



THREE RIVERS LEVEE IMPROVEMENT AUTHORITY

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Feather River East Setback Levee Safety Assurance Review Plan March 31, 2009

The approval of the Three Rivers Levee Improvement Authority's (TRLIA) Section 408 alteration for the Feather River Setback levee Project dated December 12, 2008 included a condition that a Safety Assurance Review (SAR) in compliance with Section 2035 of WRDA 2007 be performed. Preliminary HQUSACE guidance on implementation of Section 2035 and the requirements for compliance are expected in mid January. TRLIA has reviewed the language in Section 2035 and guidance for other similar type reviews. TRLIA has already taken actions to ensure an independent review of its Feather River Setback Levee design and believes that these actions satisfy Section 2035. This document will present information on and documentation of the independent review that has occurred along with a plan to continue the SAR during the remainder of construction. The intent of this document is to satisfy the requirement for a SAR as specified in the December, 12, 2008 Feather River Setback Levee Project Section 408 approval.

Background

The purpose of the Feather River Setback Levee Project is to improve flood protection for the Reclamation District (RD) 784 service area in southwestern Yuba County. The specific project design objective is to provide increased flood protection against the flood event with a 0.5 percent chance of occurrence in any given year (referred to herein as the 200-year flood event). References in this document to levels of flood protection are based on the deterministic approach (the current Federal Emergency Management Agency [FEMA] method) and should not be taken as Corps concurrence that such levels will be achieved when the Corps probabilistic approach is utilized to define system performance.

As part of the Feather River Setback Levee Project, a new levee is proposed in Segment 2 of the Feather River east levee (Project Levee Mile (PLM) 17.2 to PLM 23.4). The Feather River east levee is part of the Sacramento River Flood Control Project (SRFCP). The proposed setback levee is designed to (1) decrease flood stages in the Feather River between Shanghai Bend and Star Bend (i.e., along the setback location) by increasing the channel width; and (2) provide a well-designed, well-constructed levee using up-to-date technology. Lowering flood stages along this part of the Feather River channel provides

a hydraulic benefit to the system by reducing the backwater effects on flood stages upstream in both the Feather and Yuba Rivers. Lowering flood stages and replacing the existing levee with a well-designed, well-constructed levee using up-to-date construction standards reduces the potential for levee failures in this channel reach that has historically been plagued by levee instability and failures.

The proposed Project levee alteration consists of a 5.7-mile-long setback levee located approximately 0.5 mile to the east of the existing Feather River east levee in Segment 2. The proposed alignment for the setback levee is shown on Figure 2, Regional Geology and Setback Levee Alignment. This alignment was selected to achieve substantial (up to 3 feet) reductions in river stage while maintaining a Feather River floodway width that is consistent with upstream and downstream reaches of the river. The setback levee will reduce the length of the Feather River east levee by approximately 0.5 mile. A soil-bentonite cutoff wall with variable depth of 50 to 75 feet will be constructed through the foundation of the setback levee where permeable soil layers could allow underseepage to occur. The setback levee will transition into the existing Feather River levee at two tie-in sections. These will be constructed by excavation and replacement of an approximately 300-foot-long section of the existing levee at each end of the setback levee, and by buttressing the existing levee immediately adjacent to the replacement section. The setback levee design profile will rise from crown elevation 66.2 feet (NGVD 29) at the south end to crown elevation 76.9 feet (NGVD 29) at the north end. These elevations match the existing levee elevations at the tie-in points. Levee elevations between the tie-in points are also set to match the existing levee elevations at corresponding locations. The existing levee has been reconstructed by the Corps to provide a minimum of 3 feet of freeboard above the 1957 design profile. Because the levee setback would lower most flow profiles by widening the flow channel, it follows that the setback levee, if constructed to the crown elevations described above, would also have at least 3 feet of freeboard above the 1957 design profile. In this reach of the Feather River, the 57 Design Profile is equal to or higher than the 200-year flood profile. Camber will be provided above the design crown elevation to compensate for estimated post-construction foundation and embankment settlement. In general, the height of the setback levee will range from about 20 to 30 feet above ground surface. Camber will range from 0.3 foot to 1.0 foot depending on foundation conditions.

The levee embankment is being constructed with soils meeting specified plasticity and gradation requirements. Levee template is 20 foot crown width with 3(H) to 1(V) sideslopes on both land and water side. Subsurface explorations in the southern portion of the levee setback alignment indicate the presence of soft, compressible silt and clay in the levee foundation. Stability berms are required along the landside and waterside toes of the levee from about Station 11+00 to about Station 41+00 to provide for the required factor of safety under end-of-construction conditions. In addition, a stability berm will be provided on the landside of the setback levee in two locations (Sta 0+00 to 11+00 and 41+00 to 53+00) to mitigate potential differential settlement. A waterside stability berm is also required from about Station 196+00 to about Station 212+00. An existing interior drainage pump station (Pump Station No. 3), currently located at the western end of Plumas Lake Canal where it meets the landside toe of the existing levee, will be relocated

to the landside toe of the setback levee. After the setback levee is completed, most of the existing levee will be removed to allow water to flow into the setback area during high river stages. Degradation of the levee will in effect incorporate an approximately 1,500-acre setback area (including the area between the new and existing levee and the footprint of the existing levee) into the current Feather River floodplain. The material from the existing levee will be reused to backfill borrow areas and for other project grading needs.

Detailed design of the Feather River Setback Levee was initiated in March 2007 and completed in April 2008. A summary of the setback levee design is presented in the Feather River Setback Levee Issued-for-Approval Design Report dated January 2008 (Design Report). Physical construction of the setback features not subject to Section 408 approval or requiring a Section 404 Permit was initiated in June of 2008.

Purpose of a SAR

Section 2035 requires that flood damage reduction projects be reviewed by independent experts if it is determined that a review by independent experts is necessary to assure public health, safety, and welfare. In determining whether a review of design and construction of a project is necessary the following factors will be considered:

- a. Where the failure of the project would pose a significant threat to human life;
- b. Cases where information is based on novel methods, presents complex challenges for interpretations, contains precedent-setting methods or models, or presents conclusions that are likely to change prevailing practices;
- c. The project involves the use of innovative materials or techniques;
- d. The project design lacks redundancy, robustness, or resiliency:
 - (1) Redundancy. The use of multiple lines of defense that are linked to potential failure modes. The most vulnerable failure modes need the greatest redundancy.
 - (2) Robustness. The use of more conservative assumptions to increase capacity to compensate for greater degrees of uncertainty and risk.
 - (3) Resilience. The use of enhancements to improve the ability of the system to sustain loads greater than the design load to achieve gradual failure modes over some duration rather than sudden failure modes.
- e. The project has unique construction sequencing or acquisition plans;
- f. The project has a reduced or overlapping design construction schedule; or
- g. As directed by the Chief of Engineers

A SAR shall include participation by independent experts selected from among individuals who are distinguished experts in engineering, hydrology, or other appropriate disciplines. Independent in this instance means that the person selected to review the design was not involved in the original design, has no conflict of interest, and does not carry out or advocate for or against Federal water resources projects. The SAR shall inform on the adequacy, appropriateness, and acceptability of the design and construction activities for the purpose of assuring public health, safety, and welfare. It shall focus on whether the assumptions made for the hazards remain valid as additional knowledge is gained and the state of the art evolves.

SARs should identify, explain, and comment upon assumptions that underlie engineering analyses, as well as evaluate the soundness of models, surveys, investigations, and methods. A review panel should bring important issues to the attention of the agency. Review panels should be able to evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable.

Independent reviews are not expected to resolve fundamental disagreements and controversies. Reviewers will aim to draw distinctions between criticisms of the regulations and guidelines and criticisms of how well TRLIA conformed to the guidance. Reviews should focus on assumptions, data, methods, and models.

SARs will assist USACE in making decisions, but reviewers should not be asked to make decisions. Reviewers should avoid findings that become “directives” in that they call for modifications or additional studies or suggest new conclusions and recommendations. In such circumstances the reviewers may have assumed the role of advisors as well as reviewers, thus introducing bias and potential conflict in their ability to provide objective review later in the project. Reviewers engaged in the review processes should be selected based upon their professional expertise and should not be “stakeholders”.

Frequent communication will help the independent review panel understand the technical and practical implications of its recommendations. Review panels should highlight areas of disagreement and controversies that may need resolution.

An issue that frequently arises in review, and one not always easily agreed upon, is defining a review panel’s boundaries of inquiry. It is not uncommon for an agency or other administrative group to try to limit a review panel’s deliberation. However, the line between technical and policy issues is often blurred, and it is often difficult to clearly separate them. USACE and TRLIA should accept comments, but make a distinction in responses when comments pertain to policy which is beyond the scope of an independent experts review, but elevated to HQUSACE for consideration under a non-project specific policy review. It is important that panelists focus on their review, and not become defenders of their recommendations.

A SAR Plan should establish a milestone schedule aligned with critical features of the project design and construction. The review should complement the Agency Technical Review (ATR) and focus on the kinds of issues highlighted above.

A SAR plan should consider the various components of the project and describe the appropriate level of review for each. Listed below are examples of engineering and construction work products that can be subject to an independent peer review:

- (1) Survey and Investigation studies to insure sufficient quality of data;
- (2) Design Documentation Reports, the record of final design;

- (3) Engineering Documentation Reports, a report to support when there are minor changes in design and costs;
- (4) Value Engineering studies;
- (5) The Design for remediation of Hazardous, Toxic, and Radioactive Waste;
- (6) Utility relocations;
- (7) Physical Model Studies;
- (8) Engineering support to preparation of Project Cooperation Participation Agreements;
- (9) Plans, specifications, and cost estimates of critical project features;
- (10) Engineering considerations and instructions for field personnel;
- (11) Project O&M Manuals.
- (12) Critical Construction Placement
- (13) Construction Foundation and Concrete Reports
- (14) Contractor Submittals
- (15) Contract Change Orders
- (16) Post Project Monitoring Plans;
- (17) Post Construction Reports such as Foundation Completion, Embankment Criteria and Performance Evaluation, and Concrete Materials Reports
- (18) Acquisition Plans

Review reports should be provided at the minimum at the record of final design in the Design Documentation Report; at the completion of the plans, specifications, and cost estimate; at the midpoint of construction for multi-year construction contracts, prior to final inspection; and at critical construction milestones. The SAR panel has the option to request additional or alternate milestones where warranted and reasonable. A SAR Plan should offer a suggested report outline for each phase. It is highly recommended that the peer review team provide comments that represent the group, be non-attributable to individuals, and where there is lack of consensus, note the non-concurrence and why. The report will contain the panel's analysis, including the panel's assessment of the adequacy and acceptability of the methods, models, and analyses used. All comments in the report will be finalized prior to their release to USACE for each review plan milestone. If the panel does not complete its review in this period, the processing of the project will continue without delay.

DrChecks will be used to manage all reviews documenting the panel's comments and USACE responses. USACE shall make all written recommendations of a reviewer or panel of reviewers and related USACE responses of USACE available to the public, including through electronic means on the Internet.

Independent review panels should be able to evaluate whether the interpretations of analysis and conclusions based on analysis are reasonable. To provide effective review, in terms of both usefulness of results and credibility, review panels should be given the flexibility to bring important issues to the attention of decision makers. However, review panels should be instructed to not make a recommendation on whether a particular alternative should be implemented, as the Chief of Engineers is ultimately responsible for

the final decision. External panels may, however, offer their opinions as to whether there are sufficient analyses upon which to base a recommendation.

The independent panel of experts established for a review for a project shall:

- a. Conduct the review for the subject project in a timely manner in accordance with the study and SAR Plan schedule;
- b. Follow the “charge”, but when deemed appropriate by the team lead, feel free to request other products relevant to the project and the purpose of the review.
- c. Receive from USACE any public written and oral comments provided on the project;
- d. Provide timely written and oral comments throughout the development of the project, as requested; and
- e. Submit reports in accordance with the review plan milestones.
- f. The team panel lead shall be responsible for insuring that comments represent the group, be non-attributable to individuals, and where there is lack of consensus, note the non-concurrence and why.

The cost of the independent review panel and the reviews shall be shared in accordance with the work phase and project purpose.

In addition, the review panel should advise whether project features adequately address redundancy, robustness, and resiliency and that the findings during construction reflect the assumptions made during design. Additional reviews will be completed periodically, on a regular schedule, until construction activities are completed.

Independent Review of Design

Because failure of the proposed setback levee would pose a significant threat to human life and to insure that the project would provide adequate redundancy, resiliency, and robustness, TRLIA early recognized the need for independent review of its designs and construction. This independent review would include an assessment of where project risks would be most likely to occur and the magnitude of what those risks might be. For setback levee design and construction, the most significant risks lay in obtaining and analyzing geotechnical information and insuring geotechnical stability. The current levee suffers from significant foundation problems. It is important for the new levee to surmount any foundation seepage problems and have a stable embankment. A two-member Board of Senior Consultants (BOSC) was assembled to provide the independent review. Board members include Dr. Faiz Makdisi and Mr. Donald Babbitt. Because of the need for strong geotechnical expertise, the independent reviewers needed to have a strong background in geotechnical engineering. Both members of the BOSC are recognized experts in flood control projects and geotechnical engineering and were selected because of their extensive experience and applicable expertise. In addition to their design expertise Dr. Makdisi and Mr. Babbitt have also been involved in the evaluation of construction of large embankments as well as serving as resources in addressing problems arising during construction. Credentials for Dr. Makdisi and Mr. Babbitt are provided in Attachment 1 and these credentials are available to the public for information. Dr. Makdisi and Mr. Babbitt are independent from the design and

construction and have no conflicts of interest with respect to the Feather River Setback Levee. Neither they nor any firms that they are associated with have been involved with the initial design of the project. They do not own land in the vicinity of the setback levee footprint nor do they own land in RD 784. Their field of expertise and practice is in geotechnical adequacy of embankment designs and construction and they do not carry out or advocate for or against Federal water resources projects. The BOSC has provided TRLIA with independent reviews of engineering design and construction activities at crucial points in the Feather River Setback design process.

A meeting was held with the BOSC on August 10, 2007 for a SAR of work plans and the Basis of Design Report (60% design submittal). The invitation letter, including questions to be addressed by the BOSC, is included as Attachment 2. The BOSC Letter in response to the first meeting questions is also included in Attachment 2. A second meeting of the BOSC was held on February 19, 2008 for a SAR of the Issued-for-Approval design drawings and technical specifications submittal. The invitation letter for meeting 2, including questions to be addressed by the BOSC, is included as Attachment 3. The BOSC letter in response to the Meeting 2 questions is also included in Attachment 3. In advance of each meeting, the design team prepared an agenda with the questions for which BOSC input was specifically requested, as well as supporting reports and meeting materials. In addition to the BOSC, representatives of TRLIA, the California Department of Water Resources (DWR), the Corps of Engineers (Corps), and the California Central Valley Flood Protection Board (CVFPB) were invited and participated in the BOSC meetings. At the conclusion of each meeting, the BOSC prepared a formal letter report to the questions posed, and the recommendations were addressed in the Design Report.

These reviews were thorough and resulted in additional investigation, analysis and design modifications. Documentation of the review and response process is provided in Attachments 4 and 5. Attachment 4 is Appendix H, Quality Control Record, of the Design Report. This attachment provides initial and final responses to the comments provided on the Basis of Design Report reviewed in August 2007. It also includes a liquefaction analysis accomplished in response to an early comment by the BOSC. Attachment 5 is the Feather River Setback Levee Design Report Addendum No.1 dated April 2008. This Addendum provides resolutions and responses to all comments received on the Issued-for-Approval Design Report, Plans, and Specifications. The Addendum also presents additional information gathered and analysis accomplished to respond to the comments. While the reviews were not accomplished in DrChecks, TRLIA thoroughly captured all comments in a written format and documented that all comments were responded to and issues resolved by completion of design, see Attachments 4 and 5. These attachments which include the BOSC review comments are available online at the TRLIA Website, www.trlia.org. Responses to these comments are also available there.

The Corps and DWR also reviewed the designs developed by TRLIA consultants, and can also be considered an independent peer review. The Corps and DWR did not prepare the designs, have no conflict of interest, and the intent of their review was to ensure that

the features to be constructed would adequately provide flood protection and to assure public health, safety, and welfare.

Redundancy, Robustness, and Resiliency

Redundancy is the use of multiple lines of defense that are linked to potential failure modes. The most vulnerable failure modes need the greatest redundancy.

Robustness is the use of more conservative assumptions to increase capacity to compensate for greater degrees of uncertainty and risk.

Resiliency is the use of enhancements to improve the ability of the system to sustain loads greater than the design load to achieve gradual failure modes over some duration rather than sudden failure modes.

While the review of the design was not exactly framed to specifically address these concepts; the project used design assumptions and includes designed features to assure that the project exhibits redundancy, robustness, and. resiliency. Examples of this are as follows:

- Camber (over-build) of the embankment was added to the design to offset future settlement of the levee and foundation.
- The setback levee will be constructed with compacted clayey material. In areas with greater potential for differential settlement a landside berm with an internal filtered drainage system has been provided, in addition to the full section of the levee embankment. The purpose of this system is to prevent internal erosion of the levee embankment due to possible transverse cracking and seepage along the cracks.
- Seepage analyses indicated that substantial portions of the setback levee alignment would meet seepage gradient criteria without the addition of a cutoff wall. Nonetheless, a cutoff wall was provided in significant portions of these areas to assure underseepage control. In addition, a cutoff wall was provided in all locations where the setback levee crosses recent alluvium, even where the seepage gradient is within criteria without a cutoff wall.
- For seepage analyses, the assumption was made that there is not a waterside blanket that would reduce seepage into the levee foundation. While there is indication of a blanket in many waterside areas, the potential for significant variations in soil stratigraphy and the potential for removal of surface soils from waterside of the embankment due to borrow activities or scour made the assumption of no waterside blanket the prudent design choice. However, to the extent a waterside blanket does exist, the cutoff wall under the levee becomes another line of defense.
- The project design is based on the 200-year water surface. However, the levee was designed to meet the seepage criteria with the water surface at the top of the levee, rather than at the design water surface.
- Relief wells are used in addition to a cutoff wall at the southern quarter of the setback levee alignment. The foundation in this reach has very deep alluvial gravel deposits. Underseepage analysis indicated that in most cases the slurry wall would reduce exit gradients to within design criteria. However, due to the

extent of sand and gravel deposits in this area, it was decided to add relief wells in addition to a cutoff wall to provide additional assurances in controlling underseepage.

- The stability analysis was performed assuming steady-state seepage, thus assuming that a fully developed phreatic surface exists within the levee embankment.
- Levee stability was also checked for the water surface at the top of the levee, a level 3 feet higher than that of the design water surface.
- In reaches of the setback levee alignment with soft, compressible foundation conditions, stability berms were provided to increase the stability safety factor for the end-of-construction condition. Over the long term and as the foundation consolidates, the stability berms increase the stability safety factor of the levee well above the design requirements.
- Where the setback levee ties into the existing levee at the north and south ends, the levee has been thickened by buttressing the landside slope to increase the stability of these critical sections.
- A surplus soil berm has been provided along the waterside toe of the levee. Even though it has not been accounted for in the design, this berm improves the stability of the waterside levee slope, particularly for rapid drawdown conditions.
- A wide landside toe access corridor has been included to provide room for future possible levee modifications and flood fighting.

Independent Review during Construction

Construction of setback levee features not requiring Section 408 or Section 404 approvals was initiated in June of 2008 and earthwork ceased in December 2008 due to wet conditions. It is anticipated that earthwork will continue in March or April 2009 depending on weather conditions. TRLIA continues with independent review during construction by inviting the DWR and the Corps to attend weekly construction meetings to keep apprised of construction progress. These meetings go over progress, immediate future construction efforts, findings made during construction, and any issues that have arisen due to changed conditions or findings that are different than those made during the design. Significant issues would also generate a meeting of the BOSC. Because all independent reviewers cannot attend all of these weekly meetings, meeting minutes and Quality Control and Quality Assurance information is emailed to TRLIA, Corps, DWR, and CVFPB reviewers after each construction meeting. Required quality control and quality assurance data will be documented and certified as it is available commensurate with the Corps of Engineers Sacramento District Quality Control (DQC) and submitted to the BOSC, Corps, DWR and CVFPB reviewers.

Additional SAR will be performed in accordance with the milestones presented below in this plan. As a minimum a SAR will be performed at the midpoint of construction and when changed conditions require any modification to the approved design. TRLIA has two BOSC SARs planned for 2009 which will focus on setback levee construction. TRLIA will schedule a meeting with the BOSC, Corps, DWR and CVFPB reviewers in March 2009 to review construction progress and findings to date. These future SARs shall focus on whether the assumptions made for design remain valid as additional

knowledge is gained and the state-of-the-art evolves. In addition, the independent review team shall advise whether project features adequately address redundancy, robustness, and resiliency; and findings during construction reflect the assumptions made during design. A second meeting is tentatively scheduled for June 2009 when construction is expected to be at its peak. Additional construction reviews would be scheduled based on construction needs or if requested by the Corps or DWR. The same group of independent reviewers will be invited to each meeting. Since this SAR Plan is a living document; review comments, questions, and responses will be included in the SAR Plan as reviews and construction continues.

In addition to regularly scheduled construction review sessions, the independent reviewers are utilized for any design modifications that are needed due to construction findings or change of conditions.

For O&M manuals, the independent reviewers shall advise whether the requirements proposed in the O&M Manual adequately maintain the conditions assumed during design and validated during construction, and that project monitoring will adequately reveal any deviations from assumptions made for performance.

Future review comments and responses will be performed in Dr.Checks. They will be made available to the public via www.trlia.org.

Adequacy of TRLIA SAR

The information provided in this document demonstrates TRLIA's effort to ensure good science, sound engineering, and public welfare are the most important considerations during the project. TRLIA feels that the actions taken and the actions planned for the future satisfy the intent of Section 2035 of WRDA 2007. While specifics of any future HQUSACE guidance on the Safety Assurance Review are not known at this time, TRLIA believes the plan presented in this document is adequate to meet the condition in the recent Section 408 approval. The SAR Plan is a living document and the TRLIA SAR Plan presented can be modified in the future, as needed. TRLIA plans to complete construction of the Feather River Setback Levee in 2009. In order for TRLIA to maintain this schedule, construction will have to initiate as soon as weather conditions allow. TRLIA requests that this SAR Plan be considered for approval.