue of PFMs gets revisited, expanded, and updated every five years.

Another aspect of validation of the PFMA results occurs through the Part 12D Independent Consulting Board's (ICB) review and comment on the PFMA report in their Part 12D Safety Inspection Report. In their report to FERC, the ICB has the discretion to opine and question PFMs on their professional opinion and experience. The 10th Part 12D ICB includes the following individuals:

- Dr. Lelio Mejia
  - Geosyntec Consultants – also IRB Member
- Dr. David Bowles
  - RAC Engineers and Economists/Professor Emeritus of Utah State
- Drew Kennedy
  - Sage Engineers

Dr. Mejia is an internationally recognized expert on dam safety and has participated in numerous risk evaluations for dams across the nation and across the world. Dr. Bowles is an internationally recognized expert on risk analyses for a variety of structures and has taught risk analyses in various university and professional settings.

In addition, FERC reviews the PFMA report for compliance with their guidelines and expectations. The FERC Regional Engineer has the discretion to accept, reject, or comment on the PFMA report.

In addition to all of this, DWR will be conducting its own Semi-Quantitative Risk Assessment (SQRA) process for the CNA Existing Conditions Assessment. This separate evaluation will review the results of the L2RA evaluations but will also expand on them to consider risks for a wider range of consequences, many of which are associated with an expanded definition of "failure" or consequence as recommended by the IFT. In essence, this provides a second, supplemental analysis process using a somewhat different SQRA process and risk matrix. Further, the CNA and the L2RA results will be reviewed by the Independent Review Board, a separate independent Board of Consultants convened to guide the CNA Project.

**Question 6: What techniques will be employed to substantiate the PFMA modifications will result in a reliable method?**

Response: As noted above, the L2RA evaluations represent an unprecedented effort to evaluate the risks associated with Oroville Dam and its appurtenant facilities. Most of the recommendations offered by the IFT for improvement to the PFMA process have been implemented in this effort, and unprecedented expertise has been brought to the project. The daily review by FERC, DSOD, and USACE experts provides a way to keep the project on track, and to adjust the process each day to better meet the intent of the federal legislation. The CNA Existing Conditions Assessment, a second parallel SQRA evaluation using a somewhat different risk matrix will be used to check and build upon the L2RA results. Both the FERC Independent Consultant Board and the Independent Review Board will review the results of both risk evaluations for consistency and completeness. FERC and DSOD staff both participate in the L2RA workshop sessions and will review the results.

By federal regulations, the PFMA process is revisited every 5 years. In DWR's experience, PFMA reports from one effort to the next result in a significant increase in the number of PFMs as well as increased understanding of the PFMs. DWR anticipates this trend to continue as the industry continues to think in terms of dams operating as systems and owners recognize the need to identify non-life loss PFM.

DWR anticipates that some of the improvements implemented for this PFMA-L2RA will be adopted by other dam owners. Undoubtedly, the improvements will evolve over time. While DWR expects that few dam owners will go to the effort and expense associated with the unprecedented Oroville L2RA evaluations currently underway, it does expect that other dam owners will be able to take lessons learned from DWR's investment in this risk evaluation process in future risk evaluations. From DWR's perspective, the most important element for establishing a reliable method is the consistent training of facilitators and subject matter experts to conduct such analyses. DWR looks forward to supporting the regulatory agencies and dam safety organizations in developing training materials and guidance. We also look forward to sharing our experiences on this endeavor for the benefit of other dam owners and agencies.