August 17, 2012

Mr. Colin Krumdieck, P.E.
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CONTRACT NO. W912HQ-10-D-0002
Task Order: 0024
SUBMITTAL OF DELIVERABLE*: Final IEPR Report*

Dear Mr. Krumdieck:

This letter accompanies the submission of the Final Report for the Independent External Peer Review (IEPR) of the Engineering, Economic, and Environmental Evaluation of the Geotechnical, Hydrological, Hydraulic, Structural and Economic Aspects of the Dam Safety Modification Report for Isabella Lake Dam, California. This deliverable is being submitted electronically in pdf format. A hard copy of the report will be sent to you via FedEx.

Please contact me at (408) 728-7008 (office) or 513-307-4345 (cell) if you have any technical questions regarding this submittal.

Sincerely,

Rachel N. Sell

Rachel Sell
Project Manager

encl.

cc: Katie Huff
Karen Johnson-Young

Battelle
The Business of Innovation

August 17, 2012

Final Independent External Peer Review Report Engineering, Economic, and Environmental Evaluation of the Geotechnical, Hydrological, Hydraulic, Structural, and Economic Aspects of the Dam Safety Modification Report for Isabella Lake Dam, California

Prepared by
Battelle Memorial Institute

Prepared for
Department of the Army
U.S. Army Corps of Engineers
Risk Management Center (RMC)
for the Sacramento District

Contract No. W912HQ-10-D-0002

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Final Independent External Peer Review Report
Engineering, Economic, and Environmental Evaluation of the Geotechnical, Hydrological, Hydraulic, Structural, and Economic Aspects of the Dam Safety Modification Report for Isabella Lake Dam, California

by

Battelle
505 King Avenue
Columbus, OH 43201

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Final Independent External Peer Review Report for the

Engineering, Economic, and Environmental Evaluation of the Geotechnical, Hydrological, Hydraulic, Structural, and Economic Aspects of the Dam Safety Modification Report for Isabella Lake Dam, California

EXECUTIVE SUMMARY

Project Background and Purpose

The Isabella Lake/Reservoir is located approximately 1 mile below the confluence of the North and South Forks of the Kern River in Kern County, California. The project consists of a 185-foot-high rolled earth fill Main Dam across the Kern River, and a 100-foot-high rolled earth fill Auxiliary Dam across Hot Springs Valley about ½ mile east of the Main Dam. The project provides flood risk reduction, irrigation, hydroelectric, and recreational benefits to the Tulare Lake Watershed. The Isabella Lake Dam, as originally constructed, was put into full operation in February 1953, and is a flood control facility with secondary benefits from water conservation.

The Main Dam was built across the Kern River and has a maximum height of 185 feet, a crest length of 1,695 feet, and a crest width of 20 feet. The crest elevation is 2637.26 feet NAVD 88, which provides 6.5 feet of freeboard above the Spillway Design Flood elevation of 2630.76 feet NAVD 88. The storage capacity at gross pool is 568,000 acre-feet, which is elevation 2609.26 feet NAVD 88. The Main Dam consists of a homogeneous, zoned, earth-fill embankment with an impervious central core and decomposed granite outer shells. A 5-foot thick drainage blanket was placed beneath the downstream shell along the base of the Main Dam and about one-third the width. The foundation consists primarily of granitic rock; however, a zone of streambed alluvium beneath a portion of the downstream shell (2 to 5 feet thick) was left in place. A layer of riprap armors the upstream slope for erosion protection. A wedge-shaped zone of rockfill up to about 40 feet thick was placed in the downstream zone below elevation 2,555.76 feet NAVD 88. A 12-foot wide centerline cutoff/inspection trench was excavated along the rippable portions of the foundation and then a single, variable depth grout curtain was installed. Zone 1 grouting was generally 15 to 25 feet deep, zone 2 was generally 50 feet deep, and zone 3 holes (few in number) were grouted to 75 feet deep.

The Auxiliary Dam is a homogeneous, rolled, earth fill structure with a maximum height of 100 feet, a crest length of 3,257 feet, and a crest width of 20 feet. The crest elevation is 2637.26 feet NAVD 88, which provides 6.5 feet of freeboard above the Spillway Design Flood elevation of 2630.76 feet NAVD 88. The foundation consists of heterogeneous valley fill alluvium with a maximum depth of approximately 130 feet, above deeply weathered granitic bedrock. Recent explorations have shown that significant portions of the alluvium are loose and therefore potentially liquefiable.

The principal structural geology feature of the Isabella Project area is the Kern Canyon Fault (KCF) system, interpreted as a fault with a complex history of extensive deformation through geologic time. The fault exhibits about nine miles of right-lateral offset of bedrock units near Isabella Lake. The middle or Isabella segment of the KCF runs directly beneath the right abutment of the Auxiliary Dam. The KCF was originally thought to be inactive; however, a comprehensive characterization was conducted and it is now considered a primary seismogenic source in the southern Sierra Nevada in Tulare and Kern counties, California. There have been two datable surface rupturing events at the dam in the last 10,000 years at M6.5 - M7.1. The average offset is 1.1 meters and the upper limit is estimated to be 2.1 meters (based on the 2 events only). The estimated recurrence is approximately 3,200 years. The investigations provide direct input for assessing the seismic stability of the Isabella Lake Main Dam and Auxiliary Dam.

The outlet works at the Main Dam consists of an intake structure and an outlet structure. The intake structure was constructed with the following components: conduit (14’9” diameter), transition section, control tower, and control section (three rectangular gated conduits). The outlet structure consists of an outlet transition section and an outlet conduit (14’9” diameter). Each of the control section conduits has a service gate (5’8” x 10’) and an emergency gate (5’8” x 10’). The controlling invert elevation of the main outlet is at 2473.76 feet NAVD 88 and is located in the approach channel. The outlet structure at the downstream slope of the Main Dam was constructed to allow for direct releases through the power generation facilities at the toe operated by Isabella Partners.

The spillway consists of an un-gated concrete ogee section located at the left abutment of the Main Dam. The elevation of the ogee crest is 2609.26 feet NAVD 88 with a length of 140 feet. The capacity of the spillway is 52,700 cubic feet per second (cfs) at the spillway flood pool elevation of 2630.76 feet NAVD 88. The spillway approach and exit were excavated into rock except where it is in contact with the Main Dam embankment.

The Borel Canal is located underneath the reservoir for the purpose of water delivery from the North Fork of the Kern River to the Southern California Edison (SCE) Power Plant during low reservoir elevations. The original construction of the Borel Canal began in 1897 and was completed in 1904. The head works to the open channel canal is located at the North Fork and runs along the floor of the reservoir for approximately 5 miles to the Auxiliary Dam. The Auxiliary Dam was constructed on top of the canal in the early 1950’s (Station 63+80). The open channel canal continues downstream of the dam to the SCE power plant which is located approximately 7 miles downstream. The outlet works at the Auxiliary Dam is used to restrict releases to the Borel Canal to a maximum of 605 cfs. A 12-inch bypass valve is provided in each barrel to allow for fine regulation of canal releases; these two valves have never been used. The portion of the canal beneath the dam consists of a 524.5 foot-long, reinforced-concrete, double-barrel conduit within the Auxiliary Dam foundation that is composed of two rectangular chambers with opening dimensions of 5’8” x 10’ each, separated by 1’8” thick concrete wall. A vertical control tower was constructed on top of the conduit 55 feet upstream of the Auxiliary Dam axis. Upstream and downstream of the Auxiliary Dam, the canal has a trapezoidal cross section, with a bottom width of 23 feet and side slopes of 1.5H:1V. The realignment construction of Borel Canal, which began in November 1951, involved removing the original

canal within the footprint of the Auxiliary Dam, placing fill for the Auxiliary Dam embankment in two separate sections east and west of the proposed relocated canal location, partially excavating the conduit section, and construction of the conduit. The water table in the vicinity of the Borel Canal was high, so the excavation for the new Borel Canal conduit required the use of French drains and pumps. Sheet piling was used to shore the excavation, and concrete was placed to create the walls of the new conduit. The conduit has joints spaced generally at 20 feet on center with reinforced concrete collars constructed around each joint. Several years after construction, it was discovered that the old Borel Canal had been built on a "very poor sand fill" from the upstream to the downstream toe of the dam.

In September 2006 USACE initiated an emergency deviation from the Water Control Plan for Isabella Dam and Lake, revised January 1978, to operate the project and maintain the reservoir elevation at or below 2,585.5 feet, Isabella Project Datum (storage at or below approximately 356,700 acre-feet). The purpose of this emergency deviation was to lower the lake level to a safe and acceptable elevation/capacity based upon recent results of USACE's seepage investigations. USACE has concluded that Isabella Lake Dam could fail due to seepage at gross pool, or during an earthquake. While a failure might be a remote probability, it was high enough to warrant the deviation. A failure at high reservoir levels would result in an uncontrollable release of water and would flood communities downstream of the lake. USACE also determined that the planned deviation restricting the reservoir level would be necessary until the permanent solution for the dam safety remediation is implemented.

The existing Isabella Lake dams were authorized for construction by the Flood Control Act of 1944 (Public Law 78-534, Chapter 665, Section 10, page 901), December 22, 1944, and became fully operational in 1953. Dam Safety studies were initiated in 2002 and have identified seismic, hydrologic (potential overtopping in a flood), and seepage deficiencies. The seepage and seismic issues have led to the reservoir's allowable maximum capacity to be reduced to 63% of normal capacity. This capacity restriction is an interim risk reduction measure (IRRM) that will remain in place until a permanent modification is constructed. Currently, the reservoir is not fully able to provide the benefits for which it was authorized and constructed. Screening-level portfolio risk assessments were completed by HQUSACE on 26 July 2005 which classified the Isabella Project as a Dam Safety Action Classification (DSAC) I (highest risk) dam due to a combination of seismic, hydrologic (inadequate spillway capacity), and seepage issues, with the combination of a large population at risk (PAR) located downstream within the dam failure inundation zone.

DSAC I is the highest of five risk classifications. In Engineer Regulation ER 1110-2-1156, DSAC I is described as urgent and compelling, and states that it is for those dams where (1) progression toward failure is confirmed to be taking place under normal operations and the dam is almost certain to fail under normal operations within a timeframe from immediately to within a few years without intervention; or (2) the combination of life or economic consequences with probability of failure is extremely high.

Remediation is necessary to address the dam safety deficiencies at the Isabella Lake dams. Currently, a reservoir restriction is in effect; however, the restriction has resulted in economic loss to water users when water is released to limit water levels as part of flood risk management efforts. In 2006, seismic, seepage, hydrologic, and hydraulic investigations and studies began at both dams to characterize the site conditions and evaluate the seismic and seepage issues and

risk. Investigations have continued through 2011. These investigations and studies will culminate in an array of potential remediation alternatives (also known as risk management plans).

Independent External Peer Review Process

Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analyses. The U.S. Army Corps of Engineers (USACE) is conducting an Independent External Peer Review (IEPR) of the Engineering, Economic, and Environmental Evaluation of the Geotechnical, Hydrological, Hydraulic, Structural, and Economic Aspects of the Dam Safety Modification Report (DSMR) for Isabella Lake Dam, California (hereinafter: Isabella Dam Safety IEPR) Battelle, a 501(c)(3) non-profit science and technology organization with experience in establishing and administering more than 100 peer review panels for USACE since 2005, was engaged to coordinate the IEPR of the technical basis for the economic, engineering, and environmental methods, models, data and analyses, and assumptions supporting the DSMR. Battelle is independent, free from conflicts of interest (COIs), and meets the requirements for an Outside Eligible Organization (OEO) per guidance described in USACE (2012). The IEPR was external to the agency and conducted following USACE and Office of Management and Budget (OMB) guidance described in USACE (2012), USACE (2007), and OMB (2004). This final report describes the IEPR process, describes the panel members and their selection, and summarizes the Final Panel Comments of the IEPR Panel (the Panel).

Based on the technical content of the Isabella Dam Safety review documents and the overall scope of the project, Battelle identified candidates for the Panel in the following key technical areas: geotechnical engineering, engineering geology, civil/structural engineering, hydraulic/ hydrologic engineering, economics, National Environmental Policy Act (NEPA) impact assessment, and planning. Six panel members were selected for the IEPR from more than 20 candidates identified. USACE was given the list of candidate panel members, but Battelle made the final selection of the Panel.

The Panel received electronic versions of the Isabella Dam Safety IEPR documents, totaling approximately 4,150 pages, along with a charge that solicited comments on specific sections of the documents to be reviewed. The charge was prepared by USACE according to guidance provided in USACE (2012) and OMB (2004). Charge questions were provided by USACE and included in the draft and final Work Plans.

The USACE Project Delivery Team (PDT) briefed the Panel and Battelle during a kick-off meeting held via teleconference prior to the start of the review. In addition, an in-person meeting to discuss the Isabella Dam Safety project was held at the USACE Isabella Dam Project Office near Kernville, California on July 10, 2012; four panel members attended this meeting. As part of this meeting, USACE led Battelle and the Panel on a visit of the Isabella Dam site, including a tour of the main and auxiliary dams and existing spillway. In addition to the kick-off teleconference and the in-person meetings/site visits, a teleconference with USACE, the Panel, and Battelle was held one week after the Senior Oversight Group (SOG) meeting to provide the Panel an opportunity to ask questions of USACE and clarify uncertainties.

IEPR panel members reviewed the Isabella Dam Safety IEPR documents individually. The Panel produced more than 250 individual comments in response to the 46 charge questions. The panel members then met via teleconference with Battelle to review key technical comments, discuss charge questions for which there were conflicting responses, and reach agreement on the Final Panel Comments to be provided to USACE. Each Final Panel Comment was documented using a four-part format consisting of: (1) a comment statement; (2) the basis for the comment; (3) the significance of the comment (high, medium, or low); and (4) recommendations on how to resolve the comment. Overall, 28 Final Panel Comments were identified and documented. Of these, seven were identified as having high significance, 20 had medium significance, and one had low significance.

Results of the Independent External Peer Review

The panel members agreed among one another on their "assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used" (USACE, 2012; p. D-4) in the Isabella Dam Safety review documents. Table ES-1 lists the Final Panel Comment statements by level of significance. The full text of the Final Panel Comments is presented in Appendix A of this report. The following statements summarize the Panel's findings.

The Dam Safety Modification Report (DSMR) and Baseline Risk Assessment Report (BRAR) provide a well thought out and thorough development and presentation of USACE's approach to risk assessment for the Isabella Lake dams and measures required to mitigate risk. From a planning standpoint, it is apparent that USACE explored a reasonable subset of alternatives, given budgetary and urgency issues. In general, the DSMR, BRAR, Draft Environmental Impact Statement (DEIS), Hydrology Report, and other technical appendices and supporting documents provide a great deal of information about the project. However, in many cases, key information is not provided, which prevents the Panel from fully and accurately assessing the project.

Plan Formulation – The Panel found the array of considered alternatives to be comprehensive; however, the review documents do not clearly demonstrate that USACE followed the Six Step Planning Process from the Principles and Guidelines and ER 1105-2-100. As such, the Panel is unable to determine whether there are sufficient analyses upon which to base a recommendation. Furthermore, if a future without project condition is not properly documented, the selection and justification of the tentative recommended plan can be affected and its expected risk reduction benefits could be questioned. Additional information is needed to specifically demonstrate that the Life Safety Plan (LSP) 4 and DSAC Plan 2 display costs and benefits of the elements that separate these two alternatives.

Engineering – The Panel found that, in general, the engineering analyses were extremely thorough and employed methods that are state-of-the practice, but not always well explained or well justified. All engineering models (e.g., HEC-HMS, HEC-RAS, FLO-2D, FLAC, etc.) used in the analyses were applied in an appropriate manner, but the uncertainty associated with the modeling, particularly the seismic modeling, has not been quantified. The modeling studies with dam break simulations effectively captured the catastrophic nature of the overtopping and seepage failure scenarios under various pool level conditions with and without the proposed

spillway improvements. The Hydrology Report goes into a detailed discussion related to the calibration of the HEC-HMS runoff model; however, there is no discussion on verifying the model to other recorded flood events. The accuracy of the HEC-HMS runoff model has direct bearing on the magnitude of the peak PMF inflow value and, in turn, the scope and cost of the proposed emergency spillway and improvements to the existing spillway. To potentially reduce uncertainty in the magnitude of the peak PMF inflow value, a site-specific PMP analysis integrated into the HEC-HMS model should be conducted. Given the large capacity flows required to be conveyed by both the existing spillway and the proposed emergency spillway under the PMF, strong consideration should be given to conducting physical hydraulic modeling studies of both structures (including their discharge channels) as part of the preliminary and final design efforts.

The information in the review documents appropriately describes existing conditions at the dam relating to hydrology and hydraulics of the spillway; however, the Panel was unclear as to whether the preferred emergency spillway alternative is being disproportionately driven by the more subjective elements of the risk analysis (i.e. Do no harm and as low as reasonably possible [ALARP]) criteria. Additionally, a more defined evaluation of risk should be presented for non-failure scenarios for other spillway configurations during more frequent flooding events (i.e., incremental damage assessment).

From a structural and geotechnical standpoint, it appears that most major conceivable hazards have been described adequately in terms of various significant modes of failure, with some exceptions. The Panel found that potential uncertainties in the FLAC analyses may influence the estimated seismic deformation, which could affect the risk assessment relative to several potential failure modes. For instance, when considering deformation analyses, the details of the potential seismic cracking nature and mechanisms are not well-defined and the use of filters to mitigate seismic displacements and seepage path formation is not well-documented in light of the uncertainty inherent in seismic modeling. In addition, the Panel found the risks associated with not retrofitting the Main Dam control tower, as well as the outlet/inlet structures with regard to structural performance under seismic loading are not fully addressed for the Life Safety Plan Alternatives. From a safety assurance perspective, it is unclear to what extent the lack of resilience and robustness will impact the selection of LSP 4. The uncertainty associated with liquefaction potential of deeper alluvium also remains.

More detailed information is needed about discontinuity characteristics in the spillway area and the potential for overtopping the spillway chute walls. The Panel also believes that a more detailed geological characterization is needed of the rock mass within the shear zone through which tunnels for Borel Canal Measures 1 and 2 are located. The Panel believes that these and other outstanding issues can be addressed and explained. The Panel also identified several components related to the existing spillway and Borel Conduit that will require further consideration during the preliminary engineering design (PED) phase of the project.

Economics – The Panel found that the project documents do not provide sufficient economic analyses to justify the selection of the tentative recommended plan. The Draft Economics Appendix lacks considerable detail on the models used to estimate the future without project condition, future without project risk, and impacts of the various alternatives carried forward. The amount of information missing from the Economics Appendix makes it difficult for the

Panel to determine whether the future without project condition is reasonable and expected to occur, or how the alternative plans were evaluated in terms of their economic outputs. The Panel believes the Economics Appendix needs much more detail in documenting analyses used to estimate plan impacts with separable elements that are independently justified.

The overall completeness of the report, specifically the alternatives ranking, is affected due to the absence of Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) results. The Panel believes that the use of HEC-FIA is appropriate for evaluating the alternatives considered. However, the Panel also believes that HEC-FDA should have been used to demonstrate that the expected annual National Economic Development (NED) benefits vs. expected annual NED costs and residual risk are acceptable. There is no USACE guidance overriding the requirement to display the NED effects of the plans carried forward for analysis and identifying which is the NED plan. The Panel also noted that – per USACE guidance – existing levee systems should be evaluated in terms of their ability to reduce flood damages and loss of life in the event of a dam failure.

Environmental –The Panel found that within the context of NEPA, the study addressed the resources identified during the scoping process that were important to the decision making process. Within the context of a tiered NEPA evaluation, the analysis was adequate; however, it has been the experience of the Panel that EISs typically include more detail regarding project impacts. The Panel recognizes that more detailed analysis will come with additional NEPA analyses conducted in the future, and a substantial amount of information will be updated or further documented prior to the final EIS (FEIS) being completed. The Panel found the mitigation measures and environmental commitments provided in the DEIS were broad and generic; additional detail would have provided a clearer understanding of how project impacts associated with each alternative would adequately be avoided, reduced and minimized, to the greatest extent practicable. Additionally, the Panel found there was a lack of detail and documentation regarding climate change resulting in an incomplete understanding of the cumulative effects of the proposed project. The issue of reservoir sediment amount and its impact on downstream ecology needs to be addressed and documented in the reports, even if the volume of sediment is small compared to the lake volume.

Table ES-1. Overview of 28 Final Panel Comments Identified by the Isabella Dam Safety IEPR Panel

No.	Final Panel Comment
Significance – High	
1	A site-specific PMP analysis integrated into the HEC-HMS model, which could potentially reduce uncertainty in the magnitude of the peak PMF inflow valve, has not been conducted.
2	The Final Hydrology Report does not discuss the verification process for the HEC-HMS model.
3	In the future without project condition, it is unlikely that the interim risk reduction measures (IRRM) would be abandoned and that the reservoir would be operated as if there were no risk of dam failure.
4	There is no description of the NED plan, why that plan was rejected, or why the recommended plan is preferable to the NED plan or preferable to dam removal.
5	The uncertainty inherent in seismic deformation modeling and its potential impact on the tentative recommended plan has not been fully considered or documented.
6	When considering deformation analyses, the details of the potential seismic cracking mechanisms are not well-defined and the use of filters to mitigate seismic displacements and seepage path formation is not well-documented.
7	It is difficult to determine whether separable elements are independently justified.
Significance – Medium	
8	The results of the incremental damage assessment for rejected alternatives under more frequent flooding events (for non-failure scenarios) are not clearly presented in the main review documents.
9	It appears the preferred emergency spillway alternative is being disproportionately driven by the more subjective elements of the risk analysis (i.e., Do No Harm and ALARP) criteria.
10	The execution of the PMF analysis under current baseline conditions (i.e., the calibration and use of the 1965 Clark sub-area Unit Hydrographs) may be outdated.
11	Several components related to the existing spillway require further consideration during the preliminary engineering design (PED) phase of the project.
12	The review documents do not clearly demonstrate that the Six Step Planning Process from the Principles and Guidelines and ER 1105-2-100 was followed.
13	The existing levee systems should be evaluated in terms of their ability to reduce flood damages and loss of life in the event of a dam failure.
14	The results of the HEC-FDA analyses, which are intended to determine how the alternatives rank in expected flood risk reduced and residual flood risk after remediation, have not been provided.

Table ES-1. Overview of 28 Final Panel Comments Identified by the Isabella Dam Safety IEPR Panel, continued

No.	Final Panel Comment
15	The Draft Economics Appendix is missing considerable detail on the models used to estimate the future without project condition, future without project risk, and impacts of the various alternatives carried forward.
16	It is unclear to what extent the lack of resilience and robustness will affect the selection of Life Safety Plan 4 as the tentative recommended plan over DSAC Plan 2 and whether sufficient redundancy is provided.
17	The effect of reservoir sediment, regardless of its volume, on downstream channel regimen and ecology has not been evaluated.
18	The structural performance of the modified Main Dam control tower under seismic loading in the absence of seismic retrofitting is not addressed.
19	Information on discontinuity orientations, types, and aperture and how these discontinuity aspects might influence erodibility of the existing spillway channel has not been provided.
20	Information about the design and construction of the seepage collection and disposal system for the proposed filter and drainage buttress is missing from the reports.
21	The EIS analysis did not provide enough detail in the cumulative effects analysis on climate change and how cloud seeding activities coincide with climate change.
22	The analysis of potential impacts of the project alternatives on various environmental constraints is not complete in the DEIS, as more current data are available for several environmental constraints.
23	The mitigation measures for water quality, noise and vibration, and biological resources, while appropriate, lack the specificity needed to adequately determine whether they would offset project impacts and/or need clarification, consistent with other state and Federal agency requirements.
24	Physical and computational fluid dynamic (CFD) modeling should be performed during the preliminary engineering design phase of the project to properly set the final design configuration of the primary and emergency spillway channels.
25	Using historical records as a means to estimate flood damages reduced is not an appropriate measure of expected future flood risk reduction loss.
26	A detailed geological characterization of the rock mass within the shear zone, through which Borel Canal Measures 1 and 2 will be located, is not provided in the reports.
27	Some of the risks associated the Borel Conduit closure, including the potential for incompatible deformations and/or strains caused by filling the Conduit and the details associated with closing it, have not been addressed.
	Significance – Low
28	The reports use economic values that have not been updated to the current fiscal year, as required by USACE guidance.

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LIST OF ACRONYMS

AEP	Annual Exceedance Probability
ALARP	As low as reasonably possible
ATR	Agency Technical Review
BRAR	Baseline Risk Assessment Report
CDR	Capacity-Demand Ratios
CEQ	Council on Environmental Quality
COI	Conflict of Interest
CFD	Computational Fluid Dynamics
DEIS	Draft Environmental Impact Statement
DrChecks	Design Review and Checking System
DSAC	Dam Safety Action Classification
DSMR	Dam Safety Modification Report
FEIS	Final Environmental Impact Statement
FHWA	Federal Highway Administration
FS	Feasibility Study
GHG	Greenhouse Gas
HEC-FDA	Hydrologic Engineering Center-Flood Damage Analysis
HTRW	Hazardous Toxic Radioactive Waste
IEPR	Independent External Peer Review
IRRM	Interim Risk Reduction Measure
KCF	Kern Canyon Fault
LEDPA	Least Environmentally Damaging Practicable Alternative
LOL	Loss of Life
LSP	Life Safety Plan
MCE	Maximum Credible Earthquake
MSAT	Mobile Source Air Toxics
NED	National Economic Development
NEPA	National Environmental Policy Act
NTP	Notice to Proceed
OEO	Outside Eligible Organization

LIST OF ACRONYMS, continued

OMB	Office of Management and Budget
PAR	Population at Risk
PDT	Project Delivery Team
PED	Preliminary Engineering Design
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SCE	Southern California Edison
SOG	Senior Oversight Group
TNM	Traffic Noise Model
UH	Unit Hydrographs
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WRDA	Water Resources Development Act

1. INTRODUCTION

The Isabella Lake/Reservoir is located approximately 1 mile below the confluence of the North and South Forks of the Kern River in Kern County, California. The project consists of a 185-foot-high rolled earth fill Main Dam across the Kern River, and a 100-foot-high rolled earth fill Auxiliary Dam across Hot Springs Valley about ½ mile east of the Main Dam. The project provides flood risk reduction, irrigation, hydroelectric, and recreational benefits to the Tulare Lake Watershed. The Isabella Lake Dam, as originally constructed, was put into full operation in February 1953, and is a flood control facility with secondary benefits from water conservation.

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The principal structural geology feature of the Isabella Project area is the Kern Canyon Fault (KCF) system, interpreted as a fault with a complex history of extensive deformation through geologic time. The fault exhibits about nine miles of right-lateral offset of bedrock units near Isabella Lake. The middle or Isabella segment of the KCF runs directly beneath the right abutment of the Auxiliary Dam. The KCF was originally thought to be inactive; however, a comprehensive characterization was conducted and it is now considered a primary seismogenic source in the southern Sierra Nevada in Tulare and Kern counties, California. There have been two datable surface rupturing events at the dam in the last 10,000 years at M6.5 – M7.1. The average offset is 1.1 meters and the upper limit is estimated to be 2.1 meters (based on the 2 events only). The estimated recurrence is approximately 3,200 years. The investigations provide

direct input for assessing the seismic stability of the Isabella Lake Main Dam and Auxiliary Dam.

The outlet works at the Main Dam consists of an intake structure and an outlet structure. The intake structure was constructed with the following components: conduit (14'9" diameter), transition section, control tower, and control section (three rectangular gated conduits). The outlet structure consists of an outlet transition section and an outlet conduit (14'9" diameter). Each of the control section conduits has a service gate (5'8" x 10') and an emergency gate (5'8" x 10'). The controlling invert elevation of the main outlet is at 2473.76 feet NAVD 88 and is located in the approach channel. The outlet structure at the downstream slope of the Main Dam was constructed to allow for direct releases through the power generation facilities at the toe operated by Isabella Partners.

The spillway consists of an un-gated concrete ogee section located at the left abutment of the Main Dam. The elevation of the ogee crest is 2609.26 feet NAVD 88 with a length of 140 feet. The capacity of the spillway is 52,700 cubic feet per second (cfs) at the spillway flood pool elevation of 2630.76 feet NAVD 88. The spillway approach and exit were excavated into rock except where it is in contact with the Main Dam embankment.

The Borel Canal is located underneath the reservoir for the purpose of water delivery from the North Fork of the Kern River to the Southern California Edison (SCE) Power Plant during low reservoir elevations. The original construction of the Borel Canal began in 1897 and was completed in 1904. The head works to the open channel canal is located at the North Fork and runs along the floor of the reservoir for approximately 5 miles to the Auxiliary Dam. The Auxiliary Dam was constructed on top of the canal in the early 1950's (Station 63+80). The open channel canal continues downstream of the dam to the SCE power plant which is located approximately 7 miles downstream. The outlet works at the Auxiliary Dam is used to restrict releases to the Borel Canal to a maximum of 605 cfs. A 12-inch bypass valve is provided in each barrel to allow for fine regulation of canal releases; these two valves have never been used. The portion of the canal beneath the dam consists of a 524.5 foot-long, reinforced-concrete, double-barrel conduit within the Auxiliary Dam foundation that is composed of two rectangular chambers with opening dimensions of 5'8" x 10' each, separated by 1'8" thick concrete wall. A vertical control tower was constructed on top of the conduit 55 feet upstream of the Auxiliary Dam axis. Upstream and downstream of the Auxiliary Dam, the canal has a trapezoidal cross section, with a bottom width of 23 feet and side slopes of 1.5H:1V. The realignment construction of Borel Canal, which began in November 1951, involved removing the original canal within the footprint of the Auxiliary Dam, placing fill for the Auxiliary Dam embankment in two separate sections east and west of the proposed relocated canal location, partially excavating the conduit section, and construction of the conduit. The water table in the vicinity of the Borel Canal was high, so the excavation for the new Borel Canal conduit required the use of French drains and pumps. Sheet piling was used to shore the excavation, and concrete was placed to create the walls of the new conduit. The conduit has joints spaced generally at 20 feet on center with reinforced concrete collars constructed around each joint. Several years after construction, it was discovered that the old Borel Canal had been built on a "very poor sand fill" from the upstream to the downstream toe of the dam.

In September 2006 USACE initiated an emergency deviation from the Water Control Plan for Isabella Dam and Lake, revised January 1978, to operate the project and maintain the reservoir elevation at or below 2,585.5 feet, Isabella Project Datum (storage at or below approximately 356,700 acre-feet). The purpose of this emergency deviation was to lower the lake level to a safe and acceptable elevation/capacity based upon recent results of USACE's seepage investigations. USACE has concluded that Isabella Lake Dam could fail due to seepage at gross pool, or during an earthquake. While a failure might be a remote probability, it was high enough to warrant the deviation. A failure at high reservoir levels would result in an uncontrollable release of water and would flood communities downstream of the lake. USACE also determined that the planned deviation restricting the reservoir level would be necessary until the permanent solution for the dam safety remediation is implemented.

The existing Isabella Lake dams were authorized for construction by the Flood Control Act of 1944 (Public Law 78-534, Chapter 665, Section 10, page 901), December 22, 1944, and became fully operational in 1953. Dam Safety studies were initiated in 2002 and have identified seismic, hydrologic (potential overtopping in a flood), and seepage deficiencies. The seepage and seismic issues have led to the reservoir's allowable maximum capacity to be reduced to 63% of normal capacity. This capacity restriction is an interim risk reduction measure (IRRM) that will remain in place until a permanent modification is constructed. Currently, the reservoir is not fully able to provide the benefits for which it was authorized and constructed. Screening-level portfolio risk assessments were completed by HQUSACE on 26 July 2005 which classified the Isabella Project as a Dam Safety Action Classification (DSAC) I (highest risk) dam due to a combination of seismic, hydrologic (inadequate spillway capacity), and seepage issues, with the combination of a large population at risk (PAR) located downstream within the dam failure inundation zone.

DSAC I is the highest of five risk classifications. In Engineer Regulation ER 1110-2-1156, DSAC I is described as urgent and compelling, and states that it is for those dams where (1) progression toward failure is confirmed to be taking place under normal operations and the dam is almost certain to fail under normal operations within a timeframe from immediately to within a few years without intervention; or (2) the combination of life or economic consequences with probability of failure is extremely high.

Remediation is necessary to address the dam safety deficiencies at the Isabella Lake dams. Currently, a reservoir restriction is in effect; however, the restriction has resulted in economic loss to water users when water is released to limit water levels as part of flood risk management efforts. In 2006, seismic, seepage, hydrologic, and hydraulic investigations and studies began at both dams to characterize the site conditions and evaluate the seismic and seepage issues and risk. Investigations have continued through 2011. These investigations and studies will culminate in an array of potential remediation alternatives (also known as risk management plans).

The objective of the work described here was to conduct an Independent External Peer Review (IEPR) of the Engineering, Economic, and Environmental Evaluation of the Geotechnical, Hydrological, Hydraulic, Structural, and Economic Aspects of the Dam Safety Modification Report for Isabella Lake Dam, California (hereinafter: Isabella Dam Safety IEPR) in accordance with procedures described in the Department of the Army, U.S. Army Corps of Engineers (USACE) *Civil Works Review Policy* Engineer Circular (EC 1165-2-209) Change 1 (USACE,

2012), USACE CECW-CP memorandum *Peer Review Process* (USACE, 2007), and Office of Management and Budget (OMB) bulletin *Final Information Quality Bulletin for Peer Review* (OMB, 2004). Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analyses.

This final report details the IEPR process conducted by Battelle, describes the IEPR panel members and their selection, and summarizes the Final Panel Comments of the IEPR Panel on the existing environmental, economic, and engineering analyses contained in the Isabella Dam Safety IEPR. The full text of the Final Panel Comments is presented in Appendix A.

2. PURPOSE OF THE IEPR

To ensure that USACE documents are supported by the best scientific and technical information, USACE has implemented a peer review process that uses IEPR to complement the Agency Technical Review (ATR), as described in USACE (2012) and USACE (2007).

In general, the purpose of peer review is to strengthen the quality and credibility of USACE's decision documents in support of its Civil Works program. For the purpose of this IEPR, USACE has been directed by Congress to evaluate USACE dams for safety assurance and seepage/stability correction.

IEPR provides an independent assessment of the economic, engineering, and environmental analysis of the project study. In particular, the IEPR addresses the technical soundness of the project study's assumptions, methods, analyses, and calculations and identifies the need for additional data or analyses to make a good decision regarding implementation of alternatives and recommendations.

In this case, the IEPR of the Isabella Dam Safety project was conducted and managed using contract support from Battelle, which is an Outside Eligible Organization (OEO) (as defined by EC 1165-2-209) under Section 501(c)(3) of the U.S. Internal Revenue Code, with experience conducting IEPRs for USACE.

3. METHODS

This section describes the method followed in selecting the members of the IEPR Panel (the Panel) and in planning and conducting the IEPR. The IEPR was conducted following procedures described by USACE (2012) and in accordance with USACE (2007) and OMB (2004) guidance. Supplemental guidance on evaluation for conflicts of interest (COIs) was obtained from the *Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports* (The National Academies, 2003).

3.1 Planning and Schedule

After receiving the notice to proceed (NTP), Battelle held a kick-off meeting with USACE to review the preliminary/suggested schedule, discuss the IEPR process, and address any questions regarding the scope (e.g., clarify expertise areas needed for panel members). Battelle also

completed the process of selecting the six members of the Panel. Any revisions to the schedule were submitted as part of the final Work Plan.

Table 1 presents the schedule followed in executing the IEPR. Due dates for milestones and deliverables are based on the NTP date of June 14, 2012. The review documents were provided by USACE in two stages: the Initial Review Documents were available on June 25, 2012 and the Senior Oversight Group (SOG) Review Documents were available on July 24, 2012.

Table 1. Isabella Dam Safety IEPR Schedule.

Task	Action	Due Date
1	**Award/Effective Date (NTP)**	6/14/2012
	Initial Review Documents available	6/25/2012
	SOG Review Documents available	7/24/2012
	Battelle submits draft Work Plan to USACE[a]	6/28/2012
	USACE provides comments on draft Work Plan	7/2/2012
	Battelle convenes teleconference (if necessary)	7/3/2012
	Battelle submits final Work Plan to USACE[a]	7/9/2012
2	Battelle requests input from USACE on the conflict of interest (COI) questionnaire	6/19/2012
	USACE provides comments on COI questionnaire	6/20/2012
	Battelle submits list of selected panel members to USACE[a]	6/20/2012
	USACE confirms the Panel has no conflicts of interest (COI)	6/25/2012
	Battelle completes subcontracts for panel members	6/29/2012
3	Battelle submits draft charge (combined with draft Work Plan in Task 1)	6/28/2012
	USACE confirms draft charge (combined with draft Work Plan in Task 1)	7/2/2012
	Battelle submits final charge (combined with final Work Plan in Task 1)	7/9/2012
4	Battelle convenes kick-off meeting with USACE	6/21/2012
	Battelle convenes kickoff meeting with Panel followed by kickoff meeting with USACE and Panel	7/3/2012
	USACE/Battelle convenes kickoff/site meeting with Panel	7/10/2012
	Battelle convenes teleconference with USACE after receipt of SOG Review Documents for Panel to ask clarifying questions	7/25/2012
5	Panel members complete their individual reviews of Initial Review Documents and SOG Review Documents	7/31/2012
	Battelle provides Panel merged individual comments and talking points for Panel Review Teleconference	8/3/2012
	Battelle convenes Panel Review Teleconference	8/3/2012
	Panel members provide draft Final Panel Comments to Battelle	8/9/2012

Table 2. Isabella Dam Safety IEPR Schedule, continued.

Task	Action	Due Date
	Final Panel Comments finalized	8/14/2012
6	Battelle submits Final IEPR Report to USACE[a]	8/17/2012
7[b]	Battelle convenes teleconference with USACE to review the Post-Final Panel Comment Response Process	8/21/2012
	USACE provides draft PDT Evaluator Responses to Battelle	8/28/2012
	Battelle convenes teleconference with Panel and USACE to discuss Final Panel Comments and draft responses	9/5/2012
	USACE inputs final PDT Evaluator Responses in DrChecks	9/12/2012
	Battelle inputs the Panel's BackCheck Responses in DrChecks	9/19/2012
	Battelle submits pdf printout of DrChecks project file[a]	9/20/2012
	Project Closeout (Includes time to close out subcontracts with panel members)	11/28/2012

[a] *Deliverable.*

[b] *Task 7 occurs after the submission of this report.*

Note that the work items listed in Task 7 occur after the submission of this report. Battelle will enter the 28 Final Panel Comments developed by the Panel into USACE's Design Review and Checking System (DrChecks), a Web-based software system for documenting and sharing comments on reports and design documents, so that USACE can review and respond to them. USACE will provide responses (Evaluator Responses) to the Final Panel Comments, and the Panel will respond (BackCheck Responses) to the Evaluator Responses. All USACE and Panel responses will be documented by Battelle.

3.2 Identification and Selection of IEPR Panel Members

The candidates for the Panel were evaluated based on their technical expertise in the following seven key areas: geotechnical engineering, engineering geology, civil/structural engineering, hydraulic/hydrologic engineering, economics, National Environmental Policy Act (NEPA) impact assessment, and planning. These areas correspond to the technical content and overall scope of the Isabella Dam Safety project.

To identify candidate panel members, Battelle reviewed the credentials of the experts in Battelle's Peer Reviewer Database, sought recommendations from colleagues, contacted former panel members, and conducted targeted Internet searches. Battelle initially identified more than 20 candidates for the Panel, evaluated their technical expertise, and inquired about potential COIs. Of these, Battelle chose six of the most qualified candidates, confirmed their interest and availability, and proposed them for the final Panel.[1] The remaining candidates were not proposed for a variety of reasons, including lack of availability, disclosed COIs, or lack of the precise technical expertise required. Information about the candidate panel members, including brief biographical information, highest level of education attained, and years of experience, was

[1] One candidate was selected for a dual role in economics and planning.

provided to USACE for feedback. Battelle made the final selection of panel members according to the selection criteria described in the Work Plan.

The candidates were screened for the following potential exclusion criteria or COIs.[2] These COI questions were intended to serve as a means of disclosure and to better characterize a candidate's employment history and background. Providing a positive response to a COI screening question did not automatically preclude a candidate from serving on the Panel. For example, participation in previous USACE technical peer review committees and other technical review panel experience was included as a COI screening question. A positive response to this question could be considered a benefit.

- Involvement by you or your firm[3] in the Dam Safety Modification Report on Remediation of Isabella Lake Dam, CA, or any of the following documents in support of the Isabella Lake Dam project:
    - Baseline Risk Assessment Report
    - Baseline Risk Technical Appendices
    - Hydrology Report
    - Dam Safety Modification Report and EIS
    - Dam Safety Modification Report Appendices
    - MCACES and Risk Based Cost Estimate
    - Final Draft Environmental Impact Statement
    - Real Estate Design Memorandum
    - Real Estate Relocation Plan
    - Project Partnership Agreement
    - PED Project Management Plan.
- Involvement by you or your firm[3] in projects related to dam safety assurance, flood control, seismic, irrigation water storage, recreation, or hydroelectric power generation in Kern County CA.
- Involvement by you or your firm[3] in projects related to the Dam Safety Modification Report on Remediation of Isabella Lake Dam, CA.
- Current employment by the U.S. Army Corps of Engineers (USACE).
- Involvement in paid or unpaid expert testimony related to the Dam Safety Modification Report on Remediation of Isabella Lake Dam, CA.
- Current or previous employment or affiliation (for pay or pro bono) with members of the cooperating agencies or local sponsors, including:

[2] Battelle evaluated whether scientists in universities and consulting firms that are receiving USACE-funding have sufficient independence from USACE to be appropriate peer reviewers. See OMB (2004, p. 18), "….when a scientist is awarded a government research grant through an investigator-initiated, peer-reviewed competition, there generally should be no question as to that scientist's ability to offer independent scientific advice to the agency on other projects. This contrasts, for example, to a situation in which a scientist has a consulting or contractual arrangement with the agency or office sponsoring a peer review. Likewise, when the agency and a researcher work together (e.g., through a cooperative agreement) to design or implement a study, there is less independence from the agency. Furthermore, if a scientist has repeatedly served as a reviewer for the same agency, some may question whether that scientist is sufficiently independent from the agency to be employed as a peer reviewer on agency-sponsored projects."

[3] Includes any joint ventures in which your firm is involved and if your firm serves as a prime or as a subcontractor to a prime. Please clarify which relationship exists.

  - U.S. Department of Agriculture—Forest Service (USFS)
  - U.S. Bureau of Land Management (BLM)
  - State of California Division of Safety of Dams
  - California Department of Water Resources
  - Southern California Edison
  - Kern River Interest Irrigation Groups
  - Buena Vista Water Storage District
  - North Kern Water Storage District
  - Tulare Lake Basin Water Storage District
  - Hacienda Water District.
- Past, current, or future interests or involvements (financial or otherwise) by you, your spouse, or your children related to Lake Isabella CA or Kern County CA.
- Current personal involvement with other USACE projects, including involvement in authoring any manuals or guidance documents for USACE. If yes, provide titles of documents or description of project, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role. Please highlight and discuss in greater detail any projects that are specifically with the Sacramento District.
- Previous or current involvement in the development or testing of models that will be used for or in support of the Isabella Lake project
- Current firm[3] involvement with other USACE projects, specifically those projects/contracts that are with the Sacramento District. If yes, provide title/description, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role. Please also clearly delineate the percentage of work you personally are currently conducting for the Sacramento District. Please explain.
- Any previous employment by USACE as a direct employee or contractor (either as an individual or through your firm[3]) within the last 10 years, notably if those projects/contracts are with the Sacramento District. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
- Previous experience conducting technical peer reviews. If yes, please highlight and discuss any technical reviews concerning projects on dam safety assurance, flood control, seismic, irrigation water storage, recreation, or hydroelectric power generation, and include the client/agency and duration of review (approximate dates).
- Pending, current, or future financial interests in contracts/awards from USACE related to the Dam Safety Modification Report on Remediation of Isabella Lake Dam, CA.
- A significant portion (i.e., greater than 50%) of personal or firm[3] revenues within the last 3 years came from USACE contracts.
- Any publicly documented statement (including, for example, advocating for or discouraging against) related to the Dam Safety Modification Report on Remediation of Isabella Lake Dam, CA.
- Participation in prior Federal studies relevant to this project and/or the Dam Safety Modification Report on Remediation of Isabella Lake Dam, CA, including the documents listed in COI Statement #1 and:
  - Isabella Dam Safety Assurance Quality Control Plan
  - Approved Review Plan for Isabella Dam Safety Modification Study

  - SPRA Documentation Report for Isabella Dam
  - Isabella Major Rehabilitation Report.
- Participation in prior non-Federal studies relevant to this project and/or Dam Safety Modification Report on Remediation of Isabella Lake Dam, CA.
- Is there any past, present, or future activity, relationship, or interest (financial or otherwise) that could make it appear that you would be unable to provide unbiased services on this project? If so, please describe.

In selecting the final members of the Panel from the list of candidates, Battelle chose experts who best fit the expertise areas and had no COIs. The six final reviewers were either affiliated with consulting firms or were independent consultants. Battelle established subcontracts with the panel members when they indicated their willingness to participate and confirmed the absence of COIs through a signed COI form. USACE was given the list of candidate panel members, but Battelle made the final selections of the Panel. Section 4 of this report provides names and biographical information on the panel members.

Prior to beginning their review and within two days of their subcontracts being finalized, all members of the Panel attended a kick-off meeting via teleconference planned and facilitated by Battelle in order to review the IEPR process, the schedule, communication procedures, and other pertinent information for the Panel.

3.3 Preparation of the Charge and Conduct of the IEPR

Charge questions were provided by USACE and included in the draft and final Work Plans. In addition to a list of 46 charge questions/discussion points, the final charge included general guidance for the Panel on the conduct of the peer review (provided in Appendix B of this final report).

Battelle planned and facilitated a kick-off meeting via teleconference during which USACE presented project details to the Panel. Before the meeting, the IEPR Panel received an electronic version of the final charge as well as the Isabella Dam Safety IEPR review documents (Table 2) and supplemental documents (Table 3). In addition, throughout the review period, USACE provided additional documents at the request of panel members. These additional documents were provided to Battelle and then disseminated to the Panel as supplemental information only and were not part of the official review. A list of these additional documents requested by the Panel is provided in Table 4. These three tables are followed by a bulleted list of the USACE reference materials that were followed in conducting the Isabella Dam Safety IEPR.

In addition, an in-person meeting to discuss the Isabella Dam Safety project was held at the Isabella Dam Project Office near Kernville, California on July 10, 2012; four panel members attended this meeting. Immediately following this meeting, USACE led Battelle and the Panel on a visit of the Isabella Dam site. This tour provided an opportunity for the IEPR panel members to see the project area and proposed project features, and to ask clarifying questions of the project delivery team (PDT). A fifth panel member, who was unable to attend the site visit, attended a project briefing with a Battelle representative at the USACE Sacramento District Office on July 19, 2012 during which he could ask questions of the geotechnical, geological, and structural engineering counterparts at USACE.

Table 2. Review Documents for the Isabella Dam Safety IEPR.

Title	No. of Pages
Dam Safety Modification Report, Volume I (draft SOG Jun 2012)	207
Isabella Lake Main & Auxiliary Dams DSMR Main Report (Dam Safety Modification Report) Appendices	2159
Screening Portfolio Risk Analysis with DSAC (Dec 2008)	8
Baseline Risk Assessment Report- Volume II (April 2012)	376
Final Hydrology Report (Jan 2012)	150
Gantt Chart (PED Details)	11
Cost Estimate (June 17, 2012)	15
Draft Environmental Impact Statement (DEIS), Volume I (June 2012)	657
Draft EIS: Volume II- Appendices	406
PED Project Management Plan (May 2012)	45
Real Estate Design Memorandum (June 18, 2012)	7
Real Estate Planning Report (December 30, 1947)	25
Relocation Assistance Plan (June 18, 2012)	7
Project Map- Exhibit A	1
Forest Service L and Transfer- Exhibit B	1
Preliminary Acquisition Map- Exhibit C	1
Tract Register- Exhibit D	1
Utility Map- Exhibit F	1
Risk Register (June 12, 2012)	1
Life Safety Construction Schedule	3
Project Management Plan (May 2012)	75

Table 3. Supplemental Documents for the Isabella Dam Safety IEPR.

Title	No. of Pages
Ref 1: Isabella Dam Safety Modification Study Review Plan (April 10, 2012)	30
Ref 5: Water Agreement	103
Ref 8: Spillway Adequacy Study (2003)	97
Ref 9: Isabella Dam Reservoir Regulation Manual (1978)	108
Ref 10: Preliminary Environmental Baseline Report (2009)	151
Ref 20: Figures-- Geophysical Survey	4 sheet plans
Ref 20: USGS Geophysical Survey (March 2010)	89

Table 3. Supplemental Documents for the Isabella Dam Safety IEPR, continued.

Title	No. of Pages
Ref 22: Definite Project Report- Dam and Appurtances, Basis of Design (1948)	41
Ref 23: Technical Memorandum- Seismic Evaluation of Main Dam Outlet Works Structures (March 2011)	1624
Ref 24: Updated Seismic Performance Evaluation of Main Dam Tunnel and Borel Conduit, Considering the Effects of Seismic Waves (February 2011)	648
Ref 25: Technical Memorandum- Seismic Evaluation of Auxiliary Dam Outlet Works Structures (April 2011)	457
Ref 29: Deterministic & Probabilistic Seismic Hazard Analysis (January 2005)	201
Ref 30: Supplemental Report- Main Dam Seepage Evaluation & Seismic Deformation Analysis (April 2011)	59
Ref 31: Isabella Dam Hydroelectric Project- Construction Drawings (1988)	120 sheet plans
Ref 32: Draft Technical Memorandum- Seismic Evaluation of Auxiliary Dam Downstream Borel Outlet Works Structures (June 2011)	260
Ref 54: Seepage and Stability Evaluation (November 2007)	758
Ref 55: Borel Canal Seepage Investigation Report of Activities and Findings Isabella Auxiliary Dam (2009)	187
Ref 56: Isabella Main Dam Site Characterization, Seepage Evaluation and Seismic Deformation Analysis (October 2009)	877

Table 4. Additional Documents Provided by USACE during the Isabella Dam Safety IEPR.

Title	No. of Pages
Dynamic Modeling Procedures Document: Success Dam Seismic Remediation Project, Tule River California. Version 1 (December 18, 2009)	149
Isabella Dam, California Hydraulic Structures Report for DSMR, Appendix E (file name: Reference_22_HydraulicStructures_Rev002.pdf)	97
Dam Safety Modification Report, Volume I (post-SOG Jun 2012 with highlighted areas that were revised/added) (file name: Isabella DSMR_Draft_26July2012.pdf)	208
Draft Economic Appendix (file name: Isabella Econ Appendix.pdf)	282
Engineer Technical Letter ETL 1110-2-XXX 30 September 2010 Frequency Curve Extension for Extreme Flood Events (file name: FrequencyCurveExtForExtremeFloodEvents2010-09.pdf)	106
Supplemental Potential Failure Mode Analysis January 2010 (pfm_analysis.pdf)	98
Figure supporting response to question 8.docx	1
Isabella Dam Safety Modification Study Flood Modeling Report DRAFT (May 2012) (reference_18_isb_flood_modeling_report.pdf)	162

Table 4. Additional Documents Provided by USACE during the Isabella Dam Safety IEPR, continued.

Title	No. of Pages
Isabella Auxiliary Dam Preliminary Seismic Deformation Analysis of Remediated Sections (Section A) (file name: reference_26_embankment_stability_and_deformation.pdf)	210
Dynamic Modeling Procedures Document Success Dam Seismic Remediation Project Tule River, California Version 1 (December 18, 2009) (file name: ModelingProceduresDocumen_Ver1_2009-12-18.pdf)	149
Isabella Dam Cost Assumptions(file name: reference_21_cost_june2012.pdf)	263
Project Management Plan, Isabella Dam (file name: reference_35_isabellapmp.pdf)	61
Appendix C Core Photographs	72
Appendix D Soil Profile Descriptions	40
Appendix E Radiocarbon Reports	170
Appendix F Microscopic Analysis of Shear Fabric	15
Appendix G Technical Reviewer Letters	22
Characterization of site geology (file name: plates.pdf)	13

Reference Documents Adhered to During the Isabella Dam Safety IEPR

- **General**
  - EC 1105-2-410, Review of Decision Documents, 22 August 2008
  - EC 1105-2-412, Assuring Quality of Planning Models, 31 March 2011
  - EC 1165-2-209, Water Resources Policies and Authorities - Civil Works Review Policy, Change 1, 31 January 2012
  - EC 1165-2-210, Water Resources Policies and Authorities - Water Supply Storage and Risk Reduction Measures for Dams, 9 April 2010
  - EP 1110-2-13, Dam Safety Preparedness, 28 June 1996
  - ER 1110-1-12, Engineering and Design - Quality Management, 31 March 2011 (change 2)
  - ER 1110-2-1150, Engineering and Design - Engineering and Design for Civil Works Projects, 31 August 1999
  - ER 1110-2-1155, Engineering and Design - Dam Safety Assurance Program, 12 September 1997
  - ER 1110-2-1156, Engineering and Design - Safety of Dams - Policy and Procedures, 28 October 2011
  - ER 1110-1-8159, Engineering and Design - DrChecks, 10 May 2001
  - Water Resources Development Act of 2007, Sections 2034 & 2035, Pub. L. 110-114. Privacy Act, 5 U.S.C. § 522a as amended

- **Environmental/Planning**
  - ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies. CECW-P, 28 December 1990
  - Council on Environmental Quality. 1978. Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act. 40 CFR Parts 1500-1508. Washington, DC: U.S. Government Printing Office (November 29, 1978).
  - ER 200-2-2, Environmental Quality, Procedures for Implementing NEPA. CECWRE (now CECW-A), 4 March 1988.
- **Engineering Geology**
  - EM 1110-1-1804, Engineering and Design - Geotechnical Investigations, 01 January 2001
  - ER 1110-1-1807, Engineering and Design - Procedures for Drilling in Earth Embankments, 01 March 2006
  - EM 1110-1-2908, Engineering and Design - Rock Foundations, 30 November 1994
  - EM 1110-2-2901, Engineering and Design - Tunnels and Shafts in Rock, 30 May 1997
  - EM 1110-1-1802, Geophysical Exploration for Engineering and Environmental Investigations, 31 August 1995
  - ER 1110-2-1806, Engineering and Design - Earthquake Design and Evaluation for Civil Works Projects, 31 July 1995
- **Geotechnical Engineering**
  - EM 1110-2-1901, Engineering and Design - Seepage Analysis and Control for Dams, 30 April 1993
  - EM 1110-2-1902, Engineering and Design - Slope Stability, 31 October 2003
  - EM 1110-2-2300, Engineering and Design - General Design and Construction Considerations For Earth and Rock-Fill Dams, 30 July 2004
  - EM 1110-2-1908, Engineering and Design - Instrumentation of Embankment Dams and Levees, 30 June 1995
  - ER 1110-2-103, Engineering and Design - Strong-Motion Instruments for Recording Earthquake Motions on Dams, 10 December 1981
  - ER 1110-2-110, Engineering and Design - Instrumentation for Safety Evaluations of Civil Works Projects, 8 July 1985
- **Materials Engineering**
  - ER 1110-1-1901, Project Geotechnical and Concrete Materials Completion Report for Major USACE Project, 22 February 1999
  - EM 1110-2-1906, Laboratory Soils Testing, 20 August 1986
  - EM 1110-2-2301, Test Quarries and Test Fills, 30 September 1994
  - ER 1110-2-1911, Engineering and Design - Construction Control for Earth and Rock-Fill Dams, 30 September 1995
- **Structural Engineering**
  - EM 1110-2-2100, Engineering and Design – Stability Analysis of Concrete Structures, 01 December 2005
  - EM 1110-2-2400, Engineering and Design - Structural Design and Evaluation of Outlet Works, 02 June 2003

  - ER 1110-2-100, Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures, 15 February 1995

- **Hydraulic Engineering**
  - EM 1110-2-1602, Engineering and Design - Hydraulic Design of Reservoir Outlet Works, 15 October 1980
  - EM 1110-2-1603, Engineering and Design - Hydraulic Design of Spillways, 16 January 1990
  - EM 1110-2-2902, Engineering and Design - Conduits, Culverts, and Pipes, 31 March 1998
  - EM 1110-2-3600, Engineering and Design - Management of Water Control Systems, 30 November 1987
  - ER 1110-8-2 (FR), Inflow Design Floods for Dams and Reservoirs, 1 March 1991
  - ER 1110-2-240, Water Control Management, 8 October 1998
  - ER 1130-2-530, Flood Control Operations and Maintenance Policies, 30 October 1996
  - ER 1110-2-8156, Preparation of Water Control Manuals, 31 August 1995

About three-quarters of the way through the review of the Isabella Dam Safety review documents, and one week after the SOG meeting, a teleconference was held with USACE, the Panel, and Battelle so that USACE could answer any questions the Panel had concerning either the review documents or the project. Prior to this teleconference, Battelle submitted 41 panel member questions to USACE. USACE was able to provide responses to some of the questions during the teleconference; the remaining panel member questions that required additional coordination within USACE were addressed by USACE by August 1, 2012.

3.4 Review of Individual Comments

The Panel was instructed to address the charge questions/discussion points within a comment-response form provided by Battelle. At the end of the review period, the Panel produced approximately 250 individual comments in response to the charge questions/discussion points. Battelle reviewed the comments to identify recurring themes, areas of potential conflict, and other overall impressions. As a result of the review, Battelle summarized the 250 comments into a preliminary list of 39 overall comments and discussion points. Each panel member's individual comments were shared with the full Panel in a merged individual comments table.

3.5 IEPR Panel Teleconference

Battelle facilitated a 4-hour teleconference with the Panel so that the panel members, many of whom are from diverse scientific backgrounds, could exchange technical information. The main goal of the teleconference was to identify which issues should be carried forward as Final Panel Comments in the Final IEPR Report and decide which panel member would serve as the lead author for the development of each Final Panel Comment. This information exchange ensured that the Final IEPR Report would accurately represent the Panel's assessment of the project, including any conflicting opinions. The Panel engaged in a thorough discussion of the overall positive and negative comments, added any missing issues of high-level importance to the findings, and merged any related individual comments. In addition, Battelle confirmed each Final Panel Comment's level of significance to the Panel.

The Panel also discussed responses to six specific charge questions where there appeared to be disagreement among panel members. The conflicting comments were resolved based on the professional judgment of the Panel, and all sets of comments were determined not to be conflicting. Each comment was either incorporated into a Final Panel Comment, determined to be consistent with other Final Panel Comments already developed, or determined to be a non-significant issue.

At the end of these discussions, the Panel identified 28 comments and discussion points that should be brought forward as Final Panel Comments.

3.6 Preparation of Final Panel Comments

Following the teleconference, Battelle prepared a summary memorandum for the Panel documenting each Final Panel Comment (organized by level of significance). The memorandum provided the following detailed guidance on the approach and format to be used to develop the Final Panel Comments for the Isabella Dam Safety IEPR:

- Lead Responsibility: For each Final Panel Comment, one Panel member was identified as the lead author responsible for coordinating the development of the Final Panel Comment and submitting it to Battelle. Battelle modified lead assignments at the direction of the Panel. To assist each lead in the development of the Final Panel Comments, Battelle distributed the merged individual comments table, a summary detailing each draft final comment statement, an example Final Panel Comment following the four-part structure described below, and templates for the preparation of each Final Panel Comment.
- Directive to the Lead: Each lead was encouraged to communicate directly with other IEPR panel members as needed and to contribute to a particular Final Panel Comment. If a significant comment was identified that was not covered by one of the original Final Panel Comments, the appropriate lead was instructed to draft a new Final Panel Comment.
- Format for Final Panel Comments: Each Final Panel Comment was presented as part of a four-part structure:
    1. Comment Statement (succinct summary statement of concern)
    2. Basis for Comment (details regarding the concern)
    3. Significance (high, medium, low; see description below)
    4. Recommendation(s) for Resolution (see description below).
- Criteria for Significance: The following were used as criteria for assigning a significance level to each Final Panel Comment:
    1. High: Describes a fundamental problem with the project that could affect the recommendation, success, or justification of the project. Comments rated as high indicate that the Panel analyzed or assessed the methods, models, and/or analyses and determined that there is a “showstopper” issue.
    2. Medium: Affects the completeness of the report in describing the project, but will not affect the recommendation or justification of the project. Comments rated as medium indicate that the Panel does not have sufficient information to analyze or assess the methods, models, or analyses.
    3. Low: Affects the understanding or accuracy of the project as described in the report, but will not affect the recommendation or justification of the project. Comments

rated as low indicate that the Panel identified information (tables, figures, equations, discussions) that was mislabeled or incorrect or data or report sections that were not clearly described or presented.

- Guidance for Developing Recommendations: The recommendation section was to include specific actions that USACE should consider to resolve the Final Panel Comment (e.g., suggestions on how and where to incorporate data into the analysis, how and where to address insufficiencies, areas where additional documentation is needed).

An additional Final Panel Comment was submitted for consideration after the panel review teleconference, bringing the total from 28 to 29 Final Panel Comments. However, during the Final Panel Comment development process, the Panel felt that one of the Final Panel Comments no longer met the criteria for a high, medium, or low level significance; therefore, the total Final Panel Comment count was reduced back to 28. Battelle reviewed and edited the Final Panel Comments for clarity, consistency with the comment statement, and adherence to guidance on the Panel's overall charge, which included ensuring that there were no comments regarding either the appropriateness of the selected alternative or USACE policy. There was no direct communication between the Panel and USACE during the preparation of the Final Panel Comments. The Final Panel Comments are presented in Appendix A of this report.

4. PANEL DESCRIPTION

Candidates for the Panel were identified using Battelle's Peer Reviewer Database, targeted Internet searches using key words (e.g., technical area, geographic region), searches of websites of universities or other compiled expert sites, and referrals. Battelle prepared a draft list of primary candidate panel members (who were screened for availability, technical background, and COIs), and provided it to USACE for feedback. Battelle made the final selection of panel members.

An overview of the credentials of the final six primary members of the Panel and their qualifications in relation to the technical evaluation criteria is presented in Table 5. More detailed biographical information regarding each panel member and his area of technical expertise is presented below.

Table 5. Isabella Dam Safety IEPR Panel: Technical Criteria and Areas of Expertise.

Technical Criterion	Rudolph	Shakoor	Powell	Baril	Luckie	Young
Geotechnical Engineering (one expert needed)						
Minimum 20 years' experience in embankment dam design and evaluation	X					
Minimum 20 years' experience in geotechnical seismic design	X					
Experience in subsurface investigations	X					

Table 5. Isabella Dam Safety IEPR Panel: Technical Criteria and Areas of Expertise, continued.

Technical Criterion	Rudolph	Shakoor	Powell	Baril	Luckie	Young
Experience in soil mechanics	X					
Experience in seepage and piping	X					
Experience in slope stability evaluations	X					
Experience in liquefaction analyses	X					
Experience in analyses of earthquake-induced embankment/structural deformation	X					
Experience in dewatering and excavation in active stream channels	X					
Experience in soil compaction	X					
Experience in earthwork construction	X					
Experience in design and construction of foundations on alluvial soils	X					
Experience in retaining wall design	X					
Experience in erosion protection design	X					
Experience in levee and stream bank protection incl. sheet piling	X					
Experience in soil cement	X					
Experience in grouted riprap and stone protection	X					
Experience preparing plans and specifications for USACE projects	X					
Knowledge of USACE design and construction procedures and policies	X					
Minimum 10 years' experience in piping and seepage failure mode analysis	X					
Minimum 10 years' experience in risk analysis of embankment dams	X					
Familiarity with USACE dam safety assurance policy and guidance	X					
Competency in seismic modeling with FLAC v6	X					
Experience with DAMRAE (USACE risk analysis software)	X					
Ph.D in geotechnical engineering						
M.S. in geotechnical engineering PLUS professional registration as a geotechnical engineer	X					
Engineering Geology (one expert needed)						
Minimum 20 years' experience in engineering geology		X				
Experience in geomorphology		X				
Experience in geologic hazards		X				
Experience in exploration techniques		X				

Table 5. Isabella Dam Safety IEPR Panel: Technical Criteria and Areas of Expertise, continued.

Technical Criterion	Rudolph	Shakoor	Powell	Baril	Luckie	Young
Experience in instrumentation		X				
Experience in field and laboratory testing		X				
Experience in material properties		X				
Experience in assessing seepage and piping through and beneath dams constructed on or within various geologic environments		X				
Experience in subsurface flow		X				
Experience in foundation grouting		X				
Experience in landslides and slope stability		X				
Experience in soil and rock mechanics		X				
Experience in tunneling		X				
Experience in drilling and blasting		X				
Minimum 10 years' experience in piping seepage failure mode analysis		X				
Minimum 10 years' experience in risk analysis of embankment dams		X				
Familiarity with USACE dam safety assurance policy and guidance		X				
Competency in seismic modeling with FLAC v6		X				
Ph.D. in geology		X				
Civil/Structural Engineering (one expert needed)						
Minimum 10-15 years' experience in static and seismic design per industry code standards and USACE projects			X			
Minimum 10-15 years' experience in dynamic site-specific response spectra analysis and evaluation			X			
Minimum 10-15 years' experience in soil-structure interaction evaluation and design			X			
Demonstrated knowledge in site layout			X			
Demonstrated knowledge in surveying			X			
Demonstrated knowledge in 3-dimensional modeling			X			
Demonstrated knowledge in construction techniques			X			
Demonstrated knowledge in grading			X			
Demonstrated knowledge in hydraulic structures			X			
Demonstrated knowledge in erosion control			X			
Demonstrated knowledge in interior drainage			X			

Table 5. Isabella Dam Safety IEPR Panel: Technical Criteria and Areas of Expertise, continued.

Technical Criterion	Rudolph	Shakoor	Powell	Baril	Luckie	Young
Demonstrated knowledge in earthwork			X			
Demonstrated knowledge in concrete placement			X			
Demonstrated knowledge in design of access roads			X			
Demonstrated knowledge in retaining walls design			X			
Demonstrated knowledge in relocation of underground utilities			X			
Practical knowledge of construction methods and techniques as they relate to structural portions of projects			X			
Ph.D in engineering science			[4]			
M.S. in engineering science PLUS professional registration as a Civil Engineer or Structural Engineer			[4]			
Hydraulic/Hydrologic Engineering (one expert needed)						
Minimum 10-15 years' experience in analysis and design of outlet works and spillways for embankment dams				X		
Minimum 5-10 years' experience in physical and numerical modeling				X		
Familiarity with USACE standard hydrologic and hydraulic computer models				X		
Familiar with USACE application of risk and uncertainty analysis in flood damage reduction studies				X		
Minimum M.S. in engineering or engineering science				X		
Registered Professional Engineer				X		
Economics (one expert needed)						
Minimum 10 years' experience directly related to water resource economic evaluation or review					X	
Minimum 5 years' directly working for or with USACE					X	
Minimum 5 years' experience directly dealing with HEC-FDA					X	
Minimum 2 years' experience reviewing Federal water resource economic documents justifying construction efforts					X	
Minimum B.S. degree in economics					X	

[4] Battelle proposed Mr. Rex Powell as the civil/structural engineer for this IEPR. Mr. Powell does not possess an M.S. or Ph.D. degree; he has a B.S. in civil engineering and is a registered professional engineer with more than 31 years of experience in civil and structural engineering (especially in the areas of tunneling, outlet works, and seismic evaluation). Battelle believes his experience is commensurate with a higher degree.

Table 5. Isabella Dam Safety IEPR Panel: Technical Criteria and Areas of Expertise, continued.

Technical Criterion	Rudolph	Shakoor	Powell	Baril	Luckie	Young
NEPA Impact Assessment (one expert needed)						
Minimum 10 years' demonstrated experience evaluating and conducting NEPA impact assessments, including cumulative effects analyses, for complex multi-objective public works projects with competing trade-offs						X
Experience in determining the scope and appropriate methodologies for impact assessment and analyses for a variety of projects and programs with high public and interagency interests and having project impacts to nearby sensitive habitats.						X
Minimum M.S. degree in an appropriate field of study						[5]
Plan Formulation (one expert needed)						
Minimum 15-20 years' experience in planning					X	
Experience working with project teams to identify and evaluate measures and alternatives using appropriate planning methodologies to reduce life safety risk					X	
Extensive experience reviewing the analysis with which the measures and alternatives were evaluated and that they are sufficiently comprehensive and complete to result in approval of a recommended alternative					X	
Direct experience working for or with USACE					X	
Familiarity with USACE plan formulation process, procedures, and standards					X	
Familiarity with USACE hurricane and coastal storm damage risk reduction projects					X	
Minimum 5 years experience directly dealing with the USACE six-step planning process, which is governed by ER 1105-2-100, Planning Guidance Notebook					X	
Experience identifying and evaluating impacts to environmental resources from structural flood risk management and hurricane and coastal storm damage risk reduction projects					X	

[5] Battelle proposed Mr. Dave Young as the NEPA impact assessment expert for this IEPR. Mr. Young does not possess an M.S. degree; he has a B.Sc. in marine biology. Battelle believes that his 18 years of experience, in addition to his experience with NEPA-related dam reviews, is commensurate with a higher degree.

Bill Rudolph, P.E., G.E.

Role: Geotechnical engineering experience and expertise
Affiliation: Independent Consultant

Bill Rudolph, P.E., G.E., an independent geotechnical engineering consultant, has served as principal engineer and project manager on a wide variety of geotechnical projects throughout California and the West for more than 30 years. He earned his M.S. in civil/geotechnical engineering in 1978 from the University of California at Berkeley and is a registered civil engineer and geotechnical engineer in California. Mr. Rudolph specializes in flood control, earth fill dams and levees, and water resources projects. He is a geotechnical earthquake engineering expert with experience reviewing ground motions studies, liquefaction analyses, and seismic deformation analyses. As the Principal Consultant for the earth fill water supply reservoirs in California, he consulted on site selection, geologic and seismic assessment, and design alternatives, and provided recommendations for spillway design and modification and seepage cutoffs.

His experience in piping and seepage failure mode analysis includes his involvement in the IEPR panel for the East St. Louis Flood Protection Project, which involved geotechnical engineering analysis of under-seepage and through-seepage, as well as seepage mitigation alternatives; review of historic embankment seepage and piping problems; and review of geotechnical models, including the application of the blanket theory approach to under-seepage analysis and relief well design, and finite element seepage analyses (Seep/W). He also participated in the American River Common Features Project IEPR, for which he reviewed the geotechnical risk and reliability analysis of the embankments, including seepage, stability, and erosion analyses. He is familiar with the Sacramento District's Dam Safety Assurance Program, particularly with regard to seismic analysis, design, and remediation.

Mr. Rudolph's experience in reviewing geotechnical models includes (1) the Hamilton Wetlands Restoration Plan project levees (Novato, California), for which he used a variety of slope stability methods (including Spencer's Method) and interpreted computer outputs for Slope/W, UTEXAS4, and other slope stability programs, and (2) the Galbraith Upland Dredge Material Disposal Facility Port project (Oakland, California), for which he performed slope stability analyses for levee embankments on soft soils using UTEXAS4 and Slope/W. He has also participated in and reviewed advanced analytical models for static and seismic embankment deformation analysis using FLAC and recently completed a training course given by PLAXIS. Mr. Rudolph is also quite familiar with the DAMRAE software and the fundamentals of event tree analysis for dam safety risk.

Abdul Shakoor, Ph.D., P.G.

Role: Engineering geology experience and expertise.
Affiliation: Kent State University / Independent Consultant

Abdul Shakoor, Ph.D., P.G. earned his highest degree in engineering geology in 1982 from Purdue University. He is currently a professor of engineering geology and a member of the

Water Resources Research Institute at Kent State University and has 45 years of experience in engineering geology. He is a certified professional geologist with the American Institute of Professional Geologists and a registered professional geologist with the state of Pennsylvania.

Dr. Shakoor has more than 30 years of experience examining landslides and geomorphology, having published nearly 30 landslide-related papers and being currently involved in developing a computer model for landslide identification using LiDAR data. He has expertise in evaluating geologic hazards relating to slope instability, mine subsidence, and swelling of clay soils and mudrocks and has served as an expert witness in court cases involving slope movements. Dr. Shakoor teaches exploration techniques in detail including field observations, measurements, geophysical methods, and mapping as well as subsurface exploration. His slope stability studies have used instrumentation data from slope inclinometers, TDR cables, and vibrating wire piezometers. He has vast experience with field testing such as SPT, Schmidt hammer, point load tester, pocket penetrometer, Torvane, and slug tests. He also has well equipped labs in both soil mechanics and rock mechanics. Dr. Shakoor regularly teaches about seepage and piping problems under the topic of stability analysis for dams, including computing seepage quantities using flow nets, determining uplift pressure using flow nets and piezometric data, and evaluating piping potential through and beneath embankment dams. He has also been involved in assessing seepage and piping problems (which involves a thorough understanding of subsurface flow as well as piping and seepage failure mode analysis) at several dams: Mangla Dam (Pakistan); Chagrin River Dam (Ohio); Clearwater Dam (Missouri); Wolf Creek Dam (Kentucky); and Bolivar Dam (Ohio). He discusses foundation grouting (cement grouting and chemical grouting) in his introduction to engineering geology and advanced engineering geology courses. His research at the Clearwater Dam exposed him to state-of-the-art grouting operations and, as a member of other IEPR teams, he has been involved in review of grouting operations both for foundations and anchor installation.

Dr. Shakoor's experience with tunneling includes his work on the Mangla Dam project, where he was in charge of mapping the geology of hydraulic tunnels before placement of the support system. He has seen the excavation and support system design for hydraulic tunnels (> 40 ft diameter) at Tarbella Dam (a zoned earth and rockfill dam), Pakistan, excavation and support design for the sewer tunnels for the cities of Chicago and Cleveland, and a tunnel in difficult ground under construction in Greece. He teaches tunneling in his advanced engineering geology course where he discusses excavation methods and support system for tunnels in both soft and hard ground.

Dr. Shakoor is very familiar with drilling and blasting operations for cut slope design and underground excavation and with controlled blasting and damage criteria. He has served as an expert witness in cases involving damage to residential structures caused by blasting operations at nearby quarries or surface mining activities and drilling and blasting were important aspects of his research study on developing design criteria for cut slopes in OH. He is also familiar with the risk analysis for embankment dams under varying loading and seepage conditions. Through his participation on other IEPR panels, he is familiar with the USACE dam safety assurance policy and guidance and he is familiar with the FLAC v6 model.

Rex Powell, P.E.

Role: Civil/structural engineering experience and expertise.
Affiliation: Bergmann Associates

Rex Powell, P.E. is a Senior Discipline Specialist, Structural at Bergmann Associates and has 30 years of experience in design and analysis of structures as well as mechanical, geotechnical, and hydraulics design. He earned a B.S. in civil engineering from Rensselaer Polytecnic Institute in 1981 and is a registered professional engineer in New York. Mr. Powell has been responsible for the design of all structural aspects of hydropower plants and dams, and structural designs for industrial plants and transportation projects. He is experienced in the design of concrete gravity dams and structures, including prestressed and post-tensioned elements, structural steel, timber, masonry, and cofferdam design. He has been the Independent Consultant on several FERC Part 12 dam safety inspections, as well as a number of state-regulated dam safety inspections, and was a member of the IEPR team for the Herbert Hoover Dike Culvert Replacement project.

Some of Mr. Powell's most recent work has included repair and rehabilitation of existing locks and dams and other concrete and steel hydraulic structures. He designed a new reinforced concrete liner for the Station 5 power tunnel (Genesee River, New York) for Rochester Gas & Electric. The tunnel was 16 ft wide horseshoe-shaped with roughly horizontal alignment, transitioning to a 20-ft diameter intake shaft. A “per foot” analysis of the main tunnel liner was conducted using a single row of shell elements and compression-only external springs to simulate support from the surrounding bedrock. The liner was subjected to full external hydrostatic head under dewatered conditions. A much larger 3D model was developed to design the transition elbow and determine the minimum practicable liner thickness. Another project involving tunneling included the Canyon del Pato hydroelectric expansion project, Rio Santa, Peru. There Mr. Powell designed a complementary intake structure that joined to the existing intake tunnel upstream of the common underground desander. Improvements also included enlargement of the existing rock sluice and discharge tunnel. He was also part of the team that performed the field inspection of the surface and underground features and coordinated the structural evaluation of the existing works. He has been involved in the design, evaluation, study, and review of numerous dams and hydroelectric projects with heads varying from a few feet up to 1,000 ft and including many different foundation conditions, from clays to hard rock.

Mr. Powell’s seismic experience includes a seismic evaluation of the High Falls Surge Tank for which he and his team performed a modal analysis to determine the fundamental vibration frequencies and calculated the lateral force coefficient accordingly. Lateral forces were distributed spatially according to National Earthquake Hazards Reduction Program (NEHRP) guidelines and other relevant standards and applied using a linear finite element analysis of the structure to evaluate its response and ultimately whether it was structurally satisfactory. Other relatively recent seismic/dynamic analyses include the vibration analyses of turbine/generator foundations at the Eshkol and Alon Tabor power stations in Israel and the Tait and Darby power plants in Ohio. Mr. Powell’s work on the Lock E-10 Overflow Spillway Replacement included designing reinforced concrete aprons and mitigating for future erosion. He was also responsible for detail design, drawing production, specifications, and construction for a dam on the Mohawk River (New York), which included retaining wall design.

Peter Baril, P.E.

Role: Hydraulic and hydrologic engineering experience and expertise.
Affiliation: GZA GeoEnvironmental, Inc.

Peter Baril, P.E. is a principal and hydrologic engineer with GZA GeoEnvironmental, Inc. in Norwood, Massachusetts, and a registered professional engineer in the states of Massachusetts, Maine, Connecticut, and New Hampshire. He earned his M.S. in hydrology in 1980 from University of New Hampshire, and has more than 30 years' experience in the fields of dam and water resources engineering and specializes in urban hydrology, flood control analysis and design, and surface water hydrology and open channel hydraulics. Much of his project experience is focused in the areas of dam safety inspections, emergency action planning and design/improvement of spillways and related hydraulic structures.

Mr. Baril was the Principal-in-Charge of Dam Safety Repairs at West Hartford, Connecticut Reservoir Dam No. 2 and was involved in designing the repairs and submitting permit applications. Design modifications were intended to address embankment seepage and slope stability issues, as well as provide sufficient spillway capacity to pass the Spillway Design Flood and upgrade outlets works to eliminate the original (100-year old) charged pipes through the embankment. Design repairs included regrading of downstream face including installation of toe drains for improved stability and seepage control; repairs to low level outlets to provide gate control on upstream side of dam; addition of an auxiliary spillway to provide sufficient capacity and minimum freeboard under the design flood (full PMF [Probable Maximum Flood]), and breaching of a division dike to allow water to flow from the larger main basin to the new auxiliary spillway.

He was the Principal-in-Charge of the hydrologic review of the spillway capacity for USACE's Knightville Dam, a 160- foot high, 1,200 foot long earthen flood control structure in western Massachusetts. Mr. Baril and his team reassessed the spillway design flood hydrograph for the 162-square mile water shed and estimated the magnitude of "Threshold Flood." As part of the work, his firm evaluated various structural modifications to the spillway to pass the design flood (PMF), review outlet works operation, and conduct dam break routing simulations for USACE New England District.

Mr. Baril is well versed in hydrologic processes including the use of the latest state-of-the-practice computer applications including rainfall/runoff models such as HEC-HMS, TR-20, and HMR-52, as well as hydraulic modeling of riverine systems using HEC-RAS and the National Weather Service dam break simulation program (DAMBRK).

David Luckie

Role: Economic and plan formulation experience and expertise – *dual role.*
Affiliation: CivilTech Engineering, Inc.

David Luckie is the Principal Economist at CivilTech Engineering, Inc., and has more than 20 years of professional experience in economics, planning, plan formulation, benefit-cost analysis, and risk-based analysis. He earned his B.S. in economics from the University of South Alabama

in 1986. His professional experience includes Federal feasibility studies, flood risk management studies, flood damage reduction studies, ecosystem restoration projects, shallow and deep-draft navigation studies, beach and shoreline protection projects, water supply studies, and recreation studies. His technical capabilities include such applications as Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) "Flood Damage Analysis" package, municipal water demand modeling using USACE's Institute for Water Resources (IWR)-Main, and many other IWR products.

Mr. Luckie worked for USACE Mobile District for 17 years. During that time, he either led or worked on numerous multi-disciplinary teams to produce complex water resource studies and was involved in numerous high-profile Civil Works projects, including the Village Creek Watershed Study (Birmingham, Alabama) for which he provided economic analyses and plan formulation services. Mr. Luckie assisted in developing the without project condition and subsequently provided economic analyses and plan formulation expertise to develop alternative plans with multiple high-priority outputs. The study included extensive use of HEC-FDA and careful coordination with the study team's hydrology and hydraulic engineers.

Mr. Luckie is intimately familiar with the USACE Six-Step Planning Process governed by ER 1105-2-100, Planning Guidance Notebook and his experience includes close coordination with multi-disciplinary teams to identify, formulate, and evaluate alternatives using the six-step planning process.

Dave Young

Role: NEPA impact assessment experience and expertise.
Affiliation: Dixie Environmental Services Co., L.P.

Dave Young is a project manager and senior environmental planner at Dixie Environmental Services Co., L.P. He earned his B.S. in marine biology from Texas A&M University at Galveston in 1993. He has 18 years of experience in wetland delineation, environmental assessments (EAs), water quality, and NEPA, and has been directly involved in water resource evaluation and NEPA assessments for more than 10 years. Throughout his career, he has been tasked with performing cumulative effects analyses for multi-objective public works projects, which include dam safety, flood control, navigation channel improvement projects, transportation, linear (utility), seismic exploration (geophysical exploration) on Federal lands, and oil and gas prospect development on Federal lands.

He recently completed an EA/FONSI for a proposed 3D seismic survey project at the Big Thicket National Preserve, which involved extensive coordination with the Preserve and included cumulative effects analysis for seismic exploration and oil and gas field development over a 80+ square mile area. Pre-plot surveys were conducted to provide avoidance measures to seismic drilling activities and documentation on an assessment for vegetation communities within the project area was performed using spatial and statistical analyses that was coordinated with the NPS. Impacts on sensitive habitats were assessed and included freshwater marsh, freshwater cypress/tupelo swamp, and brackish marshes within the project area. Coordination was performed, including scoping, with various Federal, state, local, and non-governmental stakeholders.

Mr. Young has been directly involved in water resource environmental evaluation or review and NEPA for more than 10 years, having prepared numerous NEPA documents for public and private clients, including USACE. His experience is highlighted by managing, preparing, and/or providing support on numerous Programmatic Categorical Exclusions, Categorical Exclusions, EA/FONSIs, and Environmental Impact Statements. He has attended numerous training efforts on various aspects of NEPA, including Section 106 coordination, and state (Florida, Arizona, Texas) Department of Transportation processes related to NEPA compliance.

5. SUMMARY OF FINAL PANEL COMMENTS

The panel members agreed among one another on their "assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used" (USACE, 2012; p. D-4) in the Isabella Dam Safety review documents. Table 6 lists the Final Panel Comment statements by level of significance. The full text of the Final Panel Comments is presented in Appendix A of this report. The following statements summarize the Panel's findings.

The Dam Safety Modification Report (DSMR) and Baseline Risk Assessment Report (BRAR) provide a well thought out and thorough development and presentation of USACE's approach to risk assessment for the Isabella Lake dams and measures required to mitigate risk. From a planning standpoint, it is apparent that USACE explored a reasonable subset of alternatives, given budgetary and urgency issues. In general, the DSMR, BRAR, Draft Environmental Impact Statement (DEIS), Final Hydrology Report, and other technical appendices and supporting documents provide a great deal of information about the project. However, in many cases, key information is not provided, which prevents the Panel from fully and accurately assessing the project.

Plan Formulation – The Panel found the array of considered alternatives to be comprehensive; however, the review documents do not clearly demonstrate that USACE followed the Six Step Planning Process from the Principles and Guidelines and ER 1105-2-100. As such, the Panel is unable to determine whether there are sufficient analyses upon which to base a recommendation. Furthermore, if a future without project condition is not properly documented, the selection and justification of the tentative recommended plan can be affected and its expected risk reduction benefits could be questioned. Additional information is needed to specifically demonstrate that the Life Safety Plan (LSP) 4 and DSAC Plan 2 display costs and benefits of the elements that separate these two alternatives.

Engineering – The Panel found that, in general, the engineering analyses were extremely thorough and employed methods that are state-of-the practice, but not always well explained or well justified. All engineering models (e.g., HEC-HMS, HEC-RAS, FLO-2D, FLAC, etc.) used in the analyses were applied in an appropriate manner, but the uncertainty associated with the modeling, particularly the seismic modeling, has not been quantified. The modeling studies with dam break simulations effectively captured the catastrophic nature of the overtopping and seepage failure scenarios under various pool level conditions with and without the proposed spillway im-

provements. The Hydrology Report goes into a detailed discussion related to the calibration of the HEC-HMS runoff model; however, there is no discussion on verifying the model to other recorded flood events. The accuracy of the HEC-HMS runoff model has direct bearing on the magnitude of the peak PMF inflow value and, in turn, the scope and cost of the proposed emergency spillway and improvements to the existing spillway. To potentially reduce uncertainty in the magnitude of the peak PMF inflow value, a site-specific PMP analysis integrated into the HEC-HMS model should be conducted. Given the large capacity flows required to be conveyed by both the existing spillway and the proposed emergency spillway under the PMF, strong consideration should be given to conducting physical hydraulic modeling studies of both structures (including their discharge channels) as part of the preliminary and final design efforts.

The information in the review documents appropriately describes existing conditions at the dam relating to hydrology and hydraulics of the spillway; however, the Panel was unclear as to whether the preferred emergency spillway alternative is being disproportionately driven by the more subjective elements of the risk analysis (i.e. Do no harm and As low as reasonably possible [ALARP]) criteria. Additionally, a more defined evaluation of risk should be presented for non-failure scenarios for other spillway configurations during more frequent flooding events (i.e., incremental damage assessment).

From a structural and geotechnical standpoint, it appears that most major conceivable hazards have been described adequately in terms of various significant modes of failure, with some exceptions. The Panel found that potential uncertainties in the FLAC analyses may influence the estimated seismic deformation, which could affect the risk assessment relative to several potential failure modes. For instance, when considering deformation analyses, the details of the potential seismic cracking nature and mechanisms are not well-defined and the use of filters to mitigate seismic displacements and seepage path formation is not well-documented in light of the uncertainty inherent in seismic modeling. In addition, the Panel found the risks associated with not retrofitting the Main Dam control tower, as well as the outlet/inlet structures with regard to structural performance under seismic loading are not fully addressed for the Life Safety Plan Alternatives. From a safety assurance perspective, it is unclear to what extent the lack of resilience and robustness will impact the selection of LSP 4. The uncertainty associated with liquefaction potential of deeper alluvium also remains.

More detailed information is needed about discontinuity characteristics in the spillway area and the potential for overtopping the spillway chute walls. The Panel also believes that a more detailed geological characterization is needed of the rock mass within the shear zone through which tunnels for Borel Canal Measures 1 and 2 are located. The Panel believes that these and other outstanding issues can be addressed and explained. The Panel also identified several components related to the existing spillway and Borel Conduit that will require further consideration during the preliminary engineering design (PED) phase of the project.

Economics – The Panel found that the project documents do not provide sufficient economic analyses to justify the selection of the tentative recommended plan . The Draft Economics Appendix lacks considerable detail on the models used to estimate the future without project condition, future without project risk, and impacts of the various alternatives carried forward. The amount of information missing from the Economics Appendix makes it difficult for the Panel to determine whether the future without project condition is reasonable and expected to

occur, or how the alternative plans were evaluated in terms of their economic outputs. The Panel believes the Economics Appendix needs much more detail in documenting analyses used to estimate plan impacts with separable elements that are independently justified.

The overall completeness of the report, specifically the alternatives ranking, is affected due to the absence of Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) results. The Panel believes that the use of HEC-FIA is appropriate for evaluating the alternatives considered. However, the Panel also believes that HEC-FDA should have been used to demonstrate that the expected annual National Economic Development (NED) benefits vs. expected annual NED costs and residual risk are acceptable. There is no USACE guidance overriding the requirement to display the NED effects of the plans carried forward for analysis and identifying which is the NED plan. The Panel also noted that – per USACE guidance – existing levee systems should be evaluated in terms of their ability to reduce flood damages and loss of life in the event of a dam failure.

Environmental – The Panel found that within the context of NEPA, the study addressed the resources identified during the scoping process that were important to the decision making process. Within the context of a tiered NEPA evaluation, the analysis was adequate; however, it has been the experience of the Panel that EISs typically include more detail regarding project impacts. The Panel recognizes that more detailed analysis will come with additional NEPA analyses conducted in the future, and a substantial amount of information will be updated or further documented prior to the FEIS being completed. The Panel found the mitigation measures and environmental commitments provided in the DEIS were broad and generic; additional detail would have provided a clearer understanding how project impacts associated with each alternative would adequately be avoided, reduced and minimized, to the greatest extent practicable. Additionally, the Panel found there was a lack of detail and documentation regarding climate change resulting in an incomplete understanding of the cumulative effects of the proposed project. The issue of reservoir sediment amount and its impact on downstream ecology needs to be addressed and documented in the reports, even if the volume of sediment is small compared to the lake volume.

Table 6. Overview of 28 Final Panel Comments Identified by the Isabella Dam Safety IEPR Panel

No.	Final Panel Comment
	Significance – High
1	A site-specific PMP analysis integrated into the HEC-HMS model, which could potentially reduce uncertainty in the magnitude of the peak PMF inflow valve, has not been conducted.
2	The Final Hydrology Report does not discuss the verification process for the HEC-HMS model.
3	In the future without project condition, it is unlikely that the interim risk reduction measures (IRRM) would be abandoned and that the reservoir would be operated as if there were no risk of dam failure.

Table 6. Overview of 28 Final Panel Comments Identified by the Isabella Dam Safety IEPR Panel, continued.

No.	Final Panel Comment
4	There is no description of the NED plan, why that plan was rejected, or why the recommended plan is preferable to the NED plan or preferable to dam removal.
5	The uncertainty inherent in seismic deformation modeling and its potential impact on the tentative recommended plan has not been fully considered or documented.
6	When considering deformation analyses, the details of the potential seismic cracking mechanisms are not well-defined and the use of filters to mitigate seismic displacements and seepage path formation is not well-documented.
7	It is difficult to determine whether separable elements are independently justified.
Significance – Medium	
8	The results of the incremental damage assessment for rejected alternatives under more frequent flooding events (for non-failure scenarios) are not clearly presented in the main review documents.
9	It appears the preferred emergency spillway alternative is being disproportionately driven by the more subjective elements of the risk analysis (i.e., Do No Harm and ALARP) criteria.
10	The execution of the PMF analysis under current baseline conditions (i.e., the calibration and use of the 1965 Clark sub-area Unit Hydrographs) may be outdated.
11	Several components related to the existing spillway require further consideration during the preliminary engineering design (PED) phase of the project.
12	The review documents do not clearly demonstrate that the Six Step Planning Process from the Principles and Guidelines and ER 1105-2-100 was followed.
13	The existing levee systems should be evaluated in terms of their ability to reduce flood damages and loss of life in the event of a dam failure.
14	The results of the HEC-FDA analyses, which are intended to determine how the alternatives rank in expected flood risk reduced and residual flood risk after remediation, have not been provided.
15	The Draft Economics Appendix is missing considerable detail on the models used to estimate the future without project condition, future without project risk, and impacts of the various alternatives carried forward.
16	It is unclear to what extent the lack of resilience and robustness will affect the selection of Life Safety Plan 4 as the tentative recommended plan over DSAC Plan 2 and whether sufficient redundancy is provided.
17	The effect of reservoir sediment, regardless of its volume, on downstream channel regimen and ecology has not been evaluated.
18	The structural performance of the modified Main Dam control tower under seismic loading in the absence of seismic retrofitting is not addressed.

Table 6. Overview of 28 Final Panel Comments Identified by the Isabella Dam Safety IEPR Panel, continued.

No.	Final Panel Comment
19	Information on discontinuity orientations, types, and aperture and how these discontinuity aspects might influence erodibility of the existing spillway channel has not been provided.
20	Information about the design and construction of the seepage collection and disposal system for the proposed filter and drainage buttress is missing from the reports.
21	The EIS analysis did not provide enough detail in the cumulative effects analysis on climate change and how cloud seeding activities coincide with climate change.
22	The analysis of potential impacts of the project alternatives on various environmental constraints is not complete in the DEIS, as more current data are available for several environmental constraints.
23	The mitigation measures for water quality, noise and vibration, and biological resources, while appropriate, lack the specificity needed to adequately determine whether they would offset project impacts and/or need clarification, consistent with other state and Federal agency requirements.
24	Physical and computational fluid dynamic (CFD) modeling should be performed during the preliminary engineering design phase of the project to properly set the final design configuration of the primary and emergency spillway channels.
25	Using historical records as a means to estimate flood damages reduced is not an appropriate measure of expected future flood risk reduction loss.
26	A detailed geological characterization of the rock mass within the shear zone, through which Borel Canal Measures 1 and 2 will be located, is not provided in the reports.
27	Some of the risks associated the Borel Conduit closure, including the potential for incompatible deformations and/or strains caused by filling the Conduit and the details associated with closing it, have not been addressed.
	Significance – Low
28	The reports use economic values that have not been updated to the current fiscal year, as required by USACE guidance.

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APPENDIX A

Final Panel Comments

on the

Isabella Dam Safety IEPR

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Final Panel Comment 1

A site-specific PMP analysis integrated into the HEC-HMS model, which could potentially reduce uncertainty in the magnitude of the peak PMF inflow valve, has not been conducted.

Basis for Comment

As presented in the Final Hydrology Report (p. 70), the key difference (uncertainty) between the magnitude of the peak PMF inflow of USACE's 2010 and 2012 studies is the methods employed for the temporal and spatial patterns for the Probable Maximum Precipitation (PMP). The PMP estimates were derived from standard guidance provided in the Hydrometeorological Report (HMR) 58/59. The total volume as well as the temporal and aerial distribution of the PMP has direct bearing on the magnitude of the estimated PMF. This in turn drives the ultimate size, configuration, and construction cost for the spillway improvements. Despite the vast difference in PMF inflows (404,000 cfs for 2010 and 581,000 cfs for 2012) and the cost ramifications for the recommended remedial measures for overtopping protection (i.e., 900-ft long emergency spillway with a 16-foot raise in dam height), USACE did not conduct a site-specific PMP analysis.

The methods used in published HMR studies are conservative and over-generalized and will typically produce total PMF volumes greater than those derived from site-specific studies. It is the Panel's understanding that using a site-specific analysis in this region would likely reduce the PMP volume by 15 to 40 percent, depending on size of drainage area, rain on snowpack characteristics, and other hydrometeorological considerations.

USACE replied on July 31, 2012 to the Panel's initial inquiry on this topic and stated: "The consistent results of the PMP from all of these [previous USACE developed hydrologic] reports indicate that a site-specific PMP would not be as helpful." However, the Panel does not believe that the apparent consistency of HMR results from the previous hydrologic studies is definitive proof that a site-specific PMP study is unwarranted. Rather, the Panel is concerned that a potential over-estimation of PMP volume, which directly affects the volume and peak rate of the PMF, creates an oversized and costly spillway modification.

Significance – High

The results of a site-specific PMP analysis (which in all likelihood will be a smaller PMP than what is developed from generalized, published HMR methods) will likely affect the project's estimated construction costs.

Recommendations for Resolution

1. Conduct a site-specific PMP analysis and apply those results to the existing HEC-HMS rainfall-runoff model for the study watershed.

Final Panel Comment 2

The Final Hydrology Report does not discuss the verification process for the HEC-HMS model.

Basis for Comment

The Final Hydrology Report includes a detailed discussion of the calibration of the HEC-HMS runoff model; however, there is no discussion of verifying the model to other recorded flood events at either the in-watershed stream gages (Nos. 11186000 and 11189500 – Figure 6, p. 24) or inflows to Lake Isabella. It is standard engineering practice to check the accuracy of calibrated simulation models through a separate verification process. Not to do so can be considered a fundamental weakness in the predictive nature of the model (in this case, an event-based flood runoff model). It is the Panel's understanding that much of the HEC-HMS calibration is based on the comparison to the estimated inflow to Lake Isabella from the 1966 and 1997 historic flooding events. These actual flood inflow hydrographs were derived by back-calculation (via reverse routing) from stage hydrographs recorded at the dam. The 1997 calibration run showed a difference (model vs. observed) of about 30 percent, which was attributed to: "inaccuracies of the measurement for outflow and elevation; especially in a major event" (p. 51).

In their response to the Panel's initial inquiry on this issue in late July, USACE stated that "Interviews with water managers indicate that in significant flood events, such as in 1997, outflow and reservoir elevation measurements, which form the basis of the inflow measurements contain errors associated with collecting data in storm conditions (wind/wave runup, transmission errors, etc). Although the gage at Isabella is known to have remained intact in the 1997 event, measurements during such an event pose accuracy challenges."

Regarding the Panel's inquiry about use of other recording stream gages, USACE stated, "Additionally, three other gages (upstream at the North Fork, South Fork, and downstream at Bakersfield) in the basin were evaluated when calibrating the hydrology model." However, the Panel could not find this information or results in the Final Hydrology Report.

Based on the review of pertinent DSMR documents, it is the Panel's understanding that most of the uncertainty related to the PMF and magnitude of the required spillway modifications are in the following areas:

- Temporal and aerial distribution of the PMF
- Approximate frequency annual exceedance probability (AEP) applied to the PMF inflow
- Assumption on antecedent lake level at the onset of the PMF
- Non-linearity adjustment to the unit hydrographs
- Incremental water surface elevation and related LOL estimations.

These uncertainties, when taken in the aggregate, tend to compound the conservative outcome of the magnitude of the PMF inflow; in turn, this dominates the remedial solution necessary to reduce the overtopping failure modes to a level of tolerable risk. However, the accuracy of the runoff model itself can introduce a level of uncertainty equal to or greater than the items noted above.

Significance – High

The lack of proof of model verification could profoundly affect the final recommendations for spillway improvement at Lake Isabella Dam.

Recommendations for Resolution

1. Conduct verification runs (where unit hydrograph variables are held constant) with the calibrated simulation models using incremental precipitation data from historic (candidate) storms within the period of record of the in-watershed stream gages. Compare model results to recorded stream flow data to verify the model as predictor of runoff inflow to Lake Isabella under the PMF.
2. Conduct additional sensitivity analyses to better understand how these uncertainties may be driving the decision on the proposed emergency spillway configuration and related dam raising.

Final Panel Comment 3

In the future without project condition, it is unlikely that the interim risk reduction measures (IRRM) would be abandoned and that the reservoir would be operated as if there were no risk of dam failure.

Basis for Comment

Engineer Regulation (ER) 1105-2-100 (USACE 2000) requires a single well-defined forecast of future without project conditions, and this forecast must consist of all reasonable and executable actions, plans, and programs to mitigate risk and avoid damage in the absence of a Federal project. The report describes a dam operation regime that does not meet this criterion.

The Panel finds that operating the dam without the IRRM would create an intolerably high risk scenario and that the future without project condition as described in the reports is not likely to exist. Accordingly, the Panel believes that the alternatives considered should be compared to a future without project condition in which the dam is operated with the IRRM in place, or describe why removing the IRRM is the most reasonable future without project condition.

Significance – High

If a future without project condition is not properly described and credibly introduced, the selection and justification of the recommended plan can be affected and its expected risk reduction benefits can be questioned.

Recommendations for Resolution

1. Either forecast a future without project condition that is both reasonable and credible, or
2. Provide clear and concise reasoning for a forecast that includes removal of the IRRM as the most likely future without project condition. The Panel recommends choosing either Recommendation 1 or 2.
3. Ensure that the future without project condition in all report documents and appendices is clearly defined and identically described in all respects.

Literature Cited

USACE (2000). Planning Guidance Notebook. ER 1105-2-100. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. April 22.

Final Panel Comment 4

There is no description of the NED plan, why that plan was rejected, or why the recommended plan is preferable to the NED plan or preferable to dam removal.

Basis for Comment

Standing USACE guidance requires that the National Economic Development (NED) effects be displayed. Specifically, ER 1105-2-100 (USACE 2000, p. 2-6, paragraph 4) states:

> Display of the national economic development and environmental quality accounts is required. Display of the regional economic development and other social effects accounts is discretionary. Evaluation of the beneficial and adverse effects of the alternatives will provide a basis to determine which plans should be considered further, dropped or reformulated.

If the recommended plan is different from the NED plan, a series of questions arise that must be addressed. If the recommended plan is more or less costly than the NED plan, or if the recommended plan produces fewer net NED benefits, then justification for deviation from the NED plan needs to be provided so that the Panel can understand how the recommended plan was selected.

The Panel recognizes that life safety is the primary objective of dam safety evaluations and that USACE may formulate for and select the plan that best satisfies that objective. However, the Panel also recognizes that applicable guidance must be followed and that the NED effects of the alternatives be displayed. There is no USACE guidance overriding the requirement to display the NED effects of the plans carried forward for analysis and identifying which is the NED plan.

Significance – High

If the NED plan is not described and, therefore, it is not determined if an alternative produces positive net NED benefits, dam removal should be given serious consideration.

Recommendations for Resolution

1. Display the NED costs and benefits of each alternative carried forward for detailed analysis.
2. Provide justification, if only a short statement, for selection of a plan other than the NED plan.
3. Provide documentation, discussion, and supporting information describing why dam removal is not preferable if no alternatives produce net NED benefits.

Literature Cited

USACE (2000). Planning Guidance Notebook. ER 1105-2-100. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. April 22.

Final Panel Comment 5

The uncertainty inherent in seismic deformation modeling and its potential impact on the tentative recommended plan has not been fully considered or documented.

Basis for Comment

Seismic deformation is a key component of the engineering analyses on which the tentative recommended plan (Life Safety Plan [LSP] 4) was selected. The analyses were conducted using the computer program FLAC. The Panel acknowledges that FLAC likely represents the best available technology for conducting such analyses; however, there is not a complete discussion or assessment of the many sources of uncertainty that can influence the results. These include:

- uncertainties in the model itself
- geologic characterization of various significant layers (vertical and lateral extent/continuity, grain size, age, depositional history, etc.), especially in the case of deeper alluvium
- data used to characterize the soils comprising each layer (i.e., $N_{160(cs)}$ values, etc.)
- constitutive models used to describe soil behavior
- relationship used to assign the residual strength of liquefied sand
- characteristics of the ground motions reflected in the selected time histories.

Uncertainty in the soil properties is considered by using 35th percentile $N_{160(cs)}$ values and uncertainty in the design ground motions are addressed in the scaling and selection of time histories. However, the other sources of uncertainty are not explicitly addressed in the documents, nor is the cumulative uncertainty considered.

This issue was raised in the Panel's preliminary questions to the PDT submitted on July 25, 2012. Their response was that it is generally accepted that the actual deformations are within plus or minus 50% of the result. While the Panel generally concurs, this uncertainty does not appear to be reflected in the deformation results presented in Table 4.22 of the DSMR. Consideration of this additional uncertainty may have a significant impact on the results and the selection of the recommended plan.

For example, considering Auxiliary Buttress Measure 2 (no deep liquefaction remediation), if potential crest settlement under the maximum credible earthquake (MCE) event is increased by adding 50%, the results would indicate an upper limit crest settlement of about 18 feet. With a 16-foot raise, the new crest would be constructed to about elevation 2,653 feet. Following the MCE earthquake and the upper limit settlement value, the crest could be lowered to about 2,633 feet (NAVD88), which is within a few feet of the elevation of the spillway (2,631 feet). If this is the case, the risk of overtopping due to seismic deformation (PFM #35) may be understated, affecting the probability of failure, loss of life, and damages calculations.

Similarly, understated risks may exist for PFM #38/44 associated with transverse cracking due to earthquakes, which also depend on the magnitude of predicted seismic deformations. Changes in these risk-based calculations may change the values in the DSMR Tables 1-14 and 1-15,which provide a comparison of the ALARP (as-low-as-reasonably-practicable) considerations and the overall comparisons of risk management plans on which the selection of the tentative recommended plan is based.

The analyses show that full depth treatment of the alluvium reduces predicted MCE crest settlement by about 50%. When the total uncertainty is considered, the risk reduction associated with full depth treatment of the alluvium may favor Auxiliary Buttress Measure 3, which incorporates full depth treatment of the alluvium.

Significance – High

The magnitude of seismic deformations affects risk calculations throughout the analysis. When uncertainty is fully considered, the changes in risk associated with seismic deformation considered in PFM #s 35 and 38/44 could affect the selection of the recommended plan.

Recommendations for Resolution

1. Provide a detailed assessment of the uncertainties associated with seismic deformation analysis, including the uncertainty inherent in deformation of deeper alluvium due to liquefaction. This should incorporate the uncertainty associated with detailed geological characterization of deeper alluvium (thicknesses, aerial extents, and properties of liquefiable layers).
2. Reassess the range of potential deformation considering the total uncertainty.
3. Reevaluate annual probability of failure (APF) and annual loss of life (ALL) consistent with changes to risks associated with PFM #35 and PFM #38/44.
4. Reassess risk and cost values in the ALARP Comparison Table and Comparison of Alternatives Risk Management Plans (DSMR Tables 1-14 and 1-15, respectively).
5. Confirm that LSP 4 is still justified as the recommended plan.

Final Panel Comment 6

When considering deformation analyses, the details of the potential seismic cracking mechanisms are not well-defined and the use of filters to mitigate seismic displacements and seepage path formation is not well-documented.

Basis for Comment

The DSMR (Section 4.3.2.6.1, Addition of Filtering Capability, pg. 110) states that

> In general, the addition of a full height buttress with filters and drains to the Auxiliary Dam addresses the non overtopping failure modes (PFM 12, 13, 35, 38/44 and 47) if the conduit through the dam is decommissioned.

While the Panel concurs that this is reasonable for non-seismic failure modes where the filter and drains are not expected to be subject to significant distortion, additional consideration is warranted for the seismic failure modes PFM #35 and #38/44.

The Section 4.3.2.6.1, pg. 110 further states that

> The effectiveness of the filter for the seismic related failure modes was determined to be a function of the level of seismic loading using either peak ground acceleration or moment magnitude for fault rupture. The greater thickness of the filters and drain over the fault zone in the Auxiliary Buttress Measure 2 and 3 are the primary reason the system response probability is lower than the Auxiliary Buttress Measure 1. The deep treatment included in the DSAC Auxiliary Buttress reduces the deformation and resulting potential differential settlement of the filters and drains which help increase the filter performance when a transverse crack could occur at this site as identified under PFM 38/44.

While the Panel conceptually agrees with this statement, neither the DSMR nor its appendices provide a detailed discussion or calculations demonstrating the relationship between peak ground surface acceleration, earthquake magnitude, and resulting seismic deformation and crack formation, including crack characteristics and filter performance. In addition, it is unclear how the results of the seismic deformation analyses were used to estimate open crack characteristics (continuity, depth, aperture) and the high permeability zones below the open cracks associated with shear strain propagation. It is also unclear whether three-dimensional effects associated with changes in deformation between sections along the Auxiliary Dam axis were considered. Additional detailed evaluation of crack formation within the new and existing portions of the embankment is warranted.

The FLAC analyses results presented in Section 4.3.3.6.2, Effects of Liquefaction of Deep Alluvium, pgs 143-145, suggest there will be significant extension of the proposed filter and drains due to differential lateral displacement ranging from 14 to 23 feet across the dam cross-section during a MCE event. It is unclear what extensional

displacements will occur across the filter and drain layers. The potential reduced effectiveness of the filters and drains due to elongation associated with extensional seismic deformation should be evaluated for both the Auxiliary Buttress Measure 2 and Auxiliary Buttress Measure 3.

Significance – High

Verifying the ability of the filters and drains to be functional and prevent piping failures following a seismic event is critical to reducing seismic-related risks of dam failure.

Recommendations for Resolution

1. Provide additional documentation of seismically induced cracking mechanisms including the continuity, depth, aperture, and distribution of cracks within the existing and new portions of the remediated embankment.
2. Conduct additional analysis of the elongation of the proposed filter and drainage layers due to seismic deformation.
3. Consider the three-dimensional geometry of the embankment when evaluating maximum elongation and shear strains.
4. Evaluate the impact of elongation and extension on the filter and drain layers and the impact on enhanced erosion potential.

Final Panel Comment 7

It is difficult to determine whether separable elements are independently justified.

Basis for Comment

The Panel understands that many of the review documents are still in draft form and subject to modification. However, the review documents, particularly a detailed Economics Appendix, need much more detail in documenting analyses used to estimate plan impacts with separable elements that are independently justified. ER 1105-2-100 (USACE 2000) defines a separable element:

> (2) Separable Element. A separable element is any part of a project which has separately assigned benefits and costs, and which can be implemented as a separate action (at a later date or as a separate project). Separable elements so considered are similar to the planning concept of last added increments, with the added idea of separation or detachment of the increment from the whole.

Separable elements are usually required to be incrementally justified by providing outputs equal to or greater than their costs, or at least provide a reasonable tradeoff between life safety risk reduction and cost. An NED analysis would identify the separable benefits and costs associated with various project features or increments. However, there is no NED analysis for the Isabella Dam Safety project.

Specifically, the costs, benefits, and effects of the project elements that differentiate the LSP 4 and DSAC 2 plans are not clearly identified. This includes a direct comparative cost estimate between:

- Borel Conduit Measures 2 and 3 – Tunnel alignment through the right abutment of the Auxiliary Dam as compared to Tunnel alignment from the Main Dam Outlet Works
- Auxiliary Buttress Measures 2 and 3 – 80-foot wide downstream buttress the full length of the Auxiliary Dam with shallow depth foundation treatment compared to 100-foot-wide buttress with full depth foundation treatment
- Additional Main Dam Measure to Meet DSAC Objective including retrofit of the Main Dam intake, control tower, and outlet structures.

Significance – High

If the tentative recommended plan has separable elements that are not incrementally justified, its recommendation could be scrutinized. Conversely, if there are additional separable elements associated with the array of alternatives that were not carried into analysis, another alternative from that array could rise to become the tentative recommended plan.

Recommendations for Resolution

1. Provide NED benefit/cost analysis of separable plan elements for each alternative

carried forward.

2. For the comparison of Life Safety Plan 4 and DSAC Plan 2, display costs and benefits of the elements that separate these two alternatives.

Literature Cited

USACE (2000). Planning Guidance Notebook. ER 1105-2-100. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. April 22.

Final Panel Comment 8

The results of the incremental damage assessment for rejected alternatives under more frequent flooding events (for non-failure scenarios) are not clearly presented in the main review documents.

Basis for Comment

The preferred spillway improvement configuration included in Life Safety Plan 4, which includes a 16-foot increase in the top of dam elevation, is highly dependent upon the incremental damage simulations under existing versus future conditions. The results of these hydraulic/dam breach routing scenarios are used to estimate potential loss of life, thereby satisfying the "Do No Harm" principal. It is the Panel's opinion that the current documents do not fully provide the evidence to back up the selection of the preferred spillway improvement configuration.

Based on the Panel's review, it appears that the currently recommended emergency spillway configuration (designated as Life Safety Plan 4 and dam safety action classification [DSAC] 2) has been advanced based primarily on the convention that there can be no occurrence of an incremental increase in peak outflows more frequently than what is experienced under current conditions. Thus, the emergency spillway crest is to be set at the elevation of the existing top of dam. There is discussion within the Dam Safety Modification Report (DSMR) and Baseline Risk Assessment Report (BRAR) that any marginal increase in peak flows for more frequently occurring floods (that would occur for increasing spillway capacity at elevations lower than the existing top of dam) would most definitely cause additional loss of life and property damage downstream. It is unclear to the Panel whether this statement has been supported in the DSMR by incremental damage assessment studies using the existing HEC-RAS and FLO-2D hydraulic models.

The Panel also recommends clarification and presentation of results for the development of incremental damage assessments for other potential emergency spillway alternatives, under non-failure conditions for flooding events with more frequent return periods (i.e., 50- to 1,000-year). There is some general discussion embedded in the documentation indicating that other emergency spillway alternatives generate incremental increases in peak runoff from these more frequent flooding events that would create significant additional Loss of Life (LOL). As a consequence, these other alternatives were deemed not viable for further considerations as they violated USACE's "Do No Harm" criteria, even though they may have provided tolerable risk on the f-N diagram. This includes the alternative including fuse gate with 4-foot embankment raise (DSAC 1). Table 1-7 in the DSMR shows that DSAC 1 (4-foot raise) and DSAC 2 (16-foot raise) both fall within the f-N diagram designated as demonstrating tolerable risk.

USACE provided a response on July 31, 2012 to the Panels' inquiry on this technical issue; however, the Panel is still concerned that the DSMR documents do not fully capture the incremental damage assessment for DSAC 1 and other alternatives that do

not require a significant (16-foot) increase in the total height of the dam embankments.

Significance – Medium

The lack of complete information on the extent of incremental flooding under more frequent flooding events affects the completeness of the report and the overall understanding of the project.

Recommendations for Resolution

1. Provide a more definitive discussion and presentation of incremental flooding impacts for other more frequent storms, under non-failure conditions (existing vs. future). The Panel suggests that this include additional water surface profiles and aerial mapping of the extent of the incremental flooding under more frequent flooding events for other spillway alternatives.
2. Include earlier in the documents a discussion and summary of the incremental flooding modeling studies that definitively rules out these other emergency spillway configurations (especially those that do not require such a large dam raising) as creating intolerable risk under lesser flood conditions.
3. Present the results of incremental flooding analyses for these other storms in tabular and aerial plan maps in a more prominent location in the Hydrology, DSMR, and BRAR.
4. Include the routed peak outflow from the dam in the HEC-HMS results for various frequency storms under different spillway alternatives; this should include the baseline condition as well.

Final Panel Comment 9

It appears the preferred emergency spillway alternative is being disproportionately driven by the more subjective elements of the risk analysis (i.e., Do No Harm and ALARP) criteria.

Basis for Comment

Based on the Panel's review of pertinent documents, the current recommended spillway modifications have been developed based on the dam safety risk management considerations, namely: (a) achieving tolerable risk (i.e., f-N diagrams); (b) adhering to USACE engineering guidelines; (c) using the "as low as reasonably possible" (ALARP) considerations; and (d) applying the "Do No Harm" principle. Given the fact that several of these four elements are very subjective in nature, the Panel is concerned that the recommended overtopping mitigation (which includes the 16-foot raise) is driven more by the subjective components of the risk management approach (i.e., "Do No Harm" and ALARP). The Panel is unclear as to how raising the dam 16 feet (and incurring more maximum hydraulic potential) to solve the issue of spillway capacity can be the best solution to reducing risk to downstream life and property.

As indicated in USACE's response on July 31, 2012 to the Panel's initial inquiry on this issue, the Panel recognizes that the magnitude of the estimated probable maximum flood (PMF) is well beyond the existing spillway capacity and that a second, emergency spillway is required to help safely pass this design flood event. Furthermore, it is the Panel's understanding that the threshold flood for the existing spillway is on the order of a 3,000- to 4,000-year event and that the PMF has been estimated (by extrapolation methods) to have a return period of about 9,000 years.

The Panel is concerned that an unreasonable equivalence is potentially being derived that compares the existing condition to a future condition where no additional outflow discharges can be allowed up to the PMF. The Panel feels that consideration should be given to comparing the flooding due to failure of the existing dam versus resulting routed outflows under the future spillway design scenarios for very rare events (i.e., exceeding 3,000- to 4,000-year events). The Panel is unclear whether USACE should be required to adhere to the strict interpretation of "Do No Harm" for such extreme events, when the various spillway improvement alternative designs have otherwise satisfied the requirement to safely pass the newly revised Spillway Design Flood (SDF).

Significance – Medium

Without a description of how the four elements are integrated into the final risk assessment, the completeness of the report and the understanding of the proposed emergency spillway and dam embankment's recommended geometry is affected.

Recommendations for Resolution

1. Provide a more detailed discussion on how each element (particularly the more subjective components of "Do No Harm" and ALARP) is considered and weighted in developing total risk for each of the structural risk management plans.

Final Panel Comment 10

The execution of the PMF analysis under current baseline conditions (i.e., the calibration and use of the 1965 Clark sub-area Unit Hydrographs) may be outdated.

Basis for Comment

The accuracy of the HEC-HMS runoff model has direct bearing on the magnitude of the PMF and, in turn, the scope and cost of the proposed spillway improvements. The HEC-HMS runoff model used to develop the PMF employs Clark Unit Hydrograph variables (i.e., time of concentration and storage coefficients), which were originally developed from a hydrologic study of the watershed conducted in 1965. From the review of the Final Hydrology Report and related documents, it is not clear to the Panel whether the unit hydrograph input variables for the numerous subareas used in the HEC-HMS model were revisited by USACE during the 2012 analysis. This would have been typically accomplished by comparing them to actual observed flood hydrographs recorded at the two stream gages located in the watershed.

It is unclear to the Panel whether an attempt was made by the modelers to check appropriateness of the 1965-derived unit hydrograph inputs (Clark Tc and R variables) by graphically estimating them from more recent (post-1965) flood hydrographs at the in-watershed stream gages. While the Panel believes that the use of the existing unit hydrographs faithfully characterizes the general rainfall-runoff response for the Kern River watershed, providing additional explanation and cross-checking with more recent recorded flooding events will reduce some of the current uncertainty related to the hydrologic modeling.

Significance – Medium

The uncertainty surrounding the hydrologic modeling and the lack of a complete description of how the modelers checked the appropriateness of model inputs affects the completeness of the report and the understanding of the project.

Recommendations for Resolution

1. Conduct supplemental analyses related to unit hydrograph development. While it is not possible to check the validity of Tc and R variables for each of the 23 sub-areas used in the HEC-HMS model for the Kern River watershed, it is possible to confirm these variables for locations within the watershed at the site of the two existing stream gages in the lower portions of the watershed.
2. Provide documentation that the calibration and verification simulations of the HEC-HMS model at the stream gage locations accurately predict the shape and magnitude of the runoff hydrograph for historic, recorded storms occurring after 1965.
3. Provide additional clarification and justification that the use of the 1965-era unit hydrographs is valid for the most recent 2012 hydrologic study.
4. Confirm that the 1965 unit hydrographs were used for all previous hydrologic studies for the dam dating back to 1978.

Final Panel Comment 11

Several components related to the existing spillway require further consideration during the preliminary engineering design (PED) phase of the project.

Basis for Comment

The Panel was unable to locate within the review materials any discussion of the hydraulic characteristics of the existing spillway discharge channel under proposed conditions with the preferred alternative in-place. A brief, four page "Memorandum for File," dated June 11, 2010, is included as Appendix 2 in the Hydraulic Structures Interim Report (July 2011). However, this analysis uses the 1-dimensional HEC-RAS computer simulation model to evaluate water surface profiles along the discharge channel for the original spillway design discharge of 52,700 cfs. While the use of HEC-RAS is acceptable at the conceptual design level, the Panel believes that more sophisticated, detailed methods of simulation analysis will be required to assess hydraulic characteristics of the preferred remedial solution at the preliminary engineering design (PED) stage of the project.

The Panel believes that there is an inconsistency within the Design Safety documents regarding the potential failure mode where flood flows being conveyed down the existing spillway discharge channel can overtop the existing right training wall and cause erosion-type failure of the main dam's left groin.

> ***2.5.1.4. Existing Spillway Measures***
> *Measures considered to modify the existing spillway include* ***raising the spillway walls****, anchoring the walls and ogee crest, and* ***lining the chute*** *with concrete to mitigate for plucking and erosion. Raising the walls and anchoring is required because of the recommended dam raise and lining the chute is to address potential failure modes. Anchoring the walls and ogee crest is required for the additional head during operation. Although the failure modes* ***are not considered significant or life threatening failure modes*** *the cost to address them are low when compared to the risk reduction gained.*" (DSMR, p. 46; emphasis added)

There is no specific mention of raising the right channel wall in this section of the DSMR, but there is an indication that modifying the existing spillway was not mission critical.
However, Erosion of the Spillway (designated as PFM #2/3/61) is prominently featured as a major failure mode for the estimation of baseline risk condition in the DSMR (Section 1.3.1, p.19 of the PDF, no page number provided). The scenario whereby spillway discharges could be diverted behind the wall and scour the groin is also discussed in the Baseline Risk Assessment Report (Section 8.3.3.1.4 , p. 321). Similar failure could occur if the chute wall is overtopped during discharge.

The proposed spillway alternative currently being advocated by USACE (LSP4)

includes a 16-foot raise to the top of the dam, which in turn will require a significantly higher rate of peak discharge over the primary spillway weir and through the discharge channel (chute) than was originally designed.

The stability analyses for the existing project structures generally appear to follow the principles outlined in EM 1110-2-2100. However, the rationale provided in the technical memorandum for Main Dam Outlet Works Structures (Ref 23) Section 5.4.1 (that the spillway walls need not be considered critical structures because they are designed to resist MCE loading) does not appear consistent with EM 1110-2-2100 (USACE 2005). Section 3-5 of the EM states that "Structures designated as critical are those structures on high hazard projects whose failure will result in loss of life. Loss of life can result directly, due to flooding or indirectly from secondary effects." App H of the EM goes on to say that "A critical structure determination involves consideration of the possibility of failure, and the potential for loss of life should failure occur… Critical structures are subject to more stringent sliding safety factor requirements." Hence, the target factors of safety for normal structures, as used in the analyses may be too low.

The preliminary designs for the main spillway walls and ogee spillway for the 16-foot dam raise and the emergency spillway are not yet well-defined. It is the Panel's opinion that there is substantial uncertainty with the potential efforts involved in raising the spillway walls, and less with stabilizing the ogee spillway under high flows. This is somewhat reflected in the high contingency in the estimate for that work, but the effort could potentially be even more significant for the relatively tall, narrow walls that would result from a 16-foot embankment raise. Details supporting the cost estimates would be helpful in understanding the current plan.

Significance – Medium

The addition of hydraulic analyses (including computer simulations) and information on spillway wall stabilization will provide a more complete understanding as to whether training wall overtopping is a key failure mode for the project.

Recommendations for Resolution

1. Revise the DMSR documents to clearly indicate whether overtopping of the spillway right training wall under the PMF is a key PFM.
2. At the DSMR phase, conduct HEC-RAS modeling of both the existing spillway and emergency spillway discharge channels under a range of extreme flood flows including the PMF condition.
3. Provide additional discussion relative to the potential required wall raising necessary to mitigate overtopping and groin erosion.
4. Evaluate the required stabilization measures for the spillway walls as critical structures for the 16-foot dam raise.
5. Provide clarification that the construction costs for any wall raising is included in the overall cost for the project.
6. During the PED, refine hydraulic characteristics of the channels by employing physical modeling and Computation Fluid Dynamic (CFD) techniques.

Literature Cited:

USACE (2005). Stability Analysis of Concrete Structures. EM 1110-2-2100, Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. December 1.

Final Panel Comment 12

The review documents do not clearly demonstrate that the Six Step Planning Process from the Principles and Guidelines and ER 1105-2-100 was followed.

Basis for Comment

The DSMR, BRAR, and Economics Appendix need to document that USACE has followed the Six Step Planning Process prescribed in Chapter 2 of ER 1105-2-100 (USACE 2000) and mirrored in ER 1110-2-1154 (USACE 2011). Specifically, Step 2 of the process—the inventory and forecast of future without project conditions—is not well documented, leading the Panel to question the completeness of the processes described in Steps 3-6. The Panel finds that the report documents do not provide a basis for understanding that USACE followed the process and clearly defined the baseline risk condition, which in ER 1105-2-100 is the future without project condition.

Significance – Medium

Without clear documentation that the Six Step Planning Process was followed, the DSMR, BRAR, and Economics Appendix do not describe a process based on ER 1105-2-100 that will result in a sound decision.

Recommendations for Resolution

1. Structure the DSMR, BRAR and Economics Appendix so that it is clear that the Six Step Planning Process was rigorously followed.

Literature Cited

USACE (2000). Planning Guidance Notebook. ER 1105-2-100. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. April 22.

USACE (2011). Safety of Dams – Policies and Procedures. ER 1110-2-1156. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. October 28.

Final Panel Comment 13

The existing levee systems should be evaluated in terms of their ability to reduce flood damages and loss of life in the event of a dam failure.

Basis for Comment

The assumptions regarding the existence of and the expected performance of the existing levee systems do not comply with applicable guidance. ER 1105-2-100 (USACE 2000) does not permit assumptions where there is uncertainty regarding existing levee performance. Applicable guidance requires that the performance of existing levee systems be addressed in the development of the without project condition.
ER 1105-2-100, Appendix E, p. E-88 states:

> d. Existing Levees/Dams. If there is any question about the reliability of an existing levee, reliability should be specifically included in the risk analysis (see ER 1105-2-101). (USACE 2006).

ER 1105-2-100, p. E-106 also states:

> (a) General. Investigations for flood damage prevention involving the evaluation of the physical effectiveness of existing levees and the related effect on the economic analysis shall use a systematic approach to resolving indeterminate, or arguable, degrees of reliability. Reasonable technical investigations shall be pursued to establish the minimum and, to the extent possible, the maximum estimated levels of physical effectiveness. Necessary information and summary of analyses shall be included in report presentations of plan formulation and shall be documented in appropriate supporting materials.

There is not enough information for the Panel to assess the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used in the reports' presentation of the without project condition damages.

Significance – Medium

The lack of a discussion about the performance of existing levee systems affects the understanding of the analyses leading to the development of the without project condition and how the alternatives are compared against that forecast.

Recommendations for Resolution

1. Establish the levels of effectiveness for the existing levee systems in reducing flood damages during the various dam failure scenarios.
2. Include a complete and detailed list of all assumptions made in the economic analysis, provide a brief rationale for the assumptions, and discuss the effects that the assumptions have on the analyses.
3. If any of the dam failure scenarios produce flood stages below the probable failure point of the existing levee systems, the reports should clearly document how the

levee systems would be expected to perform under those scenarios.

4. If all of the dam failure scenarios produce flood stages above the probable failure point of the levee systems or overtop them, the reports should clearly demonstrate the systems' inadequacy to contain those events.

Literature Cited

USACE (2000). Planning Guidance Notebook. ER 1105-2-100. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. April 22.

USACE (2006). Risk Analysis for Flood Damage Reduction Studies. ER 1105-2-101, Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. January 3.

Final Panel Comment 14

The results of the HEC-FDA analyses, which are intended to determine how the alternatives rank in expected flood risk reduced and residual flood risk after remediation, have not been provided.

Basis for Comment

Both ER 1105-2-100 (USACE 2000) and ER 1105-2-101 (USACE 2006) require a probabilistic display of the NED effects of alternatives. Specifically, ER 1105-2-101 states (p. 4):

> e. The estimate of net NED benefits and benefit/cost ratio will be reported both as a single expected value and on a probabilistic basis for each planning alternative. The probability that net benefits are positive and that the benefit/cost ratio is at or above 1.0 will be presented for each planning alternative.
> f. The flood protection performance will be presented. The risk analysis will quantify the performance of all scales of all alternatives considered for final recommendation. The analysis will evaluate and report residual risk, which includes consequence of project capacity exceedance.

HEC-FDA is best suited for this type of analysis and is capable of producing the information necessary to satisfy the requirement. However, the review documents do not contain HEC-FDA outputs; therefore, the Panel cannot determine how the alternatives rank in expected flood risk reduced and annual residual risk. If the analyses and supporting information suggest that other plans are more preferable than the tentative recommended plan, this could become a larger issue.

Significance – Medium

The overall completeness of the report, specifically the alternatives ranking, is affected due to the absence of HEC-FDA results.

Recommendations for Resolution

1. Display estimates of NED benefits and benefit/cost ratios as an expected value and on a probabilistic basis.
2. Present flood protection performance for each alternative and quantify the performance of the recommended plan.
3. Display the outputs of the HEC-FDA analysis in the Economics Appendix and refer to these results in the DSMR and Draft BRAR.

Literature Cited

USACE (2000). Planning Guidance Notebook. ER 1105-2-100. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. April 22.

USACE (2006). Risk Analysis for Flood Damage Reduction Studies. ER 1105-2-101, Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. January 3.

Final Panel Comment 15

The Draft Economics Appendix is missing considerable detail on the models used to estimate the future without project condition, future without project risk, and impacts of the various alternatives carried forward.

Basis for Comment

The Panel understands that the Economics Appendix is still in draft form and subject to modification. However, the Appendix needs much more detail in terms of documenting the models and analyses used to estimate future without project conditions and plan impacts.

Without discussion and supporting information that describe the economic evaluations conducted during the study, the Panel cannot determine whether any of the alternatives produce net economic benefits or which alternative minimizes net NED losses.

Significance – Medium

The amount of information missing from the Economics Appendix makes it difficult for the Panel to determine whether the future without project condition is reasonable and expected to occur, or how the alternative plans were evaluated in terms of their economic outputs.

Recommendations for Resolution

1. Include a clear, concise definition of the study area and the future without project conditions in the study area.
2. Include the number, types, and value of the assets at risk in the floodplain.
3. Describe the reaches, how the reaches were delineated, and the floodplain inventory assigned to each reach.
4. Describe the without project condition damages by reach.
5. Include depth damage functions for the various structure types and justification for their use.
6. Include the NED benefits and costs attributable to alternatives carried forward.

Final Panel Comment 16

It is unclear to what extent the lack of resilience and robustness will affect the selection of Life Safety Plan 4 as the tentative recommended plan over DSAC Plan 2 and whether sufficient redundancy is provided.

Basis for Comment

The DSMR states (Section 4.5.3, pg. 200):

> The Civil Work Review Policy (EC 1162-2-209) states that a project design requires resiliency, redundancy, and robustness for Safety Assurance Review (SAR). The project design for the tentatively preferred plan will require a SAR there for it requires resiliency, redundancy, and robustness.

Table 4-52 of the DSMR, page 204, shows that the DSAC Plan 2 fulfills these three criteria and that the Life Safety Plan 4 meets the criteria for redundancy, but not for robustness and resilience. The Panel generally concurs that the DSAC Plan 2 fulfills these criteria. The Panel also concurs that the Life Safety Plan 4 lacks robustness and resilience, mainly due to the potential poor seismic performance at the MCE level and the lack of retrofit measures to the Main Dam inlet, outlet, and control structures.

However, it is difficult to justify the redundancy of Life Safety Plan 4 since the critical seismic piping related failure mechanisms rely solely on filters and drains to mitigate piping due to seismic cracking. Additional measures to reduce deformation due to deep alluvium liquefaction are not included, while the potential for deep alluvium liquefaction exists. In addition, by not retrofitting the Main Dam structures, Life Safety Plan 4 relies on the filter and drain components to mitigate failure mechanisms associated with cracking and subsequent piping into these structures. Reliance on filter and drain components alone may not meet the intent of the redundancy criteria.

Per DSMR Appendix E (Ref 22): “Current operations include keeping the three 5’-8” by 10’-0” hydraulically operated slide gates fully open at all times and making releases from the power turbines or the tainter valves.” Since LSP 4 does not include seismic retrofitting of the intake structure it follows that redundancy appears to be provided by those downstream end outlet works, which could be used to stop uncontrolled discharge, but this is not clearly stated. Furthermore:

a. Global stability of the tainter gate structure is not shown in DSMR Vol II, Appendix N Section 1.2.4.5 to be satisfactory under MCE, so its function as a redundant structure is questionable, given that LSP 4 does not include stabilization of the tainter gate structure.
b. Stability of the hydroelectric plant owned by Isabella Partners, which effectively completes the downstream control, is not addressed.

It is important from an overall safety standpoint that the tentative recommended plan has resiliency, redundancy, and robustness. It is unclear what impact the lack of compliance

with these criteria will potentially have on the SAR and how this will influence the selection of a tentative recommended plan.

Significance – Medium

The assessment of resiliency, redundancy, and robustness criteria communicates the characteristics of each of the retained plans with respect to safety and affects the understanding of each plan's performance expectations.

Recommendations for Resolution

1. Provide a detailed discussion of the basis for rating the resiliency, redundancy, and robustness of the retained plans.
2. Clarify the potential impact of the lack of compliance with the SAR criteria with respect to the selection of the tentative recommended plan.
3. Clarify the consequences of deeper alluvium liquefaction on the project future if Life Safety Plan 4 is implemented.
4. Provide additional detail on how each of the retained plans fulfill the requirements for redundancy, robustness, and resilience and why the tentative recommended plan is preferred over DSAC Plan 2 in this respect.

Final Panel Comment 17

The effect of reservoir sediment, regardless of its volume, on downstream channel regimen and ecology has not been evaluated.

Basis for Comment

The Panel did not find any information in the reports about the annual rate of sedimentation or the total amount of sediment accumulated in Isabella Lake since its operation. Depending upon the amount, sediment can reduce reservoir capacity and can significantly affect channel regimen and ecology in case of a dam breach. For example, downstream flow of sediment can change the base levels of tributary streams, damage properties in the flooded area, and alter the ecosystem.

Ecosystem impacts from sedimentation and its potential effects are not analyzed in the DEIS. These ecosystem impacts may include hydrological/hydroperiod modifications in aquatic systems, including their interfaces with terrestrial systems; endangered species and modifications to their habitats; impacts to wildlife habitats; increased water temperatures due to water being closer to the surface, which may affect cold water fishery species and result in a proliferation of warm water fishery species (biodiversity changes); and water chemistry changes. Decreased values for passive and active recreation may be adversely affected by sedimentation increases within desired habitats, such as increased sedimentation downstream in the Kern River that may affect whitewater rafting.

The Panel recognizes that geology in the watershed area for Isabella Lake consists of hard rock and, therefore, the amount of sediment brought to the Lake may be quite small. In addition, verbal communication with the PDT during the teleconference on July 25, 2012 suggests that sediment volume is small compared to lake capacity and, therefore, does not affect the tentative recommended plan. However, even a small amount of sediment can impact the ecosystem in the vicinity immediately downstream of the project (Wohl and Rathburn 2003). The issue of reservoir sediment amount and its impact on downstream ecology needs to be addressed and documented in the reports, even if the volume of sediment is small compared to the lake volume.

Significance – Medium

The absence of a discussion of reservoir sediment and its downstream impacts affects the completeness of the reports.

Recommendations for Resolution

1. Include a paragraph under the dam description section of the DSMR describing the total volume of sediment accumulated in the lake since its operation and documenting the methods used for estimating the volume.
2. Include an evaluation of sediment impact on channel regimen and ecology under discussions of “No Action” and “Dam Removal” plans.

Literature Cited

Wohl, E. and Rathburn, S. (2003). Mitigation of Sedimentation Hazards Downstream from Reservoirs, International Journal of Sediment Research, Vol. 18, No. 2, pp. 97-106.

Final Panel Comment 18

The structural performance of the modified Main Dam control tower under seismic loading in the absence of seismic retrofitting is not addressed.

Basis for Comment

The capacity-demand ratios (CDR) for flexure for the existing control tower exceed allowable values for operating basis earthquake (OBE), maximum design earthquake (MDE), or maximum credible earthquake (MCE). The proposed heightening of the control tower for the 16-foot dam raise in Life Safety Plan (LSP) 4 would be expected to exacerbate CDRs in the existing portions of the structure that will remain. There is no discussion regarding the seismic effects of raising the tower.

Another potentially exacerbating issue is whether the proposed modification for access to the tower will affect its torsional response. DSMR (Paragraph 2.5.1.3) states that "Access to the raised tower will be provided by retaining walls and backfill material of the Main Dam." Given the relatively large calculated deformations under seismic loading (for the existing condition), the walls and backfill could affect the response of the structure and therefore the assumption that the modified structure is torsionally "regular" as defined in EM 1110-2-2400 (USACE 2003, paragraph 4-6d(2)). There is no discussion provided in the DSMR to address potential torsional effects of the proposed changes.

Given the proposed raising of the control tower and lack of seismic retrofit of the structure, it is not clear whether the tower will perform satisfactorily during a seismic event.

Significance – Medium

Without information on the structural performance of the control tower, the Panel cannot assess whether there is sufficient analysis on which to base the selection of the tentative recommended plan.

Recommendations for Resolution

1. Structurally evaluate the Main Dam control tower for the proposed 16-foot dam raise to demonstrate whether it will perform satisfactorily under all seismic loading conditions.

Literature Cited

USACE (2003). Structural Design and Evaluation of Outlet Works. Engineer Manual (EM) 1110-2-2400. U.S. Army Corps of Engineers, Washington, D.C. June 2.

Final Panel Comment 19

Information on discontinuity orientations, types, and aperture and how these discontinuity aspects might influence erodibility of the existing spillway channel has not been provided.

Basis for Comment

According to the baseline risk assessment report (BRAR, Section 8.3.3.1.1, p. 309), a large flood event (15-year return period to top of dam) will result in water overflowing the spillway crest, causing erosion and scouring of the spillway chute channel. Progression of erosion can undermine the right wall at monolith 6 and transition monolith, exposing the embankment to erosion by high velocity flow, which can ultimately lead to embankment breach (PFM #2/3/61: Erosion of Spillway). Since 1953, the spillway has been overtopped three times (1969, 1980, and 1983) and, therefore, the probability of future erosion exists. The BRAR uses head cut index (K_h) to evaluate spillway erosion potential. The head cut index is based on quantification of five parameters: compressive strength (20,000 psi), RQD (50%), J_n (number of joint sets - 4), J_r (joint roughness - 1), and J_a (joint alteration – 1.5). Based on a computed value of 675 for the head cut index, the BRAR develops a system response using a linear regression of empirical data of past spillway flow events and the associated amounts of erosion (BRAR, Section 8.3.3.1.4, p. 313).

The Panel is of the opinion that the head cut index does not consider other important aspects of discontinuities present in the spillway channel, such as discontinuity orientations (strike and dip) with respect to direction of water flow, types of discontinuities (shear joints versus other joints), and aperture of discontinuities. During the site visit, the Panel observed that closely spaced (6”- 24”), near vertical joints are very prominent in the left wall of the spillway channel whereas conjugate joints (some showing evidence of shear) and other orientations dominate the channel floor. The Technical Advisory Panel (TAP) report, dated June 11, 2008 (Appendix A of the BRAR), also described the presence of long shears and emphasized the need for detailed mapping of all discontinuities exposed in the spillway walls and floor. The role of shear joints/shear zones in rock plucking by water and overall spillway erodibility can be very different compared to other joints, and open joints are more conducive to rock plucking than closed joints.

The DSMR and BRAR do not provide detailed information on the above stated aspects of discontinuities or their influence on the head cut erodibility index. For example, the Panel could not find a stereonet plot of discontinuity orientations in the review documents. The Panel believes that the role of discontinuity orientations, discontinuity types, and discontinuity aperture should be considered in assessing the erodibility of the spillway channel. It is important to determine which combinations of joint sets are more likely to facilitate rock-block plucking. Discontinuity orientation data will be very important for rock anchoring of the spillway crest and left retaining wall. The data will be necessary also to evaluate the feasibility and design of the proposed “localized

anchored reinforced concrete treatment" of the main spillway channel to minimize its erosion potential (DSMR, Section 4.3.2.8.1, p. 116). Furthermore, a stereoplot of discontinuity orientations will help in choosing the exact number of joint sets for use in computing the head cut index (currently, this number is assumed to be equal to 4).

Significance – Medium

A complete evaluation of the role of discontinuities in promoting erosion of the spillway channel cannot be performed without a more detailed characterization of discontinuities exposed in the spillway channel. This information will also be relevant for rock anchoring and the proposed localized anchored reinforced concrete treatment of the spillway channel.

Recommendations for Resolution

1. Provide more detailed information about discontinuity characteristics including discontinuity orientation (in the form of a stereonet showing principal joint sets), discontinuity type (sheared vs. non-sheared joints, faults), and discontinuity aperture. This should include strike and dip values of principal joint sets, orientations and widths of any shear zones, and range and mean of joint aperture.
2. Provide an evaluation of how these additional aspects of discontinuities might influence erodibility, as indicated by the head cut index of erodibility, as well as anchor orientations.

Final Panel Comment 20

Information about the design and construction of the seepage collection and disposal system for the proposed filter and drainage buttress is missing from the reports.

Basis for Comment

The objective of the proposed filter and drainage system is to prevent piping of embankment and shallow foundation material under normal operation conditions and in the event of embankment cracking due to displacements associated with seismic loading. However, the seepage that will enter the filter and drainage buttress needs to be collected and disposed of either in the Kern River (for the Main Dam) or Borel Canal (for the Auxiliary Dam), downstream of the dams. The Panel did not find details about the engineering design (e.g., size of drain pipe, size and spacing of perforations in the drain pipe, compatibility of perforations with the surrounding filter layer, disposal details) and construction of this seepage collection system in the review documents.

In addition, significant ground deformations, on the order of 5 feet vertically and 27 feet horizontally (DSMR, Section 4.3.3.6.1, p. 141), are estimated at the downstream toe of the remediated Auxiliary Dam during a significant earthquake event. With displacements of this magnitude, it is unclear how a seepage collection system can be designed to accommodate these displacements without pipeline separation leading to additional piping pathways.

Significance – Medium

Information about design and construction of the drainage collection system is necessary for evaluating the performance of the filter and drainage buttress.

Recommendations for Resolution

1. Provide design and construction details of the seepage collection and disposal system to be used for handling the seepage entering the filter and drainage buttress. This information can be provided where various buttress options are discussed in the DSMR (Section 4.3.2.5, pp. 104-111).
2. Provide an assessment of the vulnerability of the proposed seepage collection system to seismic deformation, resulting in collection-pipe separation.

Final Panel Comment 21

The EIS analysis did not provide enough detail in the cumulative effects analysis on climate change and how cloud seeding activities coincide with climate change.

Basis for Comment

Cloud seeding, which was described in the DEIS as a component of the hydrology for the region and Lake Isabella, is a contributing factor towards establishing the hydroperiods, in combination with climatological regime changes. The Panel believes that cloud seeding is a past, present, and reasonably foreseeable action that affects the existing and future project conditions within the project area. Climate change is discussed in the DEIS.

The Panel noted that the discussion of climate change on runoff in riverine systems generally is discussed in more detail in the DEIS. In particular, studies are cited on average temperatures, rainfall/precipitation, climate modeling within the region in comparison to historical data, and predictions on changes in spring runoff from snow pack to the region. It is the Panel's understanding that USACE used the 2010 Council on Environmental Quality (CEQ) guidance to address climate change for this project. The DEIS includes an analysis for Green House Gases (GHG). Since the DEIS is a joint document with the U.S. Forest Service (USFS), it is unclear how the DEIS addressed FS guidelines.

The USFS guidelines states that an analysis can be performed to demonstrate the effect of climate change on a proposed project. Their focus is on GHGs; however, their guidance does suggest that in most cases the uncertainty regarding climate change can be documented qualitatively by how the proposals/alternatives affect or influence climate change to help inform project decisions (USFS 2009).

USACE stated in the Panel Responses dated August 1, 2012 that it is not their standard practice to account for cloud seeding for PMF studies and water control manuals. Cloud seeding is not discussed in Chapter 4 of the DEIS as an action. Cumulative effects from cloud seeding may affect hydrology within the Lake and within the region. These cumulative effects may also carry over to various environmental considerations, including but not limited to, hydroperiods for wetlands, interfaces between aquatic and terrestrial ecosystems, effects on wildlife, fisheries, and endangered species (biodiversity changes), etc.

Significance – Medium

The lack of detail and documentation regarding climate change, along with cloud seeding, results in an incomplete understanding of the cumulative effects of the proposed project.

Recommendations for Resolution

1. Revise Chapter 4 of the DEIS to include climate change discussions in a qualitative

manner consistent with USFS Guidelines.

2. Revise Chapter 4 of the DEIS to discuss how cloud seeding activities are an action that occurs currently, in the past, and in the reasonably foreseeable future.

Literature Cited

USFS (2009). Climate Change Considerations in Project Level NEPA Analysis. U.S. Forest Service. January 13. http://www.fs.fed.us/emc/nepa/climate_change/includes/cc_nepa_guidance.pdf.

Final Panel Comment 22

The analysis of potential impacts of the project alternatives on various environmental constraints is not complete in the DEIS, as more current data are available for several environmental constraints.

Basis for Comment

The data used during the development and preparation of the DEIS appear to be outdated with respect to several environmental constraints analyzed. In addition, the DEIS should provide more details on certain environmental constraints as part of the environmental constraint analysis:

- Geology/Soils: Hydric soils and the potential effects to these soils are not discussed in the Geology/Soils section of the DEIS. The DEIS identifies wetlands that are present within the project area and how they will be affected; however, additional documentation is not provided on how hydric soils would be impacted and/or created as a result of the implementation of the various project alternatives. USACE indicated in the Panel Responses dated August 1, 2012 that there were seven soil types within Lake Isabella that are potentially hydric. USACE also provided disturbance footprints for the various project elements (per Panel request during the review period); however, these footprints are not in the DEIS.

- Air Quality: Mobile Source Air Toxics (MSAT) is not included in the air quality analysis. As the DEIS is providing a programmatic/tiered analysis of impacts associated with the roadway reconstruction/relocations around the project area, a MSAT is required to satisfy Caltrans and/or FHWA requirements (Caltrans 2007 and 2012). The Caltrans SER process regarding assessing MSATs for highway projects should be referenced (FHWA 2009). At a minimum, the DEIS should discuss that MSAT was considered in the analysis of air quality as construction equipment and travel of supplies and other equipment outside the project area may increase the likelihood of mobile source air emissions in a confined area. The discussion should indicate whether there is no, low, or high potential MSAT effects from the project. USACE stated in the Panel Responses dated August 1, 2012, that the MSAT2 rule had to do with parties that produce gasoline and was not a component for compliance with the Clean Air Act for this project, which is correct; however, the application of the analysis should be conducted and documented in the DEIS consistent with Caltrans/FHWA guidance (as this is a tiered document and additional EISs/EAs will be prepared at a later date) (Caltrans 2007 and 2012).

  The cumulative effects long-term for air quality, in conjunction with potential added capacity for the reconstructed/relocated highways is not analyzed in the DEIS.

- Noise Analysis and Modeling: Background noise levels around the project area were measured in October 2010. Assuming there have been land use changes since these data were collected, background noise levels at these locations may have changed. Background and noise receiver locations were not placed in the vicinity of the South Fork Wildlife Area (SFWA) and the Kern River Preserve to determine ambient noise levels, especially since the homes of several threatened and/or endangered species are present in these areas. These areas are typically designated for conservation/preservation so low noise is typically desired from an aesthetic point of view.

  The model reference cited on p. 3-146 of the DEIS is outdated. The Traffic Noise Model (TNM) is now the model used by transportation agencies in lieu of FHWA-RED-77-108. Caltrans guidance for noise analysis was updated in May 2011. Table 3-42 has been updated and replaced by a new table identified in the Federal Register, Volume 75, No. 133, pp. 39834-38.

  Generally, noise analysis sensitive receivers include hospitals, funeral homes/ mortuaries, and cemeteries. It appears these sensitive receivers are not included in the noise analyses performed.

- Hazardous Toxic Radioactive Waste (HTRW): The Environmental Data Resources (EDR) data search performed is from 2010. ASTM 1527-05 identifies that a Phase I Environmental Site Assessment is valid for 180 days unless it has been updated within a year. It is not clear from the information provided in the DEIS that any changes to land use have occurred since 2010 and thus any new potential sites are now present within the project area.

- Listed Species: The DEIS discussion of the southwestern willow flycatcher needs to be updated to reflect its current regulatory status and critical habitat components. On July 12, 2012, the USFWS published an update regarding this species (Federal Register, Volume 77, No. 134).

- Land Use: Table 3-67 of the DEIS provides land use plan designation information from Kern County. It is unclear whether there have been any updates to this information since 2008.

- Socio-Economics and Environmental Justice: Pages 3-346 and 3-362 provide information from the 2000 census. The Census Bureau has made available information from 2010 which is the most current information available.

Significance – Medium

The lack of information regarding several environmental constraints results in some uncertainty on how the proposed alternatives would affect these resources.

Recommendations for Resolution

1. Provide documentation and analysis in the DEIS regarding hydric soils and MSATs.
2. Revise the DEIS to include sensitive noise receivers such as hospitals, funeral homes/mortuaries, and cemeteries.
3. Update the DEIS regarding noise analysis, ambient noise receivers in conservation areas adjacent to the project area, EDR data search/HTRW, land use, listed species, and 2010 Census data.

Literature Cited

FHWA (2009). Memorandum: Interim Guidance Update on Mobile Source Air Toxic Analysis in NEPA. Federal Highway Administration. September 30. http://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/100109guidmem.cfm.

Caltrans (2007). Air Toxics Analysis Tools. California Department of Transportation. http://www.dot.ca.gov/hq/env/air/pages/msat.htm.

Caltrans (2012). Mobile Source Air Toxics (MSAT) in the NEPA Process for Highways. California Department of Transportation. http://www.dot.ca.gov/ser/vol1/sec3/physical/ch11air/chap11.htm#MSATNEPA.

Final Panel Comment 23

The mitigation measures for water quality, noise and vibration, and biological resources, while appropriate, lack the specificity needed to adequately determine whether they would offset project impacts and/or need clarification, consistent with other state and Federal agency requirements.

Basis for Comment

Generally in NEPA documents, including EISs, generally provide considerable detail on how project impacts would be offset by mitigation measures.

For water quality, the mitigation measures presented in the review documents indicate that one should "consider" various mitigation measures versus providing a commitment to implementing that mitigation measure. The use of the term "consider" could imply that a mitigation measure would not be implemented. It is the Panel's experience that mitigation measures are written using terms like "would" or "will." For example, the use of turbidity screens and aeration of water would provide measures to enhance or protect water quality from short-term effects from the proposed project.

Additionally, for water quality, it is unclear how the distance of 150 feet from the Ordinary High Water Mark was determined as an adequate mitigatory vegetation buffer distance. There is no supporting documentation provided regarding this distance, and it appears to be arbitrary.

For noise and vibration, there is no information in the DEIS regarding noise mitigation measures that may be required for the relocation and/or reconstruction of the roadway facilities proposed. These would have to be performed in accordance with Caltrans/FHWA guidelines.

For biological resources, the mitigation measures include the preparation of a Wetland Mitigation Plan that would identify the least environmentally damaging practicable alternative (LEDPA). It is unclear from the DEIS that the tentative recommended plan would be the LEDPA as it has not been evaluated.

The DEIS stated that the preparation of a Biological Assessment would be performed prior to the completion of the FEIS. A mitigation measure is not included in the environmental commitments/mitigation measures section of the Biological Resources section of the DEIS that would require USACE to enter into Section 7 Consultation with the U.S. Fish and Wildlife Service (USFWS) for potential effects on threatened and endangered species.

Significance – Medium

Defining how project effects are mitigated provides a complete understanding of the various project alternatives, and the process by which a tentative recommended plan was chosen.

Recommendations for Resolution

1. Provide a qualitative assessment of the LEDPA based on the conceptual design provided in the DEIS.
2. Reword the mitigation measures from “consider” to a definitive action where appropriate, e.g., the use of turbidity curtains during construction.
3. Provide a qualitative assessment of the mitigation measures needed to address noise mitigation measures to be consistent with Caltrans/FHWA guidelines.
4. Revise the mitigation measures to include a commitment that Section 7 Consultation will be conducted with USFWS prior to the completion of the FEIS.

Final Panel Comment 24

Physical and computational fluid dynamic (CFD) modeling should be performed during the preliminary engineering design phase of the project to properly set the final design configuration of the primary and emergency spillway channels.

Basis for Comment

The DSMR documentation provides hydraulic information at the conceptual design stage of the project. Given the large capacity flows required to be conveyed by both the existing and proposed emergency spillway under the PMF, strong consideration should be given to conducting physical hydraulic modeling studies of both structures (including their discharge channels) as part of the preliminary engineering design phase (PED) of the project. This includes the use of physical scale models, which can be somewhat costly and time consuming to construct and execute. Verification of the physical models should be done via companion CFD computer simulations.

The high discharges coupled with the steep bed slope of the discharge channels will create unstable, super-critical flow conditions throughout most of the travel length of the channels. This will produce extremely high, erosive velocities, over a range of flooding scenarios, which must be accounted for in the final structural design for these key hydraulic structures. In the Panel's opinion, the use of 1- or 2-dimensional computer modeling techniques will not sufficiently capture the complexity of the flow patterns through the channels.

Given the extent and high cost of the proposed improvements, the cost of the physical and CFD modeling in this application is comparatively small. In addition, the use of physical and CFD modeling techniques is state-of-the-practice for such a significant modification to a large, high hazard dam. The Panel recognizes that USACE is considering this issue as it was confirmed by USACE's response to Panel member questions posed during the July 25, 2012 teleconference. USACE stated: "This will be discussed and decided during the design (PED) phase of the project. It is currently a line item in the PED schedule."

Significance – Medium

Physical and CFD modeling performed during the preliminary engineering design phase of the project properly sets the final design configuration of the primary and emergency spillway channels.

Recommendations for Resolution

1. Conduct physical and CFD modeling studies to evaluate hydraulic characteristics of the existing and proposed emergency spillways under a range of flood flow conditions including the PMF. These studies should also determine the final sizing of the discharge channels for both principal and emergency spillways, include approach geometry and energy dissipation structures.

Final Panel Comment 25

Using historical records as a means to estimate flood damages reduced is not an appropriate measure of expected future flood risk reduction loss.

Basis for Comment

The report includes an estimated loss of expected future flood risk reduction in the absence of Isabella Dam that is likely not an accurate measure of this value.

The loss of future protection is the area under the damage frequency curve associated with the two conditions being analyzed; a comparison between alternatives would show the differences between the comparative annual flood risk reduction loss.

Depending on the frequency of the flood events recorded in the historical time period, using an average of past damages reduced could significantly overstate the value if a number of infrequent flood events were recorded.

Conversely, this method could significantly understate annual damages reduced if the historical record includes events of higher frequency.

As the Draft Economics Appendix states:

> When compiled by all Corp districts, [damages reduced] data provides a broad national picture of storm events and the extent of national beneficial flood damage reduction produced by the Corps. Because of the general nature of the subject and the rapid compilation of the preliminary estimates, the report's accuracy and completeness are considered preliminary and not intended for detailed research.
> …
> A floodplain inventory is one of the most important components of the stage-damage curve and, accordingly, the damages prevented estimate. In general, older and out-of date floodplain inventories will probably underestimate the actual value of the damages avoided or prevented. One reason for this is that due to the presence of a flood-control structure more development is likely to have taken place in a floodplain since construction was completed. Secondly, technology and use of larger homes have added to the valuation (aside from cost adjustments) within the potential floodplains. Additionally, capital equipment costs per acre for agricultural lands have increased over the past 50-60 years while per acre labor requirements have decreased.

The review documents do not address the issue of whether the historical record accurately reflects a stage-frequency curve for the study area, nor do they include documentation of a fully updated floodplain inventory.

Significance – Medium

The completeness of the report is affected by the use of historical records of flood damages reduced.

Recommendations for Resolution

1. Show expected annual flood risk reduction lost as computed by finding the area under the damage frequency curve.
2. Display the calculation for each of the alternatives considered.
3. Display historical flood damages reduced as a reference rather than a benefit category.

Final Panel Comment 26

A detailed geological characterization of the rock mass within the shear zone, through which Borel Canal Measures 1 and 2 will be located, is not provided in the reports.

Basis for Comment

Borel Canal Measures 1 and 2 both involve curved tunnels through the right abutment of the Auxiliary Dam. These tunnels will be 1,200 and 1,450 feet long for Measures 1 and 2, respectively, with approximately half the lengths for both tunnels passing through the shear zone associated with the Kern Canyon Fault. The DSMR states that the quality of rock in the shear zone is fair to poor. Section 4.3.2.9.1 (p. 117) of the DSMR states:

> The initial support system for the tunnel will consist of rock bolts, shotcrete, wire mesh or fiber reinforced shotcrete, and steel ribs or lattice girders depending on rock mass conditions. Where the rock quality is lower, it may be desirable to replace steel ribs by lattice girders. Compared to steel ribs the lattice girders are lighter and can be erected faster. To provide the same support capacity, the lattice girder system may require nominally more shotcrete but that is more than compensated by the easier and faster erection.

Section 2.6.3.2 (pp. 12-14) of Reference 21 states:

> The ground conditions along tunnel (Borel Measure 2) is considered to range from very good to exceptionally poor, based on the Q system, and the rock support types. Ground support for the tunnel was assumed to require 2 inches fiber reinforced shotcrete and rock dowels (Type I support – 10% of length), transitioning to 4 to 6 inches of fiber reinforced shotcrete plus systematic rock dowels (Type II support – 35% of length) and lattice girders and 6 to 8 inches of fiber reinforced shotcrete near the downstream portal (Type III support - 45% of length). Additionally, some reaches may need complete closure with invert struts (Type IV support – 10% of length).

This same section further states: “The ground conditions identified in the downstream portal would require the use of spiling and/or forepoling to advance the excavation.”. It is clear from the above text from the DSMR and Reference 21 that selection of the required support system will be highly dependent upon the quality of the rock mass within the shear zone. Yet the reports do not provide a detailed geological characterization of rock mass quality within the shear zone, nor do they discuss the anticipated behavior of the shear zone during tunneling (e.g., standup time). The documents state that the Q values used for support design were based on available borehole data. Some of the parameters needed for computing Q value, such as J_n, J_r, and J_a, cannot be determined accurately from core samples alone, especially for a shear zone. It is not clear from the documents how these parameters were selected for the shear zone. It is also not clear how percent length determinations (10%, 35%, 45%) for

different support systems were made without detailed geological characterization along the tunnel alignment. Further, it is not clear if the use of spiling and forepoling in the downstream portal area is based on actual geologic conditions in the portal area, as indicated by borehole data, or the assumed conditions, nor is it clear if spiling and forepoling would be restricted only to the downstream portal area or needed elsewhere in the shear zone. The Panel is of the opinion that a more detailed geological characterization of the shear-zone rock mass along the tunnel alignment, and its relationship to the support system, is needed to better evaluate the feasibility and cost estimates of Borel Canal Measures 1 and 2.

Significance – Medium

Feasibility and cost estimates of Borel Canal Measures 1 and 2 cannot be evaluated properly without more detailed information about geological characterization of the shear zone, which will contain approximately half of the tunnel lengths for both measures.

Recommendations for Resolution

1. Provide a more detailed geological characterization of the rock mass within the shear zone through which tunnels for Borel Canal Measures 1 and 2 will pass. Also, describe how J_n, J_r, and J_a values were selected for computing the Q values.
2. Provide a detailed description of the anticipated behavior of shear-zone rock mass during tunneling.
3. Describe how length determinations for various support systems were made.

Final Panel Comment 27

Some of the risks associated the Borel Conduit closure, including the potential for incompatible deformations and/or strains caused by filling the Conduit and the details associated with closing it, have not been addressed.

Basis for Comment

All Life Safety Plans and DSAC Plans include abandoning-in-place portions of the existing Borel Conduit control tower and tunnel, but there is no description in the DSMR of how that may be accomplished. During the Panel's site visit on July 10, 2012, the PDT described that the method of doing so was still being developed, but that it may involve demolishing the downstream portion of the conduit during buttress construction. In addition the uppermost portions of the tower would also be removed in order to reduce its weight. The remaining portions of the structures would be filled with a concrete material.

Per the analyses presented in the Technical Memorandum for Updated Seismic Performance Evaluation of Main Dam Tunnel and Borel Conduit considering the Effects of Seismic Waves, February 2011 (Ref 24) ,the Borel Conduit is significantly under-designed and this, rather convincingly, provides one of the bases for abandoning the structure and for filling the tunnel with a concrete material. However, while much of the structure will be removed, the portions that remain will be subject to seismic deformations during an earthquake, which could lead to increased seepage pathways. The current design relies on the new drains and filters, constructed as part of the buttress, to mitigate seepage and piping along the remaining portion of the structure. The extent to which these measures alone will mitigate seepage/piping risks associated with the remaining portion of the conduit in the remediated condition is unclear.

Filling the structure will change the dead weight of the structure. The potential effects on settlement were also discussed during the site visit, especially in the context that the tower settled at least 4 inches after initial construction. Any additional future settlement due to increased weight could open potential seepage path(s) along the top of the existing tunnel. The DSMR does not address methods to mitigate existing seepage pathways outside the conduit (such as pressure grouting), proposed concrete materials and placement methods, the potential for cracks/gap formed by potential concrete shrinkage, or methods to mitigate shrinkage cracks/gaps (such as post-grouting).
In addition, filling the structure with a stiff concrete material will affect its response to racking forces, making it move essentially as a rigid body within the surrounding medium. The Panel is concerned whether this will have the potential to open seepage paths along the sides of the structure following a seismic event. Potential methods to mitigate seepage pathways along the sides of the structure and existing seepage collars should be considered, such as pressure grouting from within the conduit prior to filling it with concrete material.

The risks associated with these potentially incompatible deformations between the Borel

Conduit and embankment do not appear to have been addressed in the analysis of risks for this element of the Life Safety and DSAC Plans.

Significance – Medium

Additional information on the proposed abandonment measures would improve the understanding and certainty of the results presented in the current risk analyses for the Life Safety and DSAC Plans.

Recommendations for Resolution

1. Describe in detail anticipated measures for abandoning the existing Borel Conduit tunnel and control tower, including concrete/grout placement materials and methods and the potential risks associated with those measures.
2. Include the risks associated with potential incompatible deformations due to settlement and seismic response in the risk analyses for the Life Safety and DSAC Plans.

Final Panel Comment 28

The reports use economic values that have not been updated to the current fiscal year, as required by USACE guidance.

Basis for Comment

The Baseline Risk Assessment Report displays economic values in what appear to be 2009 dollars. Since no project is likely to be undertaken before the start of Fiscal Year 2013, these values will be out of date.

ER 1105-2-100 (USACE 2000, Appendix D) requires that analyses present current estimates of benefits and costs. If more than three fiscal years have elapsed since the economic values were produced, an economic reevaluation of the project is warranted. Since the without project condition and all alternatives would have their values affected proportionately, the ranking of the alternatives would not likely change.

Significance – Low

This issue affects the technical clarity and completeness of the review documents.

Recommendations for Resolution

1. Express all economic values in FY 2012 or 2013 dollars.
2. In all tables, figures, and charts displaying economic values, cite which year the values represent.

Literature Cited

USACE (2000). Planning Guidance Notebook. ER 1105-2-100. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. April 22.

APPENDIX B

Final Charge to the Independent External Peer Review Panel as submitted to USACE on July 9, 2012 on the Isabella Dam Safety IEPR

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Charge Questions and Guidance to the Peer Reviewers for the Independent External Peer Review (IEPR) of the Engineering, Economic, and Environmental Evaluation of the Geotechnical, Hydrological, Hydraulic, Structural, and Economic Aspects of the Dam Safety Modification Report for Isabella Lake Dam, California

BACKGROUND

The Isabella Lake/Reservoir is located approximately 1 mile below the confluence of the North and South Forks of the Kern River in Kern County, California. The project consists of a 185-foot-high rolled earth fill Main Dam across the Kern River, and a 100-foot-high rolled earth fill Auxiliary Dam across Hot Springs Valley about ½ mile east of the Main Dam. The project provides flood risk reduction, irrigation, hydroelectric, and recreational benefits to the Tulare Lake Watershed. The Isabella Dam, as originally constructed, was put into full operation in February 1953, and is a flood control facility with secondary benefits from water conservation.

The Main Dam was built across the Kern River and has a maximum height of 185 feet, a crest length of 1,695 feet, and a crest width of 20 feet. The crest elevation is 2637.26 feet NAVD 88, which provides 6.5 feet of freeboard above the Spillway Design Flood elevation of 2630.76 feet NAVD 88. The storage capacity at gross pool is 568,000 acre-feet, which is elevation 2609.26 feet NAVD 88. The Main Dam consists of a homogeneous, zoned, earth-fill embankment with an impervious central core and decomposed granite outer shells. A 5-foot thick drainage blanket was placed beneath the downstream shell along the base of the Main Dam and about one-third the width. The foundation consists primarily of granitic rock; however, a zone of streambed alluvium beneath a portion of the downstream shell (2 to 5 feet thick) was left in place. A layer of riprap armors the upstream slope for erosion protection. A wedge-shaped zone of rockfill up to about 40 feet thick was placed in the downstream zone below elevation 2,555.76 feet NAVD 88. A 12-foot wide centerline cutoff/inspection trench was excavated along the rippable portions of the foundation and then a single, variable depth grout curtain was installed. Zone 1 grouting was generally 15 to 25 feet deep, Zone 2 was generally 50 feet deep, and Zone 3 holes (few in number) were grouted to 75 feet deep.

The Auxiliary Dam is a homogeneous, rolled, earth fill structure with a maximum height of 100 feet, a crest length of 3,257 feet, and a crest width of 20 feet. The crest elevation is 2637.26 feet NAVD 88, that provides 6.5 feet of freeboard above the Spillway Design Flood elevation of 2630.76 feet NAVD 88. The foundation consists of heterogeneous valley fill alluvium with a maximum depth of approximately 130 feet, above deeply weathered granitic bedrock. Recent explorations have shown that significant portions of the alluvium are loose and therefore potentially liquefiable.

The outlet works at the Main Dam consists of an intake structure and an outlet structure. The intake structure was constructed with the following components: conduit (14’9” diameter), transition section, control tower, and control section (three rectangular gated conduits). The outlet structure consists of an outlet transition section and an outlet conduit (14’9” diameter). Each of the control section conduits has a service gate (5’8” x 10’) and an emergency gate (5’8” x 10’). The controlling invert elevation of the main outlet is at 2473.76 feet NAVD 88 and

is located in the approach channel. The outlet structure at the downstream slope of the Main Dam was constructed to allow for direct releases through the power generation facilities at the toe operated by Isabella Partners.

The spillway consists of an un-gated concrete ogee section located at the left abutment of the Main Dam. The elevation of the ogee crest is 2609.26 feet NAVD 88 with a length of 140 feet. The capacity of the spillway is 52,700 cubic feet per second (cfs) at the spillway flood pool elevation of 2630.76 feet NAVD 88. The spillway approach and exit were excavated into rock except where it is in contact with the Main Dam embankment.

The Borel Canal is located underneath the reservoir for the purpose of water delivery from the North Fork of the Kern River to the SCE Power Plant during low reservoir elevations. The original construction of the Borel Canal began in 1897 and was completed in 1904. The head works to the open channel canal is located at the North Fork and runs along the floor of the reservoir for approximately 5 miles to the Auxiliary Dam. The Auxiliary Dam was constructed on top of the canal in the early 1950's (Station 63+80). The open channel canal continues downstream of the dam to the SCE power plant which is located approximately 7 miles downstream. The outlet works at the Auxiliary Dam is used to restrict releases to the Borel Canal to a maximum of 605 cfs. A 12-inch bypass valve is provided in each barrel to allow for fine regulation of canal releases; these two valves have never been used. The portion of the canal beneath the dam consists of a 524.5 foot-long, reinforced-concrete, double-barrel conduit within the Auxiliary Dam foundation that is composed of two rectangular chambers with opening dimensions of 5'8" x 10' each, separated by 1'8" thick concrete wall. A vertical control tower was constructed on top of the conduit 55 feet upstream of the Auxiliary Dam axis. Upstream and downstream of the Auxiliary Dam, the canal has a trapezoidal cross section, with a bottom width of 23 feet and side slopes of 1.5H : 1V. The realignment construction of Borel Canal, which began in November 1951, involved removing the original canal within the footprint of the Auxiliary Dam, placing fill for the Auxiliary Dam embankment in two separate sections east and west of the proposed relocated canal location, partially excavating the conduit section, and construction of the conduit. The water table in the vicinity of the Borel Canal was high, so the excavation for the new Borel Canal conduit required the use of French drains and pumps. Sheet piling was used to shore the excavation, and concrete was placed to create the walls of the new conduit. The conduit has joints spaced generally at 20 feet on center with reinforced concrete collars constructed around each joint. Several years after construction, it was discovered that the old Borel Canal had been built on a "very poor sand fill" from the upstream to the downstream toe of the dam.

In September 2006 USACE initiated an emergency deviation from the Water Control Plan for Isabella Dam and Lake, revised January 1978, to operate the project and maintain the reservoir elevation at or below 2,585.5 feet, Isabella Project Datum (storage at or below approximately 356,700 acre-feet). The purpose of this emergency deviation was to lower the lake level to a safe and acceptable elevation/capacity based upon recent results of USACE's seepage investigations. USACE has concluded that Isabella Lake Dam could fail due to seepage at gross pool, or during an earthquake. While a failure might be a remote probability, it was high enough to warrant this deviation. A failure at high reservoir levels would result in an uncontrollable release of water and would flood communities downstream of the lake. USACE also determined that the planned

deviation restricting the reservoir level would be necessary until the permanent solution for the dam safety remediation is implemented.

The low-flow Borel Canal was constructed in 1904 to deliver water from the Kern River to a power plant six miles downstream of where the Auxiliary Dam now sits. The canal was rerouted within the lake, and the Auxiliary Dam was constructed over it. Construction required relocating roads and utilities and acquiring land. The town of Kernville was moved to its new location, upstream on the North Fork by 1952, and the town of Isabella was moved below the auxiliary dam and is now named Lake Isabella. Buildings and other floatable material were removed from the lake, and vegetation was removed in the vicinity of the Main Dam and from each side of the main river channel upstream of the Borel Canal. Construction of the Auxiliary Dam began in March of 1948 and was completed in January 1953. Construction of the Spillway began in November of 1951 and was completed in January 1953. The Main Dam was constructed from May 1952 to March 1953. In April 1953, water was stored in the project for the first time, and the project was first operated for water supply conservation in April 1954. Construction of the Isabella Partners power plant on the Main Dam outlet began in August 1989 and was completed in December 1990. Power production began in June 1991.

USACE performed a cone penetration test in 2005 that alerted engineers to potential seepage problems with the auxiliary dam. Tests also revealed that uplift pressures along portions of the auxiliary dam during normal lake levels were much higher than expected. In 2005, USACE built a gravel/stabilizing berm along the downstream toe of the auxiliary dam to stabilize the location and counteract high foundation pore pressures.

The principal structural feature of the Isabella Project area is the Kern Canyon Fault (KCF) system, interpreted as a fault with a complex history of extensive deformation through geologic time. The fault exhibits about nine miles of right-lateral offset of bedrock units near Isabella Lake. This right-lateral offset of the fault has been interpreted to have occurred approximately 80 to 90 Ma, contemporaneous with the emplacement of plutons in the Sierra Nevada. The middle or Isabella segment of the Kern Canyon Fault runs directly beneath the right abutment of the Auxiliary Dam. The Kern Canyon Fault was originally thought to be inactive; however, a comprehensive characterization was conducted and it is now considered a primary seismogenic source in the southern Sierra Nevada in Tulare and Kern counties, California. There have been two datable surface rupturing events at the dam in the last 10,000 years at M6.5 - M7.1. The average offset is 1.1 meters and the upper limit is estimated to be 2.1 meters (based on the 2 events only). The estimated recurrence is approximately 3,200 years. The investigations provide direct input for assessing the seismic stability of the Isabella Lake Main Dam and Auxiliary Dam.

Dam Safety studies were initiated in 2002 and have identified seismic, hydrologic (potential overtopping in a flood), and seepage deficiencies. The seepage and seismic issues have led to the reservoir's allowable maximum capacity to be reduced to 63% of normal capacity. This capacity restriction is an interim risk reduction measure (IRRM) that will remain in place until a permanent modification is constructed.

The existing Isabella Lake dams were authorized for construction by the Flood Control Act of 1944 (Public Law 78-534, Chapter 665, Section 10, page 901), December 22, 1944, became fully

operational in 1953. Currently, the reservoir is not fully able to provide the benefits for which it was authorized and constructed. Screening-level Portfolio risk assessments were completed by HQUSACE on 26 July 2005 which classified Isabella Project as a Dam Safety Action Classification (DSAC) I (highest risk) dam due to a combination of seismic, hydrologic (inadequate spillway capacity), and seepage issues, with the combination of a large population at risk (PAR) located downstream within the dam failure inundation zone.

DSAC I is the highest of five risk classifications. In Engineer Regulation ER 1110-2-1156, DSAC I is described as urgent and compelling, and states that it is for those dams where progression toward failure is confirmed to be taking place under normal operations and the dam is almost certain to fail under normal operations within a time frame from immediately to within a few years without intervention; or, the combination of life or economic consequences with probability of failure is extremely high.

Remediation is necessary to address the dam safety deficiencies at Isabella Lake dams. Currently, a reservoir restriction is in effect; however, the restriction has resulted in economic loss to water users when water releases occur to limit water levels as part of flood risk management efforts. In 2006, seismic, seepage, hydrologic, and hydraulic investigations and studies began at both dams to characterize the site conditions and evaluate the seismic and seepage issues and risk. Investigations have continued through 2011. These investigations and studies will culminate in an array of potential remediation alternatives (also known as risk management plans).

OBJECTIVES

The objective of this work is to conduct an independent external peer review (IEPR) of the Engineering, Economic, and Environmental Evaluation of the Geotechnical, Hydrological, Hydraulic, Structural, and Economic Aspects of the Dam Safety Modification Report for Isabella Lake Dam, California (hereinafter: Isabella Dam Safety IEPR) in accordance with the Department of the Army, USACE, Water Resources Policies and Authorities' *Civil Works Review Policy* (EC 1165-2-209) Change 1 dated January 31, 2012, and the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* released December 16, 2004.

Peer review is one of the important procedures used to ensure that the quality of published information meets the standards of the scientific and technical community. Peer review typically evaluates the clarity of hypotheses, validity of the research design, quality of data collection procedures, robustness of the methods employed, appropriateness of the methods for the hypotheses being tested, extent to which the conclusions follow from the analysis, and strengths and limitations of the overall product.

The purpose of the IEPR is to assess the "adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used" (EC 1165-2-209; p. D-4) for the Isabella Dam Safety IEPR documents. The IEPR will be limited to technical review and will not involve policy review. The IEPR will be conducted by subject matter experts (i.e., IEPR panel members) with extensive experience in geotechnical engineering, civil/structural engineering, hydraulic and hydrology engineering, plan formulation, NEPA impact assessment,

engineering geology, and economic issues relevant to the project. They will also have experience applying their subject matter expertise to planning and design of dam safety modification/remediation actions.

The Panel will be "charged" with responding to specific technical questions as well as providing a broad technical evaluation of the overall project. Per EC 1165-2-209, Appendix D, review panels should identify, explain, and comment upon assumptions that underlie all the analyses, as well as evaluate the soundness of models, surveys, investigations, and methods. Review panels should be able to evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable. Reviews should focus on assumptions, data, methods, and models. The panel members may offer their opinions as to whether there are sufficient analyses upon which to base a recommendation.

DOCUMENTS PROVIDED

The following is a list of documents, supporting information, and reference materials that will be provided for the review.

Documents for Review

The review documents (listed in the table below) will be provided by USACE in two stages: the Initial Review Documents will be available by June 25, 2012 and the Senior Oversight Group (SOG) Review Documents will be available by July 24, 2012.

Title	Documents	
	Initial Review (Available 6/25/2012)	SOG Review (Available 7/24/2012)
Baseline Risk Assessment Report	X	
Baseline Risk Assessment Report Technical Appendix	X	
Hydrology Report	X	
Screening Portfolio Risk Analysis	X	
Approved Review Plan	X	
Dam Safety Modification Report	X[1]	X[2]
Dam Safety Modification Report Appendices	X[1]	X[2]
MCACES and Risk Based Cost Estimate	X[1]	X[2]
Final Draft Environmental Impact Statement	X[1]	X[2]
PED Project Management Plan	X[1]	X[2]
Real Estate Design Memorandum (REDM)/Relocation Plan	X[1]	X[2]

[1]Draft versions of these documents will be provided by USACE on June 25, 2012 with the Initial Review Documents.

[2]USACE will provide revised versions of these documents after the SOG meeting; these documents may not be available in final format.

Supporting Documents

The following supporting documents will be provided by USACE for information purposes:

- Isabella Dam Safety Assurance Quality Control Plan
- Approved Review Plan for Isabella Dam Safety Modification Study
- SPRA Documentation Report for Isabella Dam
- Isabella Major Rehabilitation Report

Documents for Reference

The following references to USACE regulations shall be followed in conducting the IEPR. The most recent Engineering Regulation (ER) documents shall be used and are available at http://140.194.76.129/publications/ or http://www.hnd.usace.army.mil/techinfo/engpubs.htm.

General

- CECW-CP Memorandum dated March 31, 2007
- Office of Management and Budget's Final Information Quality Bulletin for Peer Review released December 16, 2004.
  - EC 1105-2-410, Review of Decision Documents, 22 August 2008
  - EC 1105-2-412, Assuring Quality of Planning Models, 31 March 2011
  - EC 1165-2-209, Water Resources Policies and Authorities - Civil Works Review Policy, Change 1, 31 January 2012
  - EC 1165-2-210, Water Resources Policies and Authorities - Water Supply Storage and Risk Reduction Measures for Dams, 9 April 2010
  - EP 1110-2-13, Dam Safety Preparedness, 28 June 1996
  - ER 1110-1-12, Engineering and Design - Quality Management, 31 March 2011 (change 2)
  - ER 1110-2-1150, Engineering and Design - Engineering and Design for Civil Works Projects, 31 August 1999
  - ER 1110-2-1155, Engineering and Design - Dam Safety Assurance Program, 12 September 1997
  - ER 1110-2-1156, Engineering and Design - Safety of Dams - Policy and Procedures, 28 October 2011
  - ER 1110-1-8159, Engineering and Design - DrChecks, 10 May 2001.
  - Water Resources Development Act of 2007, Sections 2034 & 2035, Pub. L. 110-114. Privacy Act, 5 U.S.C. § 522a as amended

Environmental/Planning

- ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies. CECW-P, 28 December 1990
- Council on Environmental Quality. 1978. Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act. 40 CFR Parts 1500-1508. Washington, DC: U.S. Government Printing Office (November 29, 1978).
- ER 200-2-2, Environmental Quality, Procedures for Implementing NEPA. CECWRE (now CECW-A), 4 March 1988.

Engineering Geology

- EM 1110-1-1804, Engineering and Design - Geotechnical Investigations, 01 January 2001
- ER 1110-1-1807, Engineering and Design - Procedures for Drilling in Earth Embankments, 01 March 2006
- EM 1110-1-2908, Engineering and Design - Rock Foundations, 30 November 1994
- EM 1110-2-2901, Engineering and Design - Tunnels and Shafts in Rock, 30 May 1997
- EM 1110-1-1802, Geophysical Exploration for Engineering and Environmental Investigations, 31 August 1995
- ER 1110-2-1806, Engineering and Design - Earthquake Design and Evaluation for Civil Works Projects, 31 July 1995

Geotechnical Engineering

- EM 1110-2-1901, Engineering and Design - Seepage Analysis and Control for Dams, 30 April 1993
- EM 1110-2-1902, Engineering and Design - Slope Stability, 31 October 2003
- EM 1110-2-2300, Engineering and Design - General Design and Construction Considerations For Earth and Rock-Fill Dams, 30 July 2004
- EM 1110-2-1908, Engineering and Design - Instrumentation of Embankment Dams and Levees, 30 June 1995
- ER 1110-2-103, Engineering and Design - Strong-Motion Instruments for Recording Earthquake Motions on Dams, 10 December 1981
- ER 1110-2-110, Engineering and Design - Instrumentation for Safety Evaluations of Civil Works Projects, 8 July 1985

Materials Engineering

- ER 1110-1-1901, Project Geotechnical and Concrete Materials Completion Report for Major USACE Project, 22 February 1999
- EM 1110-2-1906, Laboratory Soils Testing, 20 August 1986
- EM 1110-2-2301, Test Quarries and Test Fills, 30 September 1994
- ER 1110-2-1911, Engineering and Design - Construction Control for Earth and Rock-Fill Dams, 30 September 1995

Structural Engineering

- EM 1110-2-2400, Engineering and Design - Structural Design and Evaluation of Outlet Works, 02 June 2003
- ER 1110-2-100, Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures, 15 February 1995

Hydraulic Engineering

- EM 1110-2-1602, Engineering and Design - Hydraulic Design of Reservoir Outlet Works, 15 October 1980
- EM 1110-2-1603, Engineering and Design - Hydraulic Design of Spillways, 16 January 1990

- EM 1110-2-2902, Engineering and Design - Conduits, Culverts, and Pipes, 31 March 1998
- EM 1110-2-3600, Engineering and Design - Management of Water Control Systems, 30 November 1987
- ER 1110-8-2 (FR), Inflow Design Floods for Dams and Reservoirs, 1 March 1991
- ER 1110-2-240, Water Control Management, 8 October 1998
- ER 1130-2-530, Flood Control Operations and Maintenance Policies, 30 October 1996
- ER 1110-2-8156, Preparation of Water Control Manuals, 31 August 1995

SCHEDULE

This draft schedule below is based on the June 25, 2012 receipt of the Initial Review Documents and the July 24, 2012 receipt of the SOG Review Documents.

Task	Action	Days to Complete	Due Date
Conduct Peer Review	Battelle sends Initial Review Documents to Panel	Within 1 day of Panel being under subcontract	7/2/2012
	Battelle convenes kickoff meeting with Panel	Within 1 day of Panel being under subcontract	7/3/2012
	USACE/Battelle convenes kickoff/site meeting with Panel	Site Visit on July 10, 2012 (Total travel is 3 days: 1 day travel/1 day site visit/1 day travel)	7/9/2012 - 7/11/2012
	SOG Review Documents Available/Battelle sends to Panel	Anticipated by 7/24/2012	7/24/2012
	Battelle convenes mid-point review teleconference with USACE after receipt of SOG Review Documents for Panel to ask clarifying questions	Within 1 day of receipt of SOG Review Documents	7/25/2012
	Panel members complete their individual reviews of Initial Review Documents and SOG Review Documents	Within 20 days of Battelle/Panel kick-off meeting	7/31/2012
Prepare Final Panel Comments and Final IEPR Report	Battelle provides Panel merged individual comments and talking points for Panel Review Teleconference	Within 3 days of panel members completing their review	8/3/2012
	Battelle convenes Panel Review Teleconference	Within 3 days of panel members completing their review	8/3/2012
	Final Panel Comments finalized	Within 3 days of receipt of draft Final Panel Comments	8/14/2012
	Battelle provides Final IEPR Report to Panel for review	Within 1 day of Final Panel Comments being finalized	8/15/2012
	Panel provides comments on Final IEPR Report	Within 1 day of receipt of Final IEPR Report	8/16/2012
	***Battelle submits Final IEPR Report to USACE**	Within 3 days of the Final Panel Comments being finalized	8/17/2012
Comment/ Response Process	Battelle convenes teleconference with Panel to review the Post-Final Panel Comment Response Process (if necessary)	Within 2 days of submittal of Final IEPR Report	8/21/2012

Task	Action	Days to Complete	Due Date
	USACE provides draft PDT Evaluator Responses to Battelle	Within 7 days of receipt of Final IEPR Report	8/28/2012
	Battelle provides the Panel the draft PDT Evaluator Responses	Within 0 days of receipt of draft PDT Evaluator Responses	8/28/2012
	Panel members provide Battelle with draft comments on draft PDT Evaluator Responses (i.e., draft BackCheck Responses)	Within 3 days of receipt of draft PDT Evaluator Responses from Battelle	8/31/2012
	Battelle convenes teleconference with Panel to discuss draft BackCheck Responses	Within 1 day of receipt of draft BackCheck Responses	9/4/2012
	Battelle convenes teleconference with Panel and USACE to discuss Final Panel Comments and draft responses	Within 5 days of USACE providing draft PDT Evaluator Responses	9/5/2012
	USACE inputs final PDT Evaluator Responses in DrChecks	Within 5 days of Final Panel Teleconference	9/12/2012
	Battelle provides PDT Evaluator Responses to Panel	Within 0 days of final PDT Evaluator Responses being available	9/12/2012
	Panel members provide Battelle with final BackCheck Responses	Within 3 days of receipt of final PDT Evaluator Responses	9/17/2012
	Battelle inputs the Panel's BackCheck Responses in DrChecks	Within 5 days of notification that USACE final PDT Evaluator Responses have been posted in DrChecks	9/19/2012
	*Battelle submits pdf printout of DrChecks project file	Within 1 day of DrChecks closeout	9/20/2012

CHARGE FOR PEER REVIEW

Members of this IEPR Panel are asked to determine whether the technical approach and scientific rationale presented in the Isabella Dam Safety IEPR documents are credible and whether the conclusions are valid. The Panel is asked to determine whether the technical work is adequate, competently performed, properly documented, satisfies established quality requirements, and yields scientifically credible conclusions. The Panel is asked to provide feedback on the economic, engineering, environmental resources, and plan formulation. The panel members are not being asked whether they would have conducted the work in a similar manner.

Specific questions for the Panel (by report section or Appendix) are included in the general charge guidance, which is provided below.

General Charge Guidance

Please answer the scientific and technical questions listed below and conduct a broad overview of the Isabella Dam Safety IEPR documents. Please focus your review on the review materials assigned to your discipline/area of expertise and technical knowledge. Even though there are some sections with no questions associated with them, that does not mean that you cannot comment on them. Please feel free to make any relevant and appropriate comment on any of the sections and appendices you were asked to review. In addition, please note the following guidance. Note that the Panel will be asked to provide an overall statement related to 2 and 3 below per USACE guidance (EC 1165-2-209; Appendix D).

1. Your response to the charge questions should not be limited to a “yes” or “no.” Please provide complete answers to fully explain your response.
2. Assess the adequacy and acceptability of the engineering, economic and environmental assumptions and projections, project evaluation data, and any biological opinions of the project study.
3. Assess the adequacy and acceptability of the economic analyses, environmental analyses, engineering analyses, formulation of alternative plans, methods for integrating risk and uncertainty, and models used in evaluating economic or environmental impacts of the proposed project.
4. If appropriate, offer opinions as to whether there are sufficient analyses upon which to base a recommendation.
5. Identify, explain, and comment upon assumptions that underlie all the analyses, as well as evaluate the soundness of models, surveys, investigations, and methods.
6. Evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable
7. Please focus the review on assumptions, data, methods, and models.

Please **do not** make recommendations on whether a particular alternative should be implemented, or whether you would have conducted the work in a similar manner. Also please **do not** comment on or make recommendations on policy issues and decision making.

Comments should be provided based on your professional judgment, **not** the legality of the document.

1. If desired, panel members can contact one another. However, panel members **should not** contact anyone who is or was involved in the project, prepared the subject documents, or was part of the USACE Independent Technical Review.
2. Please contact the Battelle Project Manager (Lauren Baker-Hart, bakerhartl@battelle.org) or Deputy Program Manager (Rachel Sell (sellr@battelle.org) for requests or additional information.
3. In case of media contact, notify the Battelle Program Manager, Karen Johnson-Young (johnson-youngk@battelle.org) immediately.
4. Your name will appear as one of the panel members in the peer review. Your comments will be included in the Final IEPR Report, but will remain anonymous.

Please submit your comments in electronic form to Lauren Baker-Hart, bakerhartl@battelle.org and Rachel Sell, sellr@battelle.org, no later than July 31, 2012, COB ET.

Independent External Peer Review
of the
Independent External Peer Review (IEPR) of the Engineering, Economic, and Environmental Evaluation of the Geotechnical, Hydrological, Hydraulic, Structural and Economic Aspects of the Dam Safety Modification Report for
Isabella Lake Dam, California

Charge Questions and Relevant Sections As Supplied By USACE

General

1. Were all models used in the analyses used in an appropriate manner?
2. Are the models used sufficiently discriminatory to support the conclusions drawn from them (i.e., identify meaningful differences between alternatives)?
3. Were risk and uncertainty sufficiently considered?
4. Are potential life safety issues accurately and adequately described under existing, future without project, and future with project conditions?
5. In your opinion, are there sufficient analyses upon which to base the recommendation?

Problem, Needs, Constraints, and Opportunities

6. Are the problems, needs, constraints, and opportunities adequately and correctly defined?
7. Do the identified problems, needs, constraints, and opportunities reflect a systems, watershed, and/or ecosystem approach, addressing a geographic area large enough to ensure that plans address the cause and effect relationships among affected resources and activities that are pertinent to achieving the study objectives; i.e., evaluate the resources and related demands as a system?
8. Did the study address those resources identified during the scoping process as important in making decisions relating to the study?

Existing and Future Without Project Resources

9. Has the character and scope of the study area been adequately described and is the identified study area appropriate in terms of undertaking a systems/watershed/ecosystem based investigation?
10. Do you agree with the general analyses of the existing social, financial, and natural resources within the study area?
11. For your particular area of expertise, provide an in-depth review of whether the analyses of the existing social, financial, and natural resources within the project area are sufficient to support the estimation of impacts of the array of alternatives.
12. Given your area of expertise, does this section appropriately address the existing conditions of all resources pertinent to the study?
13. Were there surveys conducted to evaluate the existing social, financial, and natural resources adequate? If not, what types of surveys should have been conducted?

14. Were socioeconomic conditions adequately addressed? Were specific socioeconomic issues not addressed?
15. Was the hydrology discussion sufficient to characterize current baseline conditions and to allow for evaluation of how forecasted conditions (with and without proposed actions) are likely to affect hydrologic conditions? Please comment on the completeness of the discussion on the relationship between subsurface hydrology and the hydrodynamics of the project area.
16. Was the discussion of natural resources sufficient to characterize current baseline conditions and to allow for evaluation of forecasted conditions (with and without proposed actions)?
17. Were the assumptions used as the basis for developing the most probable future without project conditions reasonable? Were adequate scenarios effectively considered (applied during analyses where relevant and/or reasonably investigated)? Were the potential effects of climate change addressed?
18. Are the future conditions expected to exist in the absence of a Federal project logical and adequately described and documented?
19. Please comment on the conclusion of the most probable future without project condition. Do you envision other potential probable outcomes?

Plan Formulation/Evaluation

20. Was a reasonably complete array of possible measures considered in the development of alternatives?
21. Did the formulation process follow the requirement to avoid, minimize, and then mitigate adverse impacts to resources?
22. Does each alternative meet the formulation criteria of being effective, efficient, complete and acceptable? Definitions -
23. Were the assumptions made for use in developing the future with project conditions for each alternative reasonable? Were adequate scenarios considered? Were the assumptions reasonably consistent across the range of alternatives and/or adequately justified where different?
24. Are the changes between the without and with project conditions adequately described for each alternative?
25. Are the uncertainties inherent in our evaluation of benefits, costs, and impacts, and any risk associated with those uncertainties, adequately addressed and described for each alternative?
26. Are future Operation, Maintenance, Repair, Replacement, and Rehabilitation efforts adequately described and are the estimated cost of those efforts reasonable for each alternative?
27. Please comment on the screening of the proposed alternatives. Are the screening criteria appropriate? In your professional opinion, are the results of the screening acceptable? Were any measures or alternatives screened out too early?

28. Were the engineering, economic, and environmental analyses used for this study consistent with generally accepted methodologies? Why or why not?
29. Does any alternative include identified separable elements (a portion of a project that is physically separable, and produces hydrologic effects or physical or economic benefits that are separately identifiable from those produced by other portions of the project)? If so, is each identified separable element independently justified and are the benefits, costs, and effects of the separable elements correctly divided?

Recommended Plan

30. Comment on whether you agree or disagree with how the selected alternative was formulated and selected. Comment on the plan formulation. Does it meet the study objectives and avoid violating the study constraints?
31. Are there any unmitigated environmental impacts not identified and, if so, could they impact plan selection?
32. Please comment on the likelihood of the recommended plan to achieve the expected outputs.
33. Please comment on the completeness of the recommended plan, i.e., will any additional efforts, measures, or projects be needed to realize the expected benefits?
34. Please comment on the appropriateness of location, sizing, and design of plan features.

Dam Safety

35. Has the condition of the dam; including the design and construction of the dam and appurtenant features, project maintenance, previous major rehabilitations and dam safety modifications, and the dam's performance over time, been clearly described?
36. Is there sufficient information presented to identify, explain, and comment on assumptions that underlie engineering analyses? Why or why not?
37. Do the physical data and observed data provide adequate information to characterize the project and its performance?
38. Have all characteristics, conditions, and scenarios leading to failure, along with the potential consequences, been identified? Have all pertinent factors, including population at risk, been considered in the estimation of risk for the baseline condition? Have all the dam safety issues and opportunities been identified?
39. Have all alternatives received sufficient consideration, including those involving lowering, breaching, or removing the dam?
40. Have the potential impacts of each alternative been clearly and adequately presented, including expected risk reduction, residual risk, changes in existing outputs of the project, potential mitigation, implementation schedules and cost?

Project-Specific Questions

41. Are the methods used to evaluate the condition of Isabella Lake Dam adequate and appropriate given the circumstances?
42. Have the hazards that affect the structure been adequately described for Isabella Lake Dam?
43. Are there any additional analyses or information available or obtainable that would affect decisions regarding Isabella Lake Dam?
44. Has anything significant been overlooked in the development of the assessment of Isabella Lake Dam or the alternatives?
45. Have appropriate considerations been made to support the decisions regarding Isabella Lake Dam?
46. For the selected alternative:
    - Are the quality and quantity of the surveys, investigations, and engineering sufficient for a conceptual design?
    - Are the models used to assess hazards appropriate?
    - Are the assumptions made for the hazards appropriate?
    - Does the analysis adequately address the uncertainty given the consequences associated with the potential for loss of life for this type of project?