100-YR LEVEL OF FLOOD PROTECTION CERTIFICATION SUMMARY REPORT

FOR THE

RD 784 LEVEE SYSTEM

JUNE 2019

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LIST OF SUPPORTING DOCUMENTS

This report and certification relies on a record of evidence that has been developed by TRLIA over the last fifteen years. The below list provides the more significant documents in the record and basis of this certification. These documents are incorporated by reference and provided separately. The list is organized to follow the document organization; therefore, certain titles are duplicative because a single report covered multiple levees and/or phases. Documents are generally listed by topic, and formatting (underlining) is added to facilitate title searching.

GOLDFIELDS 100-YEAR EMBANKMENT

- ENGEO. Goldfields Geotechnical Studies Report, Evaluation of Dredge Tailing Mounds within the Yuba Goldfields. July 9, 2013.
- ENGEO. Technical Memorandum, Subject: Yuba Goldfields 100-year Project Geotechnical Update. August 3, 2016.
- TRLIA. Engineers Report, 100-Year Interim Flood Protection in the Goldfields. May 2016.
- Handen Co., ENGEO, and MBK Engineers. Construction Completion Report for the Goldfields 100-Year Interim Flood Protection Project. July 2016.
- MBK. Goldfields 100-Year Interim Embankment Project – Freeboard Analysis. March 29, 2019.

YUBA RIVER SOUTH LEVEE (SIMPSON LANE TO GOLDFIELDS)

- MBK. Three Rivers Levee Improvement Authority Phase 4 Erosion Investigation. February 2006.
- MBK. Hydraulic and Hydrologic Analysis Yuba River Patrol Road Levee. March 2010.
- MWH. Groundwater Impacts Evaluation Report, Evaluation of Groundwater Impacts from the Upper Yuba River South Levee Repair Activities. December 2009.
- Kleinfelder. Problem Identification Report, Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Simpson Lane to Yuba Gold Fields, Reclamation District No. 784, Yuba County, California. September 29, 2009.
- Kleinfelder. Revised Geotechnical Basis of Design, Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Reclamation District 784, Yuba County, California. June 11, 2010.
- HDR. Upper Yuba Levee Improvement Project, 100% Design Submittal Design Documentation Report, Upper Yuba Levee Improvement Project, Yuba River Basin, California (Sta. 102+00 to Sta. 303+59). June 21, 2010, Revised August 26, 2010.
- HDR. Upper Yuba Levee Improvement Project, Specifications Conformed for Construction. May 23, 2011.
- HDR. Construction Documentation Report, Upper Yuba Levee Improvement Project, Three Rivers Levee Improvement Authority. March 2013.

- MBK. Freeboard (Supplement), Yuba River South Levee in the Upper Yuba Levee Improvement Project, Yuba County, California. October 29, 2013.
- MBK. Memorandum on Inventory of Levee Utility Penetrations - RD 784 Levee Accreditation, Yuba River South Levee (WPRR to Simpson Lane), Bear River North Levee (Setback Levee to the WPIC), WPIC West Levee, and the ODB Ring Levee. October 20, 2015.
- Kleinfelder. FEMA Certification Evaluation, Yuba River South Levee 0+00 to 303+59, WPIC West Levee (0+00 to 9+50, 24+50 to 144+50, 167+50 to 190+28, 216+50 to 238+50, 248+50 to 259+00, 278+00 to 310+00), Olivehurst Detention Basin Ring Levee, Bear River North Levee (Setback Levee to 170+00, Reclamation District 784, Yuba County, California. March 26, 2019.

YUBA RIVER SOUTH LEVEE (UPRR TO SIMPSON LANE)

- MBK. Three Rivers Levee Improvement Authority, Phase IV Erosion Investigation. February 2006.
- MBK. Hydraulic and Hydrologic Analysis of the Three Rivers Levee Improvement Authority's Phase 4 Project, Basis of Design for the Yuba River Levee Improvements Project. May 2006.
- Kleinfelder. Problem Identification Report, Yuba River Left Bank Levee, SPRR to Simpson Lane (Approximate PLM 0.9 to 2.2). Reclamation District 784, Yuba County, California. June 14, 2005.
- HDR. Yuba River Levees Repair Project, Phase 4, Backcheck Basis of Design (Project No. 201064-36522-141). December 2006.
- HDR. Yuba River Levees Repair Project Phase 4, Conformed Technical Specifications Issued for Construction (Project No. 201064-36522-141). August 2006.
- HDR. Three Rivers Levee Improvement Authority Final Construction Documentation Report (two volumes). June 2007. (document title does not include project name for the Phase 1, Phase 2, and Phase 4 projects)
- MBK. Freeboard, Reclamation District No.784 Flood Levee System, Yuba County, California. May 3, 2010.
- MBK. Memorandum on Inventory of Levee Utility Penetrations - RD 784 Levee Accreditation, Yuba River South Levee (WPRR to Simpson Lane), Bear River North Levee (Setback Levee to the WPIC), WPIC West Levee, and the ODB Ring Levee. October 20, 2015.
- Kleinfelder. FEMA Certification Evaluation, Yuba River South Levee 0+00 to 303+59, WPIC West Levee (0+00 to 9+50, 24+50 to 144+50, 167+50 to 190+28, 216+50 to 238+50, 248+50 to 259+00, 278+00 to 310+00), Olivehurst Detention Basin Ring Levee, Bear River North Levee (Setback Levee to 170+00, Reclamation District 784, Yuba County, California. March 26, 2019.

YUBA RIVER SOUTH LEVEE (WPRR TO UPRR)

- MBK. Three Rivers Levee Improvement Authority, Phase IV Erosion Investigation. February 2006.

- MBK. Hydraulic and Hydrologic Analysis of the Three Rivers Levee Improvement Authority's Phase 2 Project, Basis of Design for Bear River, Western Pacific Interceptor Canal, & Yuba River Levee Improvements and Olivehurst Detention Basin Project (Revision 1). March 2006.
- Kleinfelder. Problem Identification Report, Yuba River Left Bank Levee, Highway 70 to SPRR (Approximate PLM 0.32 to 0.91), Reclamation District 784, Yuba County, California. June 11, 2004.
- Kleinfelder. Memorandum, Subject: Linda Break Adjacent Berm Recommendations, Yuba River South Levee, Linda, California. July 14, 2014.
- HDR. Bear River, WPIC and Yuba River Levees Repair Project (Phase 2), Basis of Design Report. Project No. 201064-19703-141. December 2006.
- HDR. Specifications Issued for Construction, Bear River, WP Interceptor Canal, and Yuba River Levees Repair Project. May 18, 2005.
- HDR. Conformed Specifications Issued for Construction, Phase 4 Yuba River South Levee Waterside Levee Slope Flattening Project. September 21, 2009.
- HDR. Three Rivers Levee Improvement Authority Final Construction Documentation Report (two volumes). June 2007. (document title does not include project name for the Phase 1, Phase 2, and Phase 4 projects)
- HDR. Final Design Documentation Report, Phase 4 Yuba River South Levee Slope Flattening Project. July 2009.
- HDR. Construction Documentation Report, Phase 4 Yuba River South Levee Waterside Levee Slope Flattening Project (STA 3+00 to 33+50). March 2010.
- Handen Co. and MBK. Construction Completion Report for the Yuba South Levee Station 2154+00 Remediation. January 2016.
- MBK. Freeboard, Reclamation District No.784 Flood Levee System, Yuba County, California. May 3, 2010.
- MBK. Memorandum on Inventory of Levee Utility Penetrations - RD 784 Levee Accreditation, Yuba River South Levee (WPRR to Simpson Lane), Bear River North Levee (Setback Levee to the WPIC), WPIC West Levee, and the ODB Ring Levee. October 20, 2015.
- Kleinfelder. FEMA Certification Evaluation, Yuba River South Levee 0+00 to 303+59, WPIC West Levee (0+00 to 9+50, 24+50 to 144+50, 167+50 to 190+28, 216+50 to 238+50, 248+50 to 259+00, 278+00 to 310+00), Olivehurst Detention Basin Ring Levee, Bear River North Levee (Setback Levee to 170+00, Reclamation District 784, Yuba County, California. March 26, 2019.

FEATHER RIVER EAST LEVEE SEGMENTS 1& 3

- GEI. Phase 4 Feather River Levee Repair Project. Geotechnical Data Report (four volumes). January 2007.
- GEI. Phase 4 Feather River Levee Repair Project. Geotechnical Data Report, Addendum No. 1. March 2007.
- GEI. Phase 4 Feather River Levee Repair Project. Design Report (three volumes). March 2007.
- GEI. Phase 4 Feather River Levee Repair Project. Design Report Addendum No. 1. May 2007.

- GEI. Phase 4 Feather River Levee Repair Project. Specifications Issued for Construction. Segments 1&3. August 15, 2007.
- GEI. Phase 4 Feather River Levee Repair Project, Technical Memorandum, Assessment of Levee Along New Soil-Bentonite Wall, Stations 220+00 to 246+00, and Proposed Remedial Measures for Cracked Reach, Stations 220+75 to 226+50. April 17, 2009. (with associated correspondence)
- GEI. Feather River Levee Repair Project Levee Segments 1&3. Construction Completion Report (three volumes). June 2009.
- GEI. Feather River Levee Repair Project Levee Segments 1&3. Construction Completion Report, Addendum No. 1 – Landside Crack Repair, Sta. 220+55 to 227+00, and Addendum No. 2 – Segment 3 – Erosion Site 2. December 2009.
- GEI. Feather River Levee Repair Project Levee Segments 1&3, Construction Completion Report, Addendum No. 3. June 2011.
- GEI. Feather River Levee Repair Project Levee Segment 3 – Toes Access Corridor Improvement Project. Construction Completion Report, Addendum No. 4. December 2014.
- GEI. Feather River Levee Repair Project Levee Segment 1 – Erosion Protection Berm Project. Construction Completion Report, Addendum No. 5. August 2015.
- MBK. Freeboard, Reclamation District No.784 Flood Levee System, Yuba County, California. May 3, 2010.
- GEI. Assessment of Levee Utility Penetrations - RD 784 Levee Accreditation, Feather River East Levee Segments 1 and 3. Memorandum. January 29, 2010 (Revised April 8, 2010).
- GEI. Assessment of Levee Encroachment Penetrations and Closures, RD 784 200-year ULDC Compliance Determination, Feather River East Levee (Segments 1 and 3). October 30, 2015.
- GEI. Due Diligence Review- 2019 FEMA Accreditation- Bear River North Setback Levee and Feather River East Levee Segments 1, 2 and 3. March 2019.

FEATHER RIVER EAST LEVEE SEGMENT 2

- GEI. Phase 4 Feather River Levee Repair Project. Feather River Setback Levee Geotechnical Data Report (six volumes). January 2008.
- Phase 4 Feather River Levee Repair Project. Feather River Setback Levee Design Report (five volumes). January 2008.
- GEI. Phase 4 Feather River Levee Repair Project. Feather River Setback Levee Design Report Addendum No. 1. April 2008.
- GEI. Phase 4 Feather River Levee Repair Project. Feather River Setback Levee Specifications Issued for Construction. April 24, 2008.
- TRLIA. Letter Subject: Feather River Setback Levee – Design Modifications of South Tie-in for Cultural Site CA-YUB-1677, dated August 13, 2009.
- GEI. Feather River Levee Repair Project, Levee Segment 2, Construction Completion Report (four volumes, with As-built Drawings). April 2010.
- GEI. Feather River Levee Repair Project, Levee Segment 2. Construction Completion Report, Addendum No. 1 (two volumes). November 2010.
- MBK. Feather River Levee Repair Project, Levee Segment 2. Construction Completion Report, Addendum No. 2 Vegetated Wave Buffer. May 2012.

- GEI. Feather River Levee Repair Project, Levee Segment 2. Construction Completion Report, Addendum No. 3. February 2012.
- MBK. Freeboard, Reclamation District No.784 Flood Levee System, Yuba County, California. May 3, 2010.
- GEI. Assessment of Levee Encroachment Penetrations and Closures, RD 784 200-year ULDC Compliance Determination, Feather River East Levee (Segment 2). October 30, 2015.
- GEI. Due Diligence Review- 2019 FEMA Accreditation- Bear River North Setback Levee and Feather River East Levee Segments 1, 2 and 3, March 2019

BEAR RIVER NORTH SETBACK LEVEE

- GEI. Bear River Setback Levee Geotechnical Data Report (two volumes). July 1, 2005.
- Bear River Setback Levee Geotechnical Data Report, Addendum 1. December 16, 2005.
- GEI. Bear River Setback Levee Final Design Report (four volumes). July 2006.
- GEI. Bear River Setback Levee, Foundation and Feather River Tie-In Contract Specifications, Issued for Construction. September 13, 2005.
- GEI. Bear River Setback Levee, Embankment Contract, Specifications, Issued for Construction. March 10, 2006.
- GEI. Bear River Setback Levee Construction Completion Report (three volumes). May 2007.
- MBK. Freeboard, Reclamation District No.784 Flood Levee System, Yuba County, California. May 3, 2010.
- GEI. Assessment of Levee Encroachment Penetrations and Closures, RD 784 200-year ULDC Compliance Determination, Bear River Setback Levee. October 30, 2015.
- GEI. Due Diligence Review- 2019 FEMA Accreditation- Bear River North Setback Levee and Feather River East Levee Segments 1, 2 and 3, March 2019.

UPPER BEAR NORTH LEVEE (SETBACK LEVEE TO WPIC), WPIC WEST LEVEE, AND ODB RING LEVEE

- MBK. Three Rivers Levee Improvement Authority Phase IV Erosion Investigation. February 2006.
- MBK. Hydraulic and Hydrologic Analysis of the Three Rivers Levee Improvement Authority's Phase 2 Project. Basis of Design for the Bear River, Western Pacific Interceptor Canal, Yuba River Levee Improvements and Olivehurst Detention Basin Project. March 2006.
- MBK. 200-yr Design Water Surface Elevation in Western Pacific Interceptor Canal. March 31, 2014.
- Kleinfelder. Problem Identification Report. Bear River North Levee and the Western Pacific Interceptor Canal West Levee Reclamation District 784. Yuba County, California. May 7, 2004.
- Kleinfelder. Geotechnical Design Memorandum Ring Levee and Pump Station Olivehurst Detention Basin. Yuba County, California. December 8, 2005.
- HDR. Final Geotechnical Basis of Design, 200-Year Urban Levee Criteria Compliance Determination Report. December 19, 2014.

- HDR. Problem Identification for Station 212+00 to 216+00 Technical Memorandum. May 7, 2015.
- MHM. Basis of Design Report. South Olivehurst Detention Basin and Storm Water Pumping Project Hazard Mitigation Grant Program. September 1998 (Revised August 2005).
- HDR. Bear River, WPIC and Yuba River Levees Repair Project (Phase 2), Basis of Design Report (Project No. 201064-19703-141). December 2006.
- HDR. Olivehurst Detention Basin 200-Year Urban Levee Design Criteria Analysis Technical Memorandum. September 10, 2015.
- HDR. Specifications Issued for Construction, Bear River, WP Interceptor Canal, and Yuba River Levees Repair Project. May 18, 2005.
- HDR. Specifications for Construction, Western Pacific Interceptor Canal (WPIC), West Levee Improvement Project, Three Rivers Levee Improvement Authority, Contract No. PH4 2016-01. June 24, 2016.
- HDR. Three Rivers Levee Improvement Authority Final Construction Documentation Report (two volumes). June 2007. (document title does not include project name for the Phase 1, Phase 2, and Phase 4 projects)
- HDR. Construction Documentation Report, Three Rivers Levee Improvement Authority, WPIC West Levee Improvement Project (Station 0+00 to 310+00). [undated 2019. *Currently in Draft]*.
- MBK. Freeboard, Reclamation District No.784 Flood Levee System, Yuba County, California. May 3, 2010.
- MBK. Memorandum on Inventory of Levee Utility Penetrations - RD 784 Levee Accreditation, Yuba River South Levee (WPRR to Simpson Lane), Bear River North Levee (Setback Levee to the WPIC), WPIC West Levee, and the ODB Ring Levee. October 23, 2015.
- Kleinfelder. FEMA Certification Evaluation, Yuba River South Levee 0+00 to 303+59, WPIC West Levee (0+00 to 9+50, 24+50 to 144+50, 167+50 to 190+28, 216+50 to 238+50, 248+50 to 259+00, 278+00 to 310+00), Olivehurst Detention Basin Ring Levee, Bear River North Levee (Setback Levee to 170+00, Reclamation District 784, Yuba County, California. March 26, 2019.
- HDR. Documentation of Review for RD784 Levee System for FEMA Recertification. April 2, 2019.

OTHER

- MHM. Interior Drainage Study – PAL Area Extension, LOMR Application Narrative – East Linda Extension, FEMA Accreditation Project, Three Rivers Levee Improvement Authority. August 10, 2010 (Revised September 17, 2010).
- USACE. Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 145 - Part No. 1. December 29, 2016.
- USACE. Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 149. December 29, 2016.
- RD784. Local Addendum to: Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 145 - Part No. 1 and Unit No. 149, Maintenance Area No. 8, Reclamation District 784 Improvements.

- Three Rivers Levee Improvement Authority Goldfields 100-Year Interim Flood Risk Reduction Project Operations, Maintenance, and Emergency Actions Requirements. September 23, 2016.

1 GENERAL [44 CFR § 65.10(A)]

1.1 BACKGROUND

Since 2004, the Three Rivers Levee Improvement Authority (TRLIA) has implemented over $425 million of improvements to the levees surrounding Reclamation District (RD) 784 in southern Yuba County. The purpose of these improvements has been to provide both 100-year and 200-year flood protection to the area. Design and construction of the improvements were accomplished using the criteria published by the U.S. Army Corps of Engineers (USACE) and the California Department of Water Resources (DWR).

Improvements completed prior to 2013 were previously certified by TRLIA in 2010 with a supplemental package in 2013, and subsequently accredited by FEMA. The 2010 certification was for the following portions of the system:

- Yuba River South Levee (UPRR to Simpson Lane)
- Yuba River South Levee (WPRR to UPRR)
- Feather River East Levee Segment 3
- Feather River East Levee Segment 2
- Feather River East Levee Segment 1
- Bear River North Setback Levee
- Upper Bear North Levee (Setback Levee to WPIC), WPIC West Levee, ODB Ring Levee

The 2013 certification was for the Yuba River South Levee (Simpson Lane to the Goldfields).

In May 2016, TRLIA published a report titled *Substantial Evidence Engineer's Report, Urban Level of Protection, Reclamation District 784 Urban Levee System, Yuba County, California*. This report, including its appendices, was developed for the purposes of supporting a finding of adequate progress in meeting State of California Urban Levee Design Criteria (ULDC) and a 200-year level of flood protection for the RD 784 levee system. As part of that effort, TRLIA and its consultants performed various evaluations and assessments specific to ULDC and a 200-year level of flood protection, but which also support certification for 100-year events.

Since the prior certifications, TRLIA has made additional improvements to the levee system to meet ULDC. These include:

- Strengthening of the Yuba River South Levee between Highway 70 and the UPRR at the site of the 1986 levee breach. Work consisted of enlargement of the landside berm. Construction was completed in 2015. This work was not required to provide a 100-year level of flood protection.
- Strengthening of the WPIC West Levee from Stations 9+50 to 24+50, 144+50 to 167+50, 190+28 to 216+50, 238+50 to 248+50, 259+00 to 278+00 as part of the WPIC 200-Year Standard Project. Work consisted of seepage remediation (cutoff walls and landside fill) to meet State of California Urban Levee Design Criteria (ULDC) for a 200-year level of flood protection, and construction of landside toe access road. Construction was completed in 2017. This work was not required to provide a 100-year level of flood protection.

- Construction of an erosion protection berm along the Feather River East Levee, Segment 1, extending from approximate Station 128+00 to 135+00. Construction was completed in 2013. This work was not required to provide a 100-year level of flood protection.

Additionally, TRLIA completed a project in the Goldfields for the purposes of providing 100-year level of flood protection:

- Goldfields Interim 100-Year Project. Work consisted of 2.1 miles of improved embankment within the Goldfields to intercept and block potential breach flows from the Yuba River. This work was completed in 2016 to provide a 100-year level of flood protection.

TRLIA continues to make improvements to the levee system to meet State of California requirements for 200-year level of protection. Specifically, TRLIA is currently designing a new levee which would extend the Yuba River South Levee east approximately 2.6 miles. This new levee is not required to provide a 100-year level of flood protection. Upon completion of this work, TRLIA will be certifying the RD784 levee system for 200-year level of flood protection.

All of the work implemented by TRLIA was in accordance with local, State, and Federal environmental rules and regulations. Environmental compliance documents are available at www.trlia.org.

1.2 PURPOSE OF CERTIFICATION

The purpose of this document is to supply FEMA with information, technical evaluations, and certifications in accordance with the provisions of 44 Code of Federal Regulations (CFR) § 65.10 for the RD 784 Levee System to become fully accredited in the National Flood Insurance Program (NFIP).

Evaluations of the levee system were accomplished by a team of engineering consultants under TRLIA's management. This team consisted of ENGEO Inc. of Rocklin, California; GEI Consultants, Inc. of Sacramento, California; HDR Engineering, Inc. of Folsom, California; Kleinfelder Inc. of Sacramento, California; MHM Engineering of Marysville, California; and MBK Engineers of Sacramento, California.

This Certification Summary is generally organized by levee and the phases and sub-phases of TRLIA's levee improvement program (i.e., design and construction packages):

1. Goldfields 100-Year Embankment
2. Yuba River South Levee (Simpson Lane to the Goldfields)
3. Yuba River South Levee (UPRR to Simpson Lane)
4. Yuba River South Levee (WPRR to UPRR)
5. Feather River East Levee Segment 3
6. Feather River East Levee Segment 2
7. Feather River East Levee Segment 1
8. Bear River North Setback Levee
9. Upper Bear North Levee (Setback Levee to WPIC), WPIC West Levee, ODB Ring Levee

This document briefly summarizes each technical evaluation performed with respect to levee certification and includes a corresponding Engineer's Opinion, stamped by a licensed Professional Engineer, as appendices to this document. These opinions are being submitted by TRLIA to

demonstrate that the appropriate standard of care has been followed to certify that the RD 784 Levee System meets the criteria listed in 44 CFR 65.10. TRLIA's certification, which is also stamped by a licensed Professional Engineer, is provided in Section 5 of this Certification Summary.

1.3 DESCRIPTION OF LEVEE SYSTEM

The levee system, herein referred to as the "RD 784 Levee System", that is the subject of this certification consists of the following key features (Plates 1 and 2):

- Approximately 29 miles of embankment to manage flooding from the Yuba River, the Feather River, the Bear River, and the WPIC:
    - Goldfields 100-Year Embankment from the upstream terminus of the Yuba River South Levee, approximately 2.1 miles. Although included as a feature of the RD784 Levee System in this document, this levee is outside the jurisdictional boundary of RD784 and is currently being operated and maintained by TRLIA. It is not anticipated that this feature will become part of the permanent RD784 Levee System as the future Goldfields 200 Year project will supersede this levee.
    - Yuba River South Levee from the confluence of the Yuba and Feather Rivers upstream to the Goldfields, approximately 6 miles.
    - Feather River East Levee from the confluence of the Yuba and Feather Rivers downstream to the confluence of the Feather and Bear Rivers, approximately 12.1 miles.
    - Bear River North Levee from the confluence of the Feather and Bear Rivers upstream to the WPIC, approximately 2.7 miles.
    - WPIC West Levee from the Bear River upstream to the ODB Ring Levee, approximately 6 miles.
    - ODB Ring Levee from the WPIC West Levee to Highway 70, and the non-levee reach of Highway 70, less than 0.5 mile.
- Two closure structures (at UPRR crossings of Yuba River South Levee and Feather River East Levee Segment 3).
- Five pumping stations (PS) at the line of protection (PS 9, PS 3, PS 2, PS 6, and ODB) to remove local runoff when high river levels prevent natural drainage to the rivers.
- Three gravity drains at the line of protection (PS 2, PS 6, and ODB).
- Seven interior pumping stations (PS 1, PS 4, PS 5, PS 7, PS 8, PS 10, and Montross PS) lift stored water from detention basins into a system of channels that convey interior drainage to the pump stations at the levees.
- Appurtenant drainage facilities (75 Miles of Drainage Channels and 14 Detention Basins).

2 DESIGN CRITERIA [44 CFR § 65.10(B)]

2.1 FREEBOARD [44 CFR § 65.10(B)(1)]

MBK performed an analysis to determine the amount of freeboard over the length of the entire RD 784 Levee System in accordance with the 44 CFR § 65.10(b)(1). This section states the following:

1. *Riverine levees must provide a minimum freeboard of three feet above the water surface level of the base flood. An additional one foot above the minimum is required within 100 feet on either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted. An additional one-half foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required.*

2. *Occasionally, exceptions to the minimum riverine freeboard requirement described in paragraph (b)(1)(i) of this section, may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood elevation profile and include, but not necessarily be limited to an assessment of statistical confidence limits of the 100-year discharge; changes in stage-discharge relationships; and the sources, potential and magnitude of debris, sediment and ice accumulation. It must be also shown that the levee will remain structurally stable during the base flood when such additional loading considerations are imposed. Under no circumstances will freeboard of less than two feet be accepted.*

MBK determined freeboard along the levee by calculating the difference in elevation between the top of the levee and the base flood, at intervals of approximately 100 feet. Based on MBK's computations, the RD 784 Levee System has riverine freeboard of at least 3 feet or more for the 100-year flood event This freeboard is equal to or greater than the required minimum of 3 feet and sufficiently protects against the base flood.

Freeboard at constrictions was also checked. Freeboard at river constrictions meets the minimum 4-foot requirement with two exceptions, both on the WPIC. At Highway 70, where two box culverts convey WPIC waters under the four-lane divided highway, freeboard is between 3.6 and 5 feet. At Algodon Road, there is 3.8 feet of freeboard. While the required freeboard of 4 feet is not provided at these locations, there is in excess 3 feet, and there is little risk of overtopping due to the constriction as the WPIC is a backwater area so debris loading would not increase the water surface elevation at the constriction.

An Engineer's Opinion signed by a Licensed Professional Engineer is included in Appendix A of this Certification Summary document. Reports titled *Freeboard, Reclamation District No. 784 Flood Levee System, Yuba County, California* (dated March 2010); *Freeboard (Supplement), Yuba River South Levee in the Upper Yuba Levee Improvement Project Yuba County, California* (dated May 17, 2013); and *Goldfields 100-Year Interim Embankment Project – Freeboard Analysis* (dated March 29, 2019), all prepared by MBK Engineers, are incorporated by reference and provided separately.

2.2 CLOSURES [44 CFR § 65.10(B)(2)]

All openings in the levee system have been fitted with closure structures in accordance with 44 CFR § 65.10(b)(2). This section states the following:

> *All openings must be provided with closure devices that are structural parts of the system during operation and design according to sound engineering practice*

2.2.1 UNION PACIFIC RAILROAD (UPRR) FLOOD GATE

This Union Pacific Railroad crossing is located east of Highway 70 at PLM 0.9 of the Yuba River South Levee (Station 34+30), where the 100-year flood elevation is approximately 72.6 feet (NGVD). The ballast under the rails forms the lowest point of the existing levee at the UPRR crossing and is at approximately elevation 75.7 feet (NGVD), which is about 3.1 feet above the 100-year flood elevation. The railway bed at the UPRR crossing does not provide adequate freeboard for the 100-year base flood. However, as part of past construction for this stretch of levee, a steel gate closure device was installed to enable levee closure to an elevation of approximately 80.6 feet. Closure of this flood gate will provide freeboard in excess of 4 feet above both the 100-year and 200-year flood elevations.

The steel flood gate has two leaf sections, each approximately 12.9 feet long. The leaves are hinged to a concrete retaining wall on each side of the UPRR. The retaining wall is an integral part of the levee embankment. To provide a levee closure, each gate end swings to the center of the UPRR track, and the gate ends are manually secured with a closing link.

The gate leaves are locked open unless an extreme flood event occurs. When the Feather River stage at the Yuba City gage indicates that the river stage is within 4 feet of the railroad bed at the UPRR levee crossing, RD 784 personnel will notify the designated UPRR representative that the flood gate needs to be closed. Once the UPRR representative gives confirmation to close the gate, RD 784 personnel will close and sandbag the gate. Flood elevations at this closure are controlled by backwater from the Feather and Yuba Rivers confluence. Due to flood regulation by Oroville Reservoir on the Feather River, flood elevations are slow rising and there is ample time to accomplish gate closure at this structure once water surface elevations reach pre-determined action levels. Additional details about the operation of the UPRR flood gate during an extreme flood event, including action levels, are discussed in the *Addendum to: Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 145 - Part No. 1 and Unit No. 149, Maintenance Area No. 8, Reclamation District 784 Improvements*, and herein referred to as the "Local Addendum".

An Engineer's Opinion regarding this closure structure signed by a Licensed Professional Engineer is included in Appendix B of this Certification Summary document. Based on MBK's evaluation, it is their opinion that this closure structure is capable of providing flood protection during the base flood.

2.2.2 Union Pacific Railroad (Former Western Pacific Railroad) Flood Gate

This Union Pacific Railroad (former Western Pacific Railroad) crossing is located just west of Highway 70 at the northern end of the Feather River East Levee Segment 3 (Station 724+18), where the 100-year flood elevation is approximately 71.9 feet (NGVD). The ballast under the rails forms the lowest point of the existing levee at the UPRR crossing and is at approximately elevation 77.6 feet (NGVD), which is about 5 feet above the 100-year flood elevation. Therefore, the railway bed at the UPRR crossing has adequate freeboard for the 100-year flood and does not constitute a closure for purposes of evaluating containment of the base flood. However, as part of the Phase 4 Feather River Levee improvements for Segment 3, a steel gate closure device was installed to enable levee closure to an elevation of approximately 80.0 feet. Closure of this flood gate will provide freeboard in excess of 4 feet above the 200-year flood elevation.

The steel flood gate has two leaf sections, each approximately 12.5 feet long. The leaves are hinged to a concrete retaining wall on each side of the UPRR. To provide a levee closure, each gate end swings to the center of the UPRR track, and the gate ends are manually secured with a closing link. Additional details about the UPRR flood gate are presented in the June 2009 Feather River Levee Segments 1&3 Construction Completion Report.

The gate leaves are locked open unless an extreme flood event occurs. When the Feather River stage at the Yuba City gage reaches the 100-year flood stage, or if it is observed that the river stage is within 4 feet of the railroad bed at the levee crossing, RD 784 personnel will notify the designated UPRR representative that the flood gate needs to be closed. Once the UPRR representative gives confirmation to close the gate, RD 784 personnel will close and sandbag the gate until the river level drops below the 100-year flood stage. Additional details about the operation of the UPRR flood gate during an extreme flood event are discussed in the Local Addendum.

2.3 EMBANKMENT PROTECTION [44 CFR § 65.10(B)(3)]

TRLIA's consultants assessed the adequacy of existing embankment protection over the length of the RD 784 Levee System. The assessment was conducted as follows:

- GEI assessed the Feather River east levee and the Bear River north setback levee.
- HDR/Kleinfelder assessed the Yuba River South Levee, the Upper Bear north levee (from the setback levee to the WPIC), and the WPIC west levee including the ODB ring levee.
- ENGEO assessed the Goldfields 100-Year Embankment.

The assessment was conducted in accordance with the 44 CFR § 65.10(b)(3). This section states the following:

> *Engineering analyses must be submitted that demonstrate that no appreciable erosion of the levee embankment can be expected during the base flood, as a result of either currents or waves, and that anticipated erosion will not result in failure of the levee embankment or foundation directly or indirectly through reduction of the seepage path and subsequent instability. The factors to be addressed in such analyses include, but are not limited to: Expected flow velocities (especially in constricted areas); expected wind and wave action; ice loading; impact of debris; slope protection*

techniques; duration of flooding at various stages and velocities; embankment and foundation materials; levee alignment, bends, and transitions; and levee side slopes.

The majority of the embankment protection within the RD 784 Levee System is either grassed slope or riprap revetment. In addition to the constructed embankment protection, significant portions of the levee system are further protected by stands of relatively closely spaced, mature trees and other riparian vegetation that grow in the floodway between the Bear, and Feather River channels and the waterside toe of the respective levee embankment. The exception is the Goldfields 100-Year Embankment which is neither grassed nor revetted (more detail below).

Based on the engineers' evaluation of their respective reaches of embankment protection, the engineers do not expect appreciable erosion of the levee embankment or foundations from currents, waves, or debris during the base flood. This opinion assumes continued regular maintenance of the constructed embankment protection and that embankment protection for any future levee modification is designed and constructed in accordance with applicable USACE criteria and guidance. Regular maintenance includes replacement and upkeep of riprap, control of vegetation, and repair of localized erosion and animal burrow damage.

Engineer's Opinions for the RD 784 levee system, signed by a Licensed Professional Engineer, are included in Appendix C of this Certification Summary document. A general description of embankment protection and associated reference reports are provided below for each RD 784 levee reach.

2.3.1 GOLDFIELDS 100-YEAR EMBANKMENT

The Goldfields 100-Year Embankment consists of dredge tailings material that is not conducive to vegetation growth and no attempt to plant erosion control grasses on the embankment was made as part of TRLIA's construction work. The dredge material consists of cobbles that resist erosion from surface flow, flow between the tailings mounds and wind generated waves.

2.3.2 YUBA RIVER SOUTH LEVEE (SIMPSON LANE TO THE GOLDFIELDS)

The levee erosion potential of the Yuba River South Levee between Simpson Lane and the Goldfields was evaluated based on anticipated design water velocities, embankment side slopes, soil characteristics, channel sinuosity and uniformity, and performance history for the existing levee. Criteria for maximum permissible water velocities were adopted from USACE guidelines for the design of flood control channels (EM 1110-2-1601).

Based on the Hydraulic Basis of Design Report (MBK, March 2010), flows occur along the waterside of this levee very infrequently due to training berms in the floodway which normally and have historically restricted flows to the north side of the floodway. The estimated maximum flow velocity along the Yuba River South Levee in this reach was computed to range from 1 to 2 feet per second (fps). The USACE guidelines, referenced above, show maximum permissible mean channel velocities for bare-earth channels ranging from 2 fps for fine sand to 6 fps for clay. The Yuba River South Levee in this reach was recently reconstructed with clayey soils. For grass-lined channels, maximum permissible velocities range from 5 fps to 6 fps depending on type of soil and grass cover. Based on

these guidelines, it was judged that the well-established vegetation on the levee slope would provide adequate erosion protection. This judgment was based on the following factors:

- The calculated water velocities are equal or less than the maximum permissible velocities for vegetated flow channels.
- The existing levee embankment material is free of significant erosion, and there was not significant erosion of the levee reported after previous flood events.
- The existing levee slopes are generally well vegetated.

As part of TRLIA's improvement project, the waterside slope of the levee received hydroseed from Station 103+00 to Station 272+00 (Simpson Lane to the area west of the Goldfields) then riprap revetment from Station 272+00 to 303+59 (Goldfields). Riprap revetment was placed along the last portion of this reach to protect against erosion from concentrated flows which can exit from the Goldfields at the end of the levee. During the 1997 flood event, flows did exit from the Goldfields and eroded a portion of the levee. The 1997 Flood was the only time that this has ever happened.

The analysis of wind setup and wave runup was included in the August 26, 2010, 100% Design Submittal Design Documentation Report by HDR. The maximum water surface capable of generating wind and wave was evaluated for the 1 in 200-year flood event. Three different sections (Station 123+00, Station 187+50, and Station 278+00) were analyzed along the reach. Calculated wave run-up was 3.69 feet, 3.69 feet, and 2.84 feet, respectively, adjusted for the 100-year water surface elevations.

These magnitude waves would be contained within the design freeboard over the base flood elevation. Detailed analysis of wave-driven erosion has not been completed. However, it was concluded that the potential for erosion would be infrequent and localized and any resulting damage would be mitigated through proper maintenance and flood fighting techniques. Minimal wind erosion during the 100-year flood event would not jeopardize levee stability.

2.3.3 Yuba River South Levee (UPRR to Simpson Lane)

The levee erosion potential of the Yuba River South Levee between UPRR and Simpson Lane was evaluated based on anticipated design water velocities, embankment side slopes, soil characteristics, channel sinuosity and uniformity, and performance history for the existing levee. Criteria for maximum permissible water velocities were adopted from USACE' guidelines for the design of flood control channels (EM 1110-2-1601).

The results of these analyses are summarized in the 2006 Backcheck Basis of Design Report and the 2006 Phase IV Erosion Investigation Report. The estimated maximum flow velocity along the Yuba River South Levee was computed to range from 1 to 2 feet per second (fps). The USACE guidelines referenced above show maximum permissible mean channel velocities for bare-earth channels ranging from 2 fps for fine sand to 6 fps for clay. The Yuba River South Levee is constructed with silty sand soils, which would have a permissible velocity of 2.0 fps. It should be noted that the levee slopes were hydroseeded upon completion of construction activities, which would increase the permissible velocity to as high as 6.0 fps. Given that the calculated velocities are within the permissible range for the soil type and channel condition, additional embankment protection was not required. In addition, there were no identified erosion sites in the 2006 Phase IV Erosion Report within the limits of this segment of levee.

The analysis of wind setup and wave runup was included in the 2006 Backcheck Basis of Design Report. The maximum water surface capable of generating wind and wave was evaluated for the 1 in 100-year flood event. A maximum average fetch of approximately 1.5 miles was measured for the Yuba River coming from the north. The peak wind velocity of 49.2 mph was used to estimate a total a wave runup of 4.4 feet. This magnitude wave would be contained within the design freeboard over the base flood elevation. Detailed analysis of wave-driven erosion has not been completed. However, it was concluded that significant erosion is unlikely to occur and any resulting damage would be mitigated through proper maintenance and flood fighting techniques. Minimal wind erosion during the 100-year flood event would not jeopardize levee stability.

2.3.4 YUBA RIVER SOUTH LEVEE (WPRR TO UPRR)

The levee erosion potential of the Yuba River South Levee between WPRR and UPRR was evaluated based on anticipated design water velocities, embankment side slopes, soil characteristics, channel sinuosity and uniformity, and performance history for the existing levee. Criteria for maximum permissible water velocities were adopted from USACE' guidelines for the design of flood control channels (EM 1110-2-1601).

The results of these analyses are summarized in the 2006 Basis of Design Report and the 2006 Phase IV Erosion Investigation Report. The estimated maximum flow velocity along the Yuba River South Levee was computed to range from 1 to 2 feet per second (fps) for the majority of the project area, although velocities as high as 5.0 fps were calculated near the Highway 70 crossing. The USACE guidelines referenced above show maximum permissible mean channel velocities for bare-earth channels ranging from 2 fps for fine sand to 6 fps for clay. The Yuba River South Levee is constructed with silty sand soils, which would have a permissible velocity of 2.0 fps, As with the previous stretch of river, the levee slopes were hydroseeded upon completion of construction activities, which would increase the permissible velocity to as high as 6.0 fps. Given that the calculated velocities are within the permissible range for the soil type and channel condition, embankment protection was not required. Caltrans has placed rock groins in the vicinity of the Highway 70 crossing to reduce near embankment velocities under the crossing where the highest velocities were calculated. In addition, there were no identified erosion sites in the 2006 Phase IV Erosion Report within the limits of this segment of levee.

The analysis of wind setup and wave runup was included in the 2006 Basis of Design Report. The maximum water surface capable of generating wind and wave was evaluated for the 1 in 100-year flood event. A maximum average fetch of approximately 1.7 miles was measured for the Yuba River coming from the north. The peak wind velocity of 51.2 mph was used to estimate a total wave runup of 0.9 feet. This magnitude wave would be contained within the design freeboard over the base flood elevation. The detailed analysis of wave-driven erosion has not been completed. However, it was concluded that significant erosion is unlikely to occur and any resulting damage would be mitigated through proper maintenance and flood fighting techniques. Minimal wind erosion during the 100-year flood event would not jeopardize levee stability.

2.3.5 Feather River East Levee Segment 3

The levee erosion potential of the Feather River East Levee Segment 3 was evaluated based on anticipated design water velocities, wave-induced water velocities, embankment side slopes, soil characteristics, channel sinuosity and uniformity, and performance history for the existing levee. An 800-foot-long reach of the levee, along a bend in the levee near the north end of Segment 3, required erosion protection. This reach, designated as Erosion Site 2, is located near the confluence of the Yuba and Feather Rivers.

Criteria for maximum permissible water velocities against the Segment 3 levee were adopted from USACE' guidelines for the design of flood control channels (EM 1110-2-1601). The results of these analyses are summarized in Section 4 of the March 2007 Phase 4 Feather River Levee Repair Project Design Report. Flow velocities for the 100-year flood are presented in the documented titled, Three Rivers Levee Improvement Authority Phase 4 Erosion Investigation, dated February 2006. This document is included as Appendix B of the March 2007 Phase 4 Feather River Levee Repair Project Design Report.

The estimated maximum flow velocity along the Segment 3 levee was computed to range from 5 to 8 feet per second (fps) along the levee bend in Erosion Site 2 and below 5 fps elsewhere within Segment 3. The USACE guidelines referenced above show maximum permissible mean channel velocities for bare-earth channels ranging from 2 fps for fine sand to 6 fps for clay. For grass-lined channels, maximum permissible velocities range from 5 fps to 6 fps depending on type of soil and grass cover. Based on these guidelines, it was judged that well-established vegetation of the levee slopes should provide adequate erosion protection. This judgment was based on the following factors:

- The calculated water velocities are equal or less than the maximum permissible velocities for vegetated flow channels.
- The existing levee embankment material is free of significant erosion, and there was not significant erosion of the levee reported after previous flood events, except in the area of Erosion Site 2.
- The existing levee slopes are generally well vegetated.

Accordingly, the levee slopes impacted by repair activities were planted with approved non-woody ground cover for erosion protection. Approved plant species for levee slopes are listed in Section 131 of the California Code of Regulations.

At Erosion Site 2 there is an overflow channel (referred to as the "State Cut") along the waterside toe of the levee that was constructed in the 1930's to improve the hydraulic efficiency at the confluence. Reportedly, Erosion Site 2 had erosion problems on the levee slope prior to 1997; however, bank protection was placed in this area, and no problems were reported because of the extreme high water conditions experienced during the January 1997 flood. The January 1997 flood is estimated to have slightly exceeded a 100-year event for the Yuba River.

Nonetheless, the levee slope was deemed to lack sufficient vegetation, and the fine sandy soil in the levee and foundation could have the potential to erode during a 100-year event if not protected by a good stand of grass. In addition, hydraulic analyses indicated that the bed of the State Cut may have the potential to scour and move laterally, potentially undermining the levee foundation over the long

term. Consequently, additional repair work has been implemented as part of the Phase 4 Feather River Levee repair project to revegetate the levee slope and provide additional scour protection at the levee toe. The repair consisted of constructing a rock slope protection layer along the bank of the State Cut below the toe of the levee and revegetating the levee waterside slope. Additional details about the design and construction of the Erosion Site 2 repair can be found in the December 2009 Feather River Levee Segments 1&3 Construction Completion Report, Addendum No. 2.

TRLIA has included some event-based and long-term monitoring of this site in the O&M Manual. Three transects have been established for Segment 3 at State Cut and monumented and photo point locations established to enable consistent repeat observations. Survey monitoring performed in February 2019 is summarized in the GEI report titled *Due Diligence Review- 2019 FEMA Accreditation - Bear River North Setback Levee and Feather River East Levee Segments 1, 2 and 3,* March 2019. Survey results indicate little change in waterside bank elevation. The waterside bank appears relatively stable with respect to erosion based on the survey results to date. The performance of the repaired reach will continue to be monitored after major flood events.

The analyses of wave-driven erosion, wind setup and wave runup are presented in Analysis of Wave-Driven Erosion, Wind Setup and Wave Runup, of the March 2007 Phase 4 Feather River Levee Repair Design Report. The maximum water surface capable of generating wind waves was evaluated for the 1 in 200-year flood event. A maximum average fetch of approximately three miles was measured along the Feather River for winds coming from the northwest. The peak wind velocity over a 66-year record of 50 mph was used to estimate a wave height of 3.4 feet, a wind setup of 0.5 feet, a wave runup of 4.4 feet, and a maximum wave water velocity of 3.4 fps. This fluid velocity quantified from wave energy was compared to data from sediment transport studies. It was concluded that significant erosion is unlikely to occur as long as the levee slope remains well vegetated.

2.3.6 Feather River East Levee Segment 2

Segment 2 is a newly constructed setback levee that replaced the east levee of the Feather River from about one mile north of Murphy Road to Star Bend and set it back approximately 0.5 mile to the east. Construction of the setback levee started in the summer of 2008 and was completed in October 2009, and the old levee was effectively degraded during September through December 2009. The erosion potential of the Segment 2 levee was evaluated based on anticipated design water velocities, wave-induced water velocities, embankment side slopes, soil characteristics, channel sinuosity and uniformity, and performance history for the old levee (now degraded). The setback levee was constructed with compacted "impervious" material in accordance with Central Valley Flood Protection Board and USACE requirements. The levee slopes were seeded with approved non-woody ground cover for erosion protection.

Criteria for maximum permissible water velocities against the levee were adopted from USACE' guidelines for the design of flood control channels (EM 1110-2-1601). The results of these analyses are summarized in Section 4 of the January 2008 Feather River Setback Levee Design Report. Flow velocities for the 100-year flood along the levee are presented in the document titled, Hydraulic and Hydrologic Analysis of the Three Rivers Levee Improvement Authority's Phase 4 Project- Basis of Design for Feather River Setback Levee Project, dated January 2008. This document is included as Appendix A1 of the January 2008 Feather River Setback Levee Design Report. In addition, a geomorphic assessment of the setback levee was performed during the project design phase. This assessment included hydrodynamic modeling to evaluate water velocities and shear stresses, for

comparison with allowable velocities and shear stresses for vegetated embankment slopes. The findings of this evaluation are presented in the document titled, Feather River Setback: Assessment of Potential Geomorphic Effects, dated January 2008 (referred to as the January 2008 Geomorphic Assessment). This document is included as Appendix G1 of the January 2008 Feather River Setback Levee Design Report.

The estimated maximum flow velocity along the Segment 2 levee was computed as 2 feet per second (fps), with most of the levee alignment experiencing flow velocities less than 2 fps. The EM 1110-2-1601 USACE guidelines show maximum permissible mean channel velocities for bare-earth channels ranging from 3.5 feet per second (fps) for silty clay to 6 fps for clay. For grass-lined channels, maximum permissible velocities range from 6 fps for silty clay to 8 fps for clay. It was judged that the combination of clayey soils and vegetation of the levee slopes should provide adequate erosion protection. This judgment was based on the following factors:

- The calculated water velocities are equal or less than the maximum permissible velocities for either bare-earth or vegetated flow channels based on USACE Guidelines.
- The calculated shear stresses determined from the January 2008 Geomorphic Assessment are relatively low and well within the allowable shear stresses for vegetated surfaces.
- The embankment material, primarily silty clay, has a relatively low susceptibility to erosion.
- The condition of the old levee was generally free of significant erosion except for a few isolated sites as noted below in this section.
- There are no major meanders, constrictions or confluences in the Feather River adjacent to the setback levee.

Accordingly, the Segment 2 levee slopes were seeded with approved non-woody ground cover for erosion protection. Approved plant species for levee slopes are listed in Section 131 of the California Code of Regulations.

The erosion sites along the old levee (now degraded) were reviewed and evaluated as part of the erosion potential evaluation for the setback levee. Sites of historical erosion problems along the waterside toe of the old levee were identified in the MBK Engineers report titled Three Rivers Levee Improvement Authority Phase IV Erosion Investigation, dated February 2006, which is included as Appendix A-2 of the January 2008 Feather River Setback Levee Design Report. Six erosion sites were identified based on a review of historic erosion problems and two-dimensional hydraulic modeling and were designated as “Sites 3 through 7” and “USACE Erosion Site – RM 19.” At Sites 3 to 7, overbank flooding caused erosion of unprotected fine-sand soil along the old levee toe. This erosion only occurred during flood events and was repaired by RD 784 after each event. At the USACE Erosion Site – RM19, the river is eroding the bank, which was in close proximity to the old levee but is now nearly 2,000 feet west of the setback levee toe and is no longer a levee safety concern.

The results in Appendix A-2 indicate that computed water velocities for the condition prior to construction of the setback levee for the 1:100 annual chance flood ranged from 2 to 3 fps for Sites 3, 6 and 7, and from 3 to 7 fps for Sites 4 and 5. The hydraulic models for the widened floodway presented in Appendix A-1 indicate that velocities will not exceed 2 fps adjacent to the setback levee for the 1:100 annual chance of exceedance flood. The reduction in water velocity, the placement of the new levee on older and stiffer soil formation wherever practicable, and the establishment of a vegetated cover over the access corridor along the waterside levee toe should further reduce the potential for erosion along the setback levee toe.

The details of the analysis of wave-driven erosion, wind setup and wave run-up are presented in Appendix C, Analysis of Wave-Driven Erosion, Wind Setup and Wave Run-up, of the January 2008 Feather River Setback Levee Design Report. The maximum water surface capable of generating wind waves was evaluated for the 0.5-percent annual (i.e. 1 in 200-year chance) chance of exceedance flood event. A maximum fetch of approximately 3.6 miles was measured along the Feather River for winds coming from the south-southeast and north-northwest. The peak wind velocity over a 66-year record was used to estimate a wave height of 4.4 feet, a wind setup of 0.9 foot and a maximum wave water velocity of 4.0 fps. This fluid velocity quantified from wave energy was compared to data from sediment transport studies. It was concluded that significant erosion is unlikely to occur on the well compacted clayey levee when the planned vegetation is well established and trees and shrubs mature in the floodplain overflow area.

2.3.7 Feather River East Levee Segment 1

The levee erosion potential of the Feather River East Levee Segment 1 was evaluated based on anticipated design water velocities, wave-induced water velocities, embankment side slopes, soil characteristics, channel sinuosity and uniformity, and performance history for the existing levee.

Criteria for maximum permissible water velocities against the Segment 1 levees were adopted from USACE' guidelines for the design of flood control channels (EM 1110-2-1601). The results of these analyses are summarized in Section 4 of the March 2007 Phase 4 Feather River Levee Repair Project Design Report. Flow velocities for the 100-year flood are presented in the document titled, Three Rivers Levee Improvement Authority Phase 4 Erosion Investigation, dated February 2006. This document is included as Appendix B of the March 2007 Phase 4 Feather River Levee Repair Project Design Report.

The estimated maximum flow velocity along the Segment 1 levee was computed as 4 feet per second (fps), with most of the Segment 1 alignment experiencing flow velocities less than 3 fps. The USACE guidelines referenced above show maximum permissible mean channel velocities for bare-earth channels ranging from 2 fps for fine sand to 6 fps for clay. For grass-lined channels, maximum permissible velocities range from 5 fps to 6 fps depending on type of soil and grass cover. Based on these guidelines, it was judged that well-established vegetation of the levee slopes should provide adequate erosion protection. This judgment was based on the following factors:

- The calculated water velocities are equal or less than the maximum permissible velocities for vegetated flow channels.
- The existing levee embankment material is free of significant erosion, and there was not significant erosion of the levee reported after previous flood events.
- The existing levee slopes are generally well vegetated.

Accordingly, the levee slopes impacted by levee repair activities were planted with approved non-woody ground cover for erosion protection. Approved plant species for levee slopes are listed in Section 131 of the California Code of Regulations.

The details of the analysis of wave-driven erosion, wind setup and wave runup are presented in Appendix E, Analysis of Wave-Driven Erosion, Wind Setup and Wave Runup, of the March 2007 Phase 4 Feather River Levee Repair Design Report. The maximum water surface capable of generating wind

waves was evaluated for the 1 in 200-year flood event. A maximum average fetch of approximately three miles was measured along the Feather River for winds coming from the northwest. The peak wind velocity over a 66-year record was used to estimate a wave height of 3.4 feet, a wind setup of 0.5 foot, a wave runup of 4.4 feet, and a maximum wave water velocity of 3.4 fps. This fluid velocity quantified from wave energy was compared to data from sediment transport studies. It was concluded that significant erosion is unlikely to occur as long as the levee slope remains well vegetated.

Within Segment 1, erosion of the river bank near the levee has been documented at the site designated as "Corps Erosion Site – Feather River RM 17.8 Left," located between approximate levee Stations 240+00 and 244+00. The river bank at Corps Erosion Site - RM 17.8 is steep, probably due to the presence of cemented soils from the Modesto Formation. The USACE' Lower Feather River Floodplain Mapping Study dated February 17, 2005 concluded that at this site "the levee will not be threatened during a 100-year event as erosion is gradual and the result of lower flows. However, formal monitoring of the berm width is strongly recommended as part of regular levee maintenance." The December 18, 2007, Field Reconnaissance Report of Bank Erosion Sites and Site Priority Ranking prepared by Ayres Associates for the USACE identifies this site as being not critical, with indications of an actively eroding berm which is greater than 50 feet wide.

The berm width was measured to be greater than 70 feet. There are mature trees growing on the bank, indicating that the rate of erosion is slow. Various geomorphic studies have estimated average bank retreat rates of 0 to 4 feet per year at this site. Results of the Feather River hydraulic analysis of the existing conditions during the January 1997 flood showed a maximum velocity of approximately 3 feet per second (fps) occurring along the east overbank and 5 to 6 fps in the main channel (Appendix B of the March 2007 Phase 4 Feather River Levee Repair Project Design Report).

Based on the observations reported in the available studies, it is possible that this site could eventually require some form of bank stabilization. The possibility of repair is not currently a safety issue, but the site is currently inventoried and monitored by the USACE and DWR, and needs to continue to be monitored. TRLIA has also included some event-based and long-term monitoring of this site in the Local Addendum. Transects have been established and monumented and photo point locations established to enable consistent repeat observations. Survey monitoring of the transects from November 2009 to January 2019 is summarized in the GEI report titled *Due Diligence Review- 2019 FEMA Accreditation- Bear River North Setback Levee and Feather River East Levee Segments 1, 2 and 3, March 2019*. The survey monitoring data indicates that the bank has remained relatively stable with no progressing trend of erosion. The performance of the bank will continue to be monitored after major flood events.

2.3.8 Bear River North Setback Levee

The levee erosion potential of the Bear River Setback Levee was evaluated based on anticipated design water velocities, wave-induced water velocities, embankment side slopes, soil characteristics, channel sinuosity and uniformity, and performance history for the existing levee. The levee was constructed with compacted "impervious" material in accordance with Central Valley Flood Protection Board and USACE requirements. The levee slopes were seeded with approved non-woody ground cover for erosion protection.

Criteria for maximum permissible water velocities were adopted from USACE' guidelines for the design of flood control channels (EM 1110-2-1601). The results of these analyses are summarized in Section 4 of the July 2006 Bear River Setback Levee Final Design Report. Flow velocities for the various flood events are presented in Appendix C, Hydraulic and Hydrologic Analysis, of the July 2006 Bear River Setback Levee Final Design Report.

The USACE guidelines referenced above show maximum permissible mean channel velocities for bare-earth channels ranging from 3.5 feet per second (fps) for silty clay to 6 fps for clay. For grass-lined channels, maximum permissible velocities range from 6 fps for silty clay to 8 fps for clay. Based on these guidelines, it was judged that the combination of clayey soils and vegetation of the levee slopes should provide adequate erosion protection. This judgment was based on the following factors:

- The calculated water velocities are equal or less than the maximum permissible velocities for either bare-earth or vegetated flow channels.
- The embankment material, primarily silty clay, has a relatively low susceptibility to erosion.
- The condition of the existing levees is free of significant erosion except for the vicinity of structure crossings that were not located within the reach of the setback levee.
- There are no major meanders, constrictions or confluences in the Bear River within the reach of the setback levee.

Accordingly, the levee slopes were seeded with approved non-woody ground cover for erosion protection. Approved plant species for levee slopes are listed in Section 131 of the California Code of Regulations.

The details of the analysis of wave-driven erosion, wind setup and wave runup are presented in Appendix D, Analysis of Wave-Driven Erosion, Wind Setup and Wave Runup, of the July 2006 Bear River Setback Levee Final Design Report. The maximum water surface capable of generating wind waves was evaluated for the 0.5-percent annual chance of exceedance flood event. A maximum fetch of approximately four miles was measured along the Feather River for winds coming from the SSW. The peak wind velocity over a 66-year record was used to estimate a wave height of 3.2 feet, a wind setup of 0.4 foot, a wave runup of 4.5 feet, and a maximum wave water velocity of 3.2 fps. This fluid velocity quantified from wave energy was compared to data from sediment transport studies. It was concluded that significant erosion is unlikely to occur on the well compacted clayey levee when the planned vegetation is well established and trees and shrubs mature in the overflow area. In the interim, there may be some potential for erosion. Treating any problem areas during high water events with standard flood fighting techniques was considered a reasonable approach. The potential for erosion and the need for repair during the early period of the levee was addressed in the Local Addendum to the existing Operation and Maintenance Manual that was submitted to the USACE and the Central Valley Flood Protection Board as a condition for their acceptance of the levee into the Sacramento River Flood Control Project.

2.3.9 Upper Bear North Levee (Setback Levee to WPIC), WPIC West Levee, and ODB Ring Levee

The levee erosion potential of the Upper Bear River North Levee from the setback levee to the WPIC, the WPIC west levee, and the ODB Ring Levee was evaluated based on anticipated design water

velocities, embankment side slopes, soil characteristics, channel sinuosity and uniformity, and performance history for the existing levee. Criteria for maximum permissible water velocities were adopted from USACE's guidelines for the design of flood control channels (EM 1110-2-1601). The results of these analyses are summarized in the 2006 Basis of Design Report and the 1998 Basis of Design Report. Analyses for the WPIC 200-Year Standard Project that was constructed in 2016-2017 are summarized in the 2014 Alternatives Analysis and the 2014 Final Geotechnical Basis of Design.

The estimated maximum flow velocity along the Bear River north levee was computed to range from 2 to 3.5 feet per second (fps). The USACE guidelines referenced above show maximum permissible mean channel velocities for sandy channels with grass-lined slopes is 6 fps. Generally, embankment protection was not required for the portions of the levee segment that met this permissible velocity. However, at the confluence of the WPIC significant scour has been identified. Questions regarding the modeling approach used to calculate the flow velocities caused additional concerns with this specific area. In order to remediate the identified scour and to protect the levee slopes, rip rap revetment was placed at the Upper Bear north levee and WPIC west levee confluence.

The WPIC mainly carries low flow drainage from upstream areas. However it becomes a backwater once stages in the Bear River increase. As a result velocities are below the threshold of concern.

The ODB ring levee was expected to experience flow velocities as high as 3 fps for the majority of the subject levee. However, where velocities were expected to be over 4 fps rip rap revetment was placed. Throughout the detention basin, slopes were hydroseeded with sufficient vegetation to further strengthen the slopes. Wave erosion is not expected to be significant in the detention basin.

The potential for wave erosion was evaluated for the Bear River North Levee. A maximum average fetch of approximately 1.4 miles was used coming from the southwest. The estimated maximum wave runup was calculated to be 2.0 feet. This magnitude wave would be contained within the design freeboard over the base flood elevation. It was concluded that significant erosion is unlikely to occur and any resulting damage would be mitigated through proper maintenance and flood fighting techniques. Minimal wind erosion during the 100-year flood event would not jeopardize levee stability.

The potential for wave erosion was evaluated for the WPIC West Levee. A maximum average fetch of less than 1 mile was used coming from the southeast. The estimated maximum wave runup was calculated to be 3.0 feet. This magnitude wave would be contained within the design freeboard over the base flood elevation. However, it was determined based on historic performance that wave erosion would be a potential issue in the northern portion of the levee segment. Accordingly, rip rap revetment was designed and placed from Station 255+00 to 308+00 to provide embankment slope protection.

2.4 EMBANKMENT AND FOUNDATION STABILITY [44 CFR § 65.10(B)(4)]

TRLIA's consultants evaluated the embankment and foundation stability over the length of the RD 784 Levee System. The evaluation was performed as follows:

- GEI evaluated the Feather River east levee and the Bear River north setback levee.

- HDR/Kleinfelder evaluated the Yuba River South Levee, the Western Pacific Interceptor Canal (WPIC) west levee, the Olivehurst Detention Basin ring levee, and the Upper Bear north levee (from the setback levee to the WPIC).
- ENGEO assessed the Goldfields 100-Year Embankment.

The evaluation was conducted by performing the following analyses and assessments for the respective levee reaches:

- Seepage analyses of selected embankment sections.
- Global stability analyses of selected embankment sections.
- Strength and stability analyses of selected embankment sections.
- Impact assessment of penetrations

The above analyses and assessments were performed in accordance with the 44 CFR § 65.10(b)(4), which states the following:

> *Engineering analyses that evaluate levee embankment stability must be submitted. The analyses provided shall evaluate expected seepage during loading conditions associated with the base flood and shall demonstrate that seepage into or through the levee foundation and embankment will not jeopardize embankment or foundation stability. An alternative analysis demonstrating that the levee is designed and constructed for stability against loading conditions for Case IV as defined in the U.S. Army Corps of Engineers (COE) manual, "Design and Construction of Levees'' (EM 1110-2-1913,Chapter 6, Section II), may be used. The factors that shall be addressed in the analyses include: Depth of flooding, duration of loading, embankment geometry and length of seepage path at critical locations, embankment and foundation materials, embankment compaction, penetrations, other design factors affecting seepage (such as drainage layers), and other design factors affecting embankment and foundation stability (such as berms).*

Based on the engineers' evaluation of their respective reaches, it is the engineers' opinions that, in general, the RD 784 Levee System meets the requirements for embankment and foundation stability during the base flood.

Engineer's Opinions for the RD 784 levee system, signed by a Licensed Professional Engineer, are included in Appendix D of this Certification Summary document. A general description of embankment and foundation stability evaluations and associated reference reports are provided below for each RD 784 levee reach

2.4.1 GOLDFIELDS 100-YEAR EMBANKMENT

The embankment and foundation stability assessment by ENGEO for the Goldfields 100-Year Embankment included seepage and stability evaluations as presented in the Goldfields Geotechnical Studies Report, Appendix F, Evaluation of Dredge Tailing Mounds within the Yuba Goldfields, dated July 9, 2013 and Technical Memorandum, Subject: Yuba Goldfields 100-year Project Geotechnical Update, dated August 3, 2016, prepared by ENGEO. Design and construction of the Goldfields 100-Year Embankment was based on the findings of the seepage and stability assessment. The work consisted of placing fill on an existing dredge tailing mound to provide a 35-foot crown width and

3H:1V waterside (WS), and 5H:1V landside (LS) slopes. Details about the construction activities for the levee improvement project, including slope stability and seepage mitigation features, are presented in the July 2016 Construction Completion Report for the Goldfields 100-Year Interim Flood Protection Project, prepared by Handen Co., ENGEO, and MBK Engineers.

Stability Evaluation

The dimensions of the levee geometry improvements as required by the Central Valley Flood Protection Board and the USACE are tabulated below:

Crown Width	20 feet minimum
Patrol Road Width (on Crown)	16 feet minimum
Waterside Slope	3H:1V maximum
Landside Slope	2H:1V maximum (based on a good history of landside slope performance and minimal potential for destabilizing seepage forces during design flood events)

Stability of the embankment cross-section (both landside and waterside slopes) and underlying foundation materials was computed for steady-state and rapid-drawdown conditions. Analyses were performed using selected cross-section geometry and site-specific strength properties for foundation and embankment materials. The steady-state seepage case was evaluated assuming a fully developed phreatic surface through the embankment because the duration of the flood hydrograph is influenced by upstream reservoirs and could be several weeks.

The results of the stability analyses performed for the embankment are summarized in the Goldfields Geotechnical Studies Report, Appendix F, Evaluation of Dredge Tailing Mounds within the Yuba Goldfields, dated July 9, 2013 and Technical Memorandum, Subject: Yuba Goldfields 100-year Project Geotechnical Update, dated August 3, 2016, prepared by ENGEO. The analyses confirmed that the levee meets or exceeds the required minimum safety factors detailed in EM 1110-2-1913, Design and Construction of Levees, Table 6-1b.

Seepage Evaluation

Seepage analyses of the Goldfields 100-Year Embankment and its foundation were based on the assumption that steady-state conditions have developed for the peak stage of the design flood event. Seepage analyses computed the distribution of hydraulic heads within the improved embankment and its foundation. The results of the seepage analyses performed for the embankment are summarized in the Goldfields Geotechnical Studies Report, Appendix F, Evaluation of Dredge Tailing Mounds within the Yuba Goldfields, dated July 9, 2013 and Technical Memorandum, Subject: Yuba Goldfields 100-year Project Geotechnical Update, dated August 3, 2016, prepared by ENGEO. The analyses confirmed that the levee does not exceed the specified maximum exit gradients detailed in EM 1110-2-1913.

Utility Penetrations

There are no utility penetrations through or under the Goldfields 100-Year Embankment.

Liquefaction and Seismic Evaluation

An evaluation of seismicity and liquefaction are described in Goldfields Geotechnical Studies Report, Appendix F, Evaluation of Dredge Tailing Mounds within the Yuba Goldfields, dated July 9, 2013 and Technical Memorandum, Subject: Yuba Goldfields 100-year Project Geotechnical Update, dated August 3, 2016, prepared by ENGEO. The dredge deposits within the Goldfields are generally gravels, cobbles, and sands, with areas of fine grained slickens. The depositional mechanism of the dredging process provides nominal compaction of materials as the spoils are dropped off the conveyor. Despite this, the potential for liquefaction and liquefaction lateral spreading is relatively low due to the very low potential ground shaking levels. Therefore, the likelihood for liquefaction induced settlement and deformation is considered relatively low.

Hydrocompaction and Heave Potential

Hydrocompaction occurs when soils with a loose open structure, such as loosely deposited silts or sands, and low moisture content become saturated upon wetting and consolidate under their own weight, or under the application of additional loads. This type of phenomena usually occurs in arid regions with windblown sand or silt deposits. Over the last 100 years, the silt and sand materials along within the Goldfields have been exposed to numerous floods, including floods that have reached the design capacity of the levee system, so the potential for additional hydrocompaction to occur along the levee alignment is considered low.

Heave potential generally occurs from increases in moisture content of predominantly clayey or silty soil with moderate to high plasticity. The Yuba Goldfields deposits are generally granular and contain relatively small percentages of low plasticity clay or silt. In addition, the groundwater conditions in the Yuba Goldfields area are relatively shallow, so it is unlikely that the in-situ moisture content of the shallow foundation soils under the embankment would vary significantly from the wet to dry season. For these reasons, heave potential is considered low.

2.4.2 Yuba River South Levee (Simpson Lane to the Goldfields)

The embankment and foundation stability assessment by Kleinfelder for the Yuba River South Levee from Simpson Lane to the Goldfields reach included seepage and stability evaluations as presented in the June 11, 2010 Revised Geotechnical Basis of Design report, Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Reclamation District 784, Yuba County, California, in 2 Volumes, prepared by Kleinfelder. Levee improvement features, summarized in below, were designed and constructed based on the findings of the seepage and stability assessment. Improvements consisted of geometry corrections to provide 20-foot crown widths and 3H:1V waterside (WS) and 2H:1V landside (LS) slopes; seepage remediation features including soil bentonite cutoff walls, and a landside stability/seepage berm; and a transition at the end of the landside berm into the Goldfields to address seepage and geometry. Details about the construction activities for the levee improvement project, including slope stability and seepage mitigation features, are presented in the March 2013 Construction Documentation Report, Upper Yuba Levee Improvement Project, Three Rivers Levee Improvement Authority, prepared by HDR.

Stability Evaluation

The dimensions of the levee geometry improvements as required by the Central Valley Flood Protection Board and the USACE are tabulated below:

Crown Width	20 feet minimum
Patrol Road Width (on Crown)	16 feet minimum
Waterside Slope	3H:1V maximum
Landside Slope	2H:1V maximum (based on a good history of landside slope performance and minimal potential for destabilizing seepage forces during design flood events)

Stability of the improved embankment cross-sections (both landside and waterside slopes) and underlying foundation materials was computed for steady-state seepage, and rapid-drawdown stability cases. No stability analysis was performed for end of construction because neither a significant raise nor new levee embankment was constructed. Slope stability analyses were performed using selected cross-section geometry and site-specific strength properties for foundation and improved embankment materials. The steady-state seepage case was evaluated assuming a fully developed phreatic surface through the embankment because the duration of the flood hydrograph is influenced by upstream reservoirs and could be several weeks. The results of the stability analyses performed for the levee are summarized in Section 5.3 and Appendices E2, I, and K of the June 11, 2010 Revised Geotechnical Basis of Design Report, Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Reclamation District 784, Yuba County, California (Kleinfelder). The analyses confirmed that the levee meets or exceeds the required minimum safety factors detailed in EM 1110-2-1913, Design and Construction of Levees, Table 6-1b.

Seepage Evaluation

Seepage analyses of the Yuba River South Levee (Simpson Lane to the Goldfields) and its foundation were based on the assumption that steady-state conditions have developed for the peak stage of the design flood event. Seepage analyses computed the distribution of hydraulic heads within the improved levee and its foundation, both in the previous foundation strata as well as in the less pervious upper stratum on which much of the levee is founded. The seepage evaluation also included an assessment of a previously installed seepage mitigation feature, which consisted of an existing 36-foot-deep soil-cement-bentonite cutoff wall through the embankment crest for a 4,150-foot reach of levee (Station 102+00 to 143+50).

The need for additional seepage remedial features was triggered by at least one of the following criteria:

- An uplift gradient (defined as the difference in hydraulic head across the less pervious upper layer divided by the layer's thickness) in excess of 0.5 when computed with water at the design water surface elevation.
- An exit gradient in excess of 0.5, also computed with water at the design water surface elevation.
- A determination that a potential exists for levee through-seepage based on embankment soil conditions observed in borings performed through the levee embankment.

The detailed methodology and results of the seepage analysis are described in Section 5.2 and Appendices E1, G, H, and J of the June 11, 2010 Revised Geotechnical Basis of Design report, Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Reclamation District 784, Yuba County, California (Kleinfelder). Constructed seepage improvement features were listed in the table above.

Construction of the soil-bentonite cutoff wall involved degrading the levee crown to provide a work platform necessary for equipment to construct the wall. The wall tied into a low-permeability layer in the levee foundation in most cases. One length of cutoff wall was left "hanging" in a predominantly sand and gravel foundation. This is the reach of 70-foot depth wall. Following construction of the cutoff wall, the levee embankment was reconstructed to design geometry and crown elevations.

Construction of the seepage berm included clearing and stripping the footprint area of the seepage berm and placing specified seepage berm material to the design dimensions.

As-built drawings and details of the construction activities for the stability and seepage mitigation features are presented in the March 2013 Construction Documentation Report, Upper Yuba Levee Improvement Project, Three Rivers Levee Improvement Authority, prepared by HDR.

Utility Penetrations

Utility penetrations through the levee that were no longer needed were removed. Those that remain in service were evaluated and reconstructed if appropriate. At Station 138+00, a PG&E 2-inch steel gas pipeline was removed and replaced by PG&E to current standards. The pipe removal and replacement was necessary to raise the pipeline above the design (200-year) water surface elevation and meet current standards. This gas line modification was authorized by the Central Valley Flood Protection Board (CVFPB) in a letter dated June 17, 2011. At Station 148+60, a Linda County Water District 6-inch steel water pipeline was removed and replaced to current standards. The pipe removal and replacement was necessary to raise the pipeline above the design (200-year) water surface elevation and meet current standards. This water line modification was authorized by the CVFPB in a letter dated July 28, 2011. As-built drawings and details of the construction activities for penetration removal and reconstruction are presented in the March 2013 Construction Documentation Report, Upper Yuba Levee Improvement Project, Three Rivers Levee Improvement Authority, prepared by HDR.

There is one additional utility penetration located within this reach of levee that was not removed or modified during levee improvements. The utility penetration protected in place is at Station 125+20 and is a 2-inch sanitary sewer force main owned by the Peach Tree Country Club. This force main is above the design elevation and meets current design standards.

Based on the available information, none of the utility penetrations are anticipated to affect embankment or foundation stability of the Yuba River South Levee (Simpson Lane to the Goldfields) within the accreditation period provided that they continue to be monitored and maintained in good operating condition.

Liquefaction and Seismic Evaluation

The detailed methodology and results of the Liquefaction and Seismic Evaluation are described in Section 5.4 and Appendix L of the June 11, 2010 Revised Geotechnical Basis of Design report, Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Reclamation District 784, Yuba County, California (Kleinfelder). The potential for some liquefaction-induced deformation was found in approximately .45 miles of the 3.10 mile reach. It is highly unlikely that an earthquake event and the base flood would occur at the same time. As part of the Urban Level of Protection determination required by the State of California, TRLIA will be preparing an earthquake recovery plan to describe how RD 784 will restore its levee system after an earthquake event.

Hydrocompaction and Heave Potential

Hydrocompaction occurs when soils with a loose open structure, such as loosely deposited silts or sands, and low moisture content become saturated upon wetting and consolidate under their own weight, or under the application of additional loads. This type of phenomena usually occurs in arid regions with windblown sand or silt deposits. Over the last 100 years, the silt and sand materials along the Yuba River South Levee have been exposed to numerous floods, including floods that have reached the design capacity of the levee system, so the potential for additional hydrocompaction to occur along the levee alignment is considered low.

Heave potential of any clayey foundation soils in the levee was also estimated to be low, based on the relatively low plasticity and thin layering of the clay soils, relatively high moisture content of the near surface foundation soils, and the relatively high levee embankment loads above the foundation soils. Groundwater conditions in the Yuba River South Levee area are generally within 10 to 20 feet of levee foundation grade, so it is unlikely that the in-situ moisture content of the shallow foundation soils under the levee would vary significantly from the wet to dry season.

2.4.3 Yuba River South Levee (UPRR to Simpson Lane)

The embankment and foundation stability assessment by Kleinfelder for the Yuba River South Levee between UPRR and Simpson Lane included seepage and stability evaluations as presented in the 2005 Problem Identification Report. Levee improvement features, summarized below, were designed and constructed based on the findings of the seepage and stability assessment. Seepage mitigation features included a soil-cement-bentonite cutoff wall throughout the entire segment and a seepage berm near the groin area between the levee and the UPRR crossing to address both through-seepage and underseepage deficiencies. Details about the construction activities for the levee repair project, including slope stability and seepage mitigation features, are presented in the 2007 Construction Documentation Report.

Stability Evaluation

A stability analysis of the existing embankment cross-sections was accomplished. This analysis included the cutoff wall through the levee embankment constructed in 2006. The analysis was based on as-built cross sections which in general met the USACE geometry criteria below:

Crown Width	20 feet minimum
Patrol Road Width (on Crown)	12 feet minimum

Waterside Slope	3H:1V maximum
Landside Slope	2H:1V maximum (based on a good history of landside slope performance and minimal potential for destabilizing seepage forces during design flood events)

A model was constructed and analyses performed to check the steady-state landside and sudden drawdown waterside stability for the 100-year water surface elevation. The model was constructed using existing PIR-level seepage model stratigraphy and parameters for model section G-G' at about Station 65+00. The geometry and mitigated conditions of the model levee section were based on as-built plans and sections. Representative shear strength parameters for the stability modeling were determined from the model constructed for analysis of the levee at about Station 20+00 (for the Highway 70 to UPRR reach) given the similarity in levee and foundation soils at these locations.

The results of the stability analysis indicate the as-built levee meets the 100-year stability criteria for both steady-state landside and sudden drawdown waterside conditions. A historic flood event in 1997 which exceeded base flood elevations exhibited no stability problems in this reach of levee.

Seepage Evaluation

Seepage analyses of this segment of levee and its foundation were based on the assumption that steady-state conditions have developed for the peak stage of the design flood event. Seepage analyses computed the distribution of hydraulic heads within the existing levee and its foundation, both in the pervious foundation strata as well as in the less pervious upper stratum on which the levee is founded.

The need for additional seepage remedial features was triggered by at least one of the following criteria:

- An uplift gradient (defined as the difference in hydraulic head across the less pervious upper layer divided by the layer's thickness) in excess of 0.5 when computed with water at the design water surface elevation.
- An exit gradient in excess of 0.5, also computed with water at the design water surface elevation.
- A determination that a potential exists for levee through-seepage based on embankment soil conditions observed in borings performed through the levee embankment.

The detailed methodology and results of the seepage analysis are described in the 2005 Problem Identification Report. Constructed seepage repair features included a 6,850-foot long soil-cement-bentonite cutoff wall through the existing levee embankment extending to an average depth of approximately 80 feet below the levee crest and a 90-foot-wide, 250-foot-long landside seepage berm in the groin area between the levee and the UPRR crossing.

Construction of the soil-cement-bentonite cutoff wall involved degrading the levee crown to provide a working platform necessary for equipment to construct the wall. The wall tied into a low-permeability layer in the levee foundation. Soils from the cutoff wall trench excavation and levee degrade were used in the soil-cement-bentonite backfill, with the exception of a gravel sublayer,

which was hauled off site. Following construction of the cutoff wall, the levee embankment was reconstructed to design crown elevations and hydroseeded with native grasses.

Construction of the seepage berm included clearing and stripping the footprint area of the seepage berm, including the removal of deleterious materials, and the placement of semipervious fill to the design grades. The top of the berm was hydroseeded with native grasses similar to the reconstructed levee embankment.

As-built drawings and details of the construction activities for the seepage mitigation features are presented in the 2007 Construction Documentation Report.

Utility Penetrations

There were three utility penetrations located within this reach of levee. The three utility penetrations are as follows:

- A 2-inch Sprint PVC Fiber Optics Line placed up and over the levee (Project Station 102+60, Simpson Lane)
- A 2-inch HDPE Comcast Cable Line placed up and over the levee (Project Station 102+60, Simpson Lane)
- A HDPE Qwest Communication Cable installed in the UPRR embankment which passes through the levee (Project Station 34+50)

In 2007, MBK performed an inventory of these utility penetrations. The results of this inventory are presented in the memorandum titled, "Inventory of Levee Utility Penetrations- RD 784 Levee Accreditation, Yuba River South Levee (WPRR to Simpson Lane), Bear River North Levee (Setback Levee to the WPIC), WPIC West Levee, and the ODB Ring Levee", dated April 7, 2010. The purpose of the inventory was to obtain information on the location and elevation of the utility, identify any historic problems at the utility penetration, and to obtain information on the maintenance and the condition and integrity of the utility penetrations located within this levee reach. Activities associated with the inventory included (1) a review of available information pertaining to the utilities and (2) discussions about utility maintenance and performance with utility engineers and RD 784 representatives.

Based on the available information, the existing utility penetrations are not anticipated to affect embankment or foundation stability of the Yuba River South Levee (UPRR to Simpson Lane) within the accreditation period provided that they continue to be monitored and maintained in good operating condition.

Liquefaction and Seismic Evaluation

The USACE document EC 1110-2-6067 titled, "Certification of Levee Systems for the National Flood Insurance Program (NFIP)", provides guidance for liquefaction and seismic stability evaluations of levee systems in regions that experience strong ground motions from earthquake activity. The document states that the peak ground acceleration (PGA) should be determined for the 10% in 50-year earthquake from the United States Geologic Survey (USGS) ground motion database. If the PGA is less than 0.15 g, no further evaluation of liquefaction potential and seismic stability is required. For the Yuba River South Levee (UPRR to Simpson Lane), the PGA as determined from the USGS

database is less than 0.15g, so a liquefaction and seismic stability evaluation was not required based on USACE levee certification protocols.

Hydrocompaction and Heave Potential

Hydrocompaction occurs when soils with a loose open structure, such as loosely deposited silts or sands, with low moisture content become saturated upon wetting and consolidate under their own weight, or under the application of additional loads. This type of phenomena usually occurs in arid regions with windblown sand or silt deposits. Over the last 100 years, the silt and sand materials along the Yuba River South Levee (UPRR to Simpson Lane) have been exposed to numerous floods, including floods that have reached the design capacity of the levee system, so the potential for additional hydrocompaction to occur along the levee alignment is considered low.

Heave potential of the clayey foundation soils in the levee was also estimated to be low, based on the relatively high moisture content of the near surface foundation soils and the relatively high levee embankment loads above the foundation soils. Groundwater conditions in the Yuba River South Levee (UPRR to Simpson Lane) area are generally within 10 to 20 feet of levee foundation grade, so it is unlikely that the in-situ moisture content of the shallow foundation soils under the levee would vary significantly from the wet to dry season.

2.4.4 Yuba River South Levee (WPRR to UPRR)

The embankment and foundation stability assessment by Kleinfelder for the Yuba River South Levee between WPRR and UPRR included seepage and stability evaluations as presented in the 2004 Problem Identification Report and the 2004 Alternatives Assessment. Levee improvement features, summarized below, were designed and constructed based on the findings of the seepage and stability assessment. Seepage mitigation features included a soil-cement-bentonite cutoff wall and seepage berms along select portions of the subject levee to address both through-seepage and underseepage deficiencies. Details about the construction activities for the levee repair project, including slope stability and seepage mitigation features, are presented in the 2007 Construction Documentation Report.

Stability Evaluation

The dimensions of the existing levee meet or exceed the criteria tabulated below as required by the Central Valley Flood Protection Board and the USACE:

Crown Width	20 feet minimum
Patrol Road Width (on Crown)	12 feet minimum
Waterside Slope	3H:1V maximum
Landside Slope	2H:1V maximum (based on a good history of landside slope performance and minimal potential for destabilizing seepage forces during design flood events)

Stability of the existing embankment cross-sections (both landside and waterside slopes) and underlying foundation materials was computed for steady-state seepage and rapid-drawdown stability cases. Detailed confirmatory slope stability analyses were performed using the selected

cross-section geometry and site-specific strength properties for foundation and existing embankment materials. The steady-state seepage case was evaluated assuming a fully developed phreatic surface through the embankment. The results of the stability analyses performed for the levee are summarized in the 2004 Problem Identification Report and 2004 Alternatives Assessment. The analyses confirmed that the levee meets or exceeds the required minimum safety factors detailed in EM 1110-2-1913, Design and Construction of Levees, Table 6-1b, with the exception of the rapid drawdown loading condition.

Additional analyses were completed for this segment of levee on the waterside slope to further analyze the rapid drawdown loading condition. The original analysis was found to have used overly conservative strength parameters. Subsequent analysis utilizing strength test data were included in the 2006 Supplement No. 2 Geotechnical Design Memorandum (included in Appendix C of the 2009 Final Design Documentation Report) and showed that the slope is stable for this loading condition. In addition, a portion of the levee segment had waterside slopes that were slightly less than the 3H:1V required slope. This area was flattened as part of levee repairs in 2009. For additional information, see the 2009 Final Design Documentation Report.

Although the factor of safety requirements were met for all cross sections analyzed, a stability berm was added to portions of the levee reach to remediate potential through-seepage issues in the levee embankment that could destabilize the landside embankment slope. Since the main purpose of this berm was to increase embankment stability in the event of through-seepage, the berm is referred in the 2005 Basis of Design Report as a stability berm. The landside stability berm was constructed with similar materials to the seepage berms discussed below.

As-built drawings and details of the construction activities for the seepage mitigation features are presented in the 2007 Construction Documentation Report.

Seepage Evaluation

Seepage analyses of the Yuba River South Levee between the WPRR and UPRR and its foundation were based on the assumption that steady-state conditions have developed for the peak stage of the design flood event. Seepage analyses computed the distribution of hydraulic heads within the existing levee and its foundation, both in the pervious foundation strata as well as in the less pervious upper stratum on which the levee is founded.

The need for additional seepage remedial features was triggered by at least one of the following criteria:

- An uplift gradient (defined as the difference in hydraulic head across the less pervious upper layer divided by the layer's thickness) in excess of 0.5 when computed with water at the design water surface elevation.
- An exit gradient in excess of 0.5, also computed with water at the design water surface elevation.
- A determination that a potential exists for levee through-seepage based on embankment soil conditions observed in borings performed through the levee embankment.

The detailed methodology and results of the seepage analysis are described in the 2004 Problem Identification Report. Constructed seepage repair features included a 2,200-foot long soil-cement-

bentonite cutoff wall through the existing levee embankment extending to an average depth of approximately 50 feet below the levee crest and 2,540 feet of seepage berm between 90- and 300-feet-wide.

Construction of the soil-cement-bentonite cutoff wall involved degrading the levee crown to provide a working platform necessary for equipment to construct the wall. Soils from the cutoff wall trench excavation and levee degrade were used in the soil-cement-bentonite backfill. Following construction of the cutoff wall, the levee embankment was reconstructed to design crown elevations and hydroseeded with native grasses.

Construction of the seepage berm included clearing and stripping the footprint area of the seepage berm, including the removal of deleterious materials, and the placement of pervious fill to the design grades to alleviate seepage pressures. The top of the berm was hydroseeded with native grasses similar to the reconstructed levee embankment.

As-built drawings and details of the construction activities for the seepage mitigation features are presented in the 2007 Construction Documentation Report.

Utility Penetrations

There were four utility penetrations located within this reach of levee. The four utility penetrations are as follows:

- Unknown size and material abandoned communication line installed in the UPRR embankment which passes through the levee (Project Station 34+00)
- A single 8&5/8-inch steel Kinder Morgan petroleum products pipeline placed up and over the levee (Project Station 33+00)
- A single steel PG&E 10-inch natural gas pipeline at Highway 70 placed up landside slope and connecting to the highway bridge crossing (Project Station 2+50)
- An AT&T Concrete Duct between Highway 70 and the WPRR Crossing placed up and over the levee (Project Station 2+25)

In 2007, MBK performed an inventory of these utility penetrations. The results of this inventory are presented in the memorandum titled, "Inventory of Levee Utility Penetrations- RD 784 Levee Accreditation, Yuba River South Levee (WPRR to Simpson Lane), Bear River North Levee (Setback Levee to the WPIC), WPIC West Levee, and the ODB Ring Levee", dated April 7, 2010. The purpose of the inventory was to obtain information on the location and elevation of the utility, identify any historic problems at the utility penetration, and to obtain information on the maintenance and the condition and integrity of the utility penetrations located within this levee reach. Activities associated with the inventory included (1) a review of available information pertaining to the utilities and (2) discussions about utility maintenance and performance with utility engineers and RD 784 representatives.

Based on the available information, the existing utility penetrations are not anticipated to affect embankment or foundation stability of the Yuba River South Levee (UPRR to Simpson Lane) within the accreditation period provided that they continue to be monitored and maintained in good operating condition.

Liquefaction and Seismic Evaluation

The USACE document EC 1110-2-6067 titled, "Certification of Levee Systems for the National Flood Insurance Program (NFIP)", provides guidance for liquefaction and seismic stability evaluations of levee systems in regions that experience strong ground motions from earthquake activity. The document states that the peak ground acceleration (PGA) should be determined for the 10% in 50-year earthquake from the United States Geologic Survey (USGS) ground motion database. If the PGA is less than 0.15 g, no further evaluation of liquefaction potential and seismic stability is required. For the Yuba River South Levee (WPRR to UPRR), the PGA as determined from the USGS database is less than 0.15g, so a liquefaction and seismic stability evaluation was not required based on USACE levee certification protocols.

Hydrocompaction and Heave Potential

Hydrocompaction occurs when soils with a loose open structure, such as loosely deposited silts or sands, with low moisture content become saturated upon wetting and consolidate under their own weight, or under the application of additional loads. This type of phenomena usually occurs in arid regions with windblown sand or silt deposits. Over the last 100 years, the silt and sand materials along the Yuba River South Levee (WPRR to UPRR) have been exposed to numerous floods, including floods that have reached the design capacity of the levee system, so the potential for additional hydrocompaction to occur along the levee alignment is considered low.

Heave potential of the clayey foundation soils in the levee was also estimated to be low, based on the relatively high moisture content of the near surface foundation soils and the relatively high levee embankment loads above the foundation soils. Groundwater conditions in the Yuba River South Levee (WPRR to UPRR) area are generally within 10 to 20 feet of levee foundation grade, so it is unlikely that the in-situ moisture content of the shallow foundation soils under the levee would vary significantly from the wet to dry season.

2.4.5 Feather River East Levee Segment 3

The embankment and foundation stability assessment by GEI for the Feather River East Levee Segment 3 included seepage and stability evaluations as presented in Volumes 1 and 3 of the March 2007 Phase 4 Feather River Repair Project Design Report and Addendum 1 dated May 2007. Levee improvement (repair) features, summarized below, were designed and constructed based on the findings of the seepage and stability assessment. Stability mitigation features included a landside stability berm along a levee reach to increase the slope stability factor of safety under assumed steady-state conditions, and the flattening of a reach of waterside slope to conform to USACE requirements for maximum levee slope inclination. Seepage mitigation features included a soil-cement-bentonite cutoff wall and a seepage berm along select levee reaches to address both through-seepage and underseepage deficiencies in the existing levee. Details about the construction activities for the levee repair project, including slope stability and seepage mitigation features, are presented in the June 2009 Feather River Levee Segments 1&3 Construction Completion Report.

Stability Evaluation

The dimensions of the existing levee as required by the Central Valley Flood Protection Board and the USACE are tabulated below:

Crown Width	20 feet minimum
Patrol Road Width (on Crown)	12 feet minimum
Waterside Slope	3H:1V maximum
Landside Slope	2H:1V maximum (based on a good history of landside slope performance and minimal potential for destabilizing seepage forces during design flood events)

Stability of the existing embankment cross-sections (both landside and waterside slopes) and underlying foundation materials was computed for end-of-construction (if a new berm was constructed), steady-state seepage, and rapid-drawdown stability cases. Detailed confirmatory slope stability analyses were performed using the selected cross-section geometry and site-specific strength properties for foundation and existing embankment materials. The steady-state seepage case was evaluated assuming a fully developed phreatic surface through the embankment because the duration of the flood hydrograph is influenced by large upstream reservoirs and could be several weeks. The results of the stability analyses performed for the levee are summarized in Section 4 and Appendix G of the March 2007 Phase 4 Feather River Levee Repair Project Design Report. The analyses confirmed that the levee meets or exceeds the required minimum safety factors detailed in EM 1110-2-1913, Design and Construction of Levees, Table 6-1b.

Although the factor of safety requirements were met for all cross sections analyzed, a stability berm was added to a 2,980-foot long levee reach of Segment 3 to intercept potential through-seepage in the levee embankment that could daylight and destabilize the landside embankment slope. Since the main purpose of this berm was to increase embankment stability in the event of through-seepage, the berm is referred in the March 2007 Phase 4 Feather River Levee Repair Project Design Report as a stability berm. The landside stability berm included a geotextile encapsulated drainage blanket to intercept embankment through-seepage, overlain by fill material that buttresses the levee slope and provides an overall 2.5H:1V landside slope configuration.

As-built drawings and details of the construction activities for the seepage mitigation features are presented in the June 2009 Feather River Levee Segments 1&3 Construction Completion Report.

Seepage Evaluation

Seepage analyses of the Segment 3 levee and its foundation were based on the assumption that steady-state conditions have developed for the peak stage of the design flood event. Seepage analyses computed the distribution of hydraulic heads within the existing levee and its foundation, both in the pervious foundation strata as well as in the less pervious upper stratum on which the levee is founded. The seepage evaluation also included an assessment of previously installed seepage mitigation features, which consisted of an existing 45- to 50-foot-deep soil-cement-bentonite cutoff wall through the embankment crest for a 6,500-foot reach of levee.

The need for additional seepage remedial features was triggered by at least one of the following criteria:

- An uplift gradient (defined as the difference in hydraulic head across the less pervious upper layer divided by the layer's thickness) in excess of 0.5 when computed with water at the design water surface elevation.
- An exit gradient in excess of 0.5, also computed with water at the design water surface elevation.
- A determination that a potential exists for levee through-seepage based on embankment soil conditions observed in borings performed through the levee embankment.

The detailed methodology and results of the seepage analysis are described in Section 4 and Appendix F of the March 2007 Phase 4 Feather River Levee Repair Project Design Report. Constructed seepage repair features included a 6,200-foot long soil-cement-bentonite cutoff wall through the existing levee embankment extending to depths of approximately 35 to 65 feet below the levee crest and an 80- to 100-foot-wide, 450-foot-long landside seepage berm.

Construction of the soil-cement-bentonite cutoff wall involved degrading the levee crown to provide a work platform necessary for equipment to construct the wall. The wall tied into a low-permeability layer in the levee foundation. Soils from the cutoff wall trench excavation and levee degrade were used in the soil-cement-bentonite backfill. Following construction of the cutoff wall, the levee embankment was reconstructed to design crown elevations.

Construction of the seepage berm included clearing and stripping the footprint area of the seepage berm and placing a filter/drainage layer consisting of a 6-inch-thick layer of filter sand and a 1-foot-thick layer of drain aggregate. A layer of geotextile was placed over the drain aggregate and a compacted fill was placed over the filter/ drainage layer and revegetated.

As-built drawings and details of the construction activities for the seepage mitigation features are presented in the June 2009 Feather River Levee Segments 1&3 Construction Completion Report.

Utility Penetrations

Utility penetrations through the levee that were no longer needed were removed. Those that remain in service were evaluated and reconstructed if appropriate. Near the south end of Segment 3, a Linda County Wastewater Treatment Plant 30-inch-diameter concrete-encased pipe effluent outfall was removed and replaced with a new 42-inch-diameter reinforced concrete cylinder pipe outfall. The pipe removal and replacement was necessary in order to construct a soil-cement-bentonite cutoff wall through the levee in this reach. In addition, an abandoned 48-inch-diameter corrugated metal pipe penetration was excavated and removed during construction of the Segment 3 levee repairs. Upon removal of the pipe, the excavated levee was backfilled with compacted low-permeability soil. As-built drawings and details of the construction activities for penetration removal and reconstruction are presented in the June 2009 Feather River Levee Segments 1&3 Construction Completion Report.

There were three utility penetrations located within Segment 3 that were not removed or modified. The three utility penetrations are as follows:

- A single steel pressure discharge pipe at Pump Station No. 9 placed up and over the 100-year flood elevation of the Segment No. 3 levee.

- A single steel PG&E natural gas pipeline at Island Avenue placed up and over the 100-year flood elevation of the Segment No. 3 levee.
- A single schedule 40 PVC Sprint fiber optics line adjacent to the Union Pacific (former Western Pacific) Railroad Crossing at the Segment No. 3 levee.

In the fall of 2009, GEI performed an assessment of these utility penetrations as presented in the memorandum titled, "Assessment of Levee Utility Penetrations- RD 784 Levee Accreditation, Segments 1 and 3", dated January 2010. The purpose of the assessment was to evaluate the condition and integrity of the utility crossings that were not modified as part of the Phase 4 Feather River Levee Repair Project. Activities associated with the assessment included (1) a review of available information pertaining to the utilities, (2) discussions about utility maintenance and performance with PG&E and RD 784 representatives, (3) a depth survey of the fiber optics line by a Sprint Representative, and (4) a video inspection of the Pump Station No. 9 steel discharge pipe.

In 2015, an additional assessment of penetrations along Segment 3 was performed with the purpose of assessing whether the penetrations posed a hazard to levee integrity under the California Department of Water Resources' Urban Levee Design Criteria. Activities associated with the assessment of penetrations included video inspections for the single steel pressure discharge pipe at Pump Station No. 9, and an additional geophysical survey of the levee embankment and foundation to confirm the absence of unknown utilities. Findings of the 2015 assessment are presented in the memorandum titled *Assessment of Levee Encroachment Penetrations and Closures, RD 784 200-year ULDC Compliance Determination, Feather River East Levee (Segments 1 and 3)*, dated October 30, 2015. The steel discharge pipeline at Pump Station 9 was observed to be in good condition.

In addition to the three existing penetrations, a new 16-inch welded steel pipe was installed in the fall of 2018 at the northern end of Segment 3 near Station 719+00, approximately 500 feet south of the UPRR (former WPRR) bridge. This pipeline crossing of Segment 3 is part of the City of Marysville Wastewater Pump Station and Force Main Project, Phase 1B and is permitted under the Central Valley Flood Protection Board (CVFPB) Permit No. 15178-1 BD. In the winter of 2019 GEI performed a desktop assessment of the design documents associated this recently installed utility crossing, as summarized in the report titled *Due Diligence Review - 2019 Accreditation - Bear River North Setback Levee and Feather River East Levee Segments 1, 2 and 3*, March 2019. Based on this assessment it was concluded that the recently installed 16-inch force main crossing was installed above the FEMA 100-year flood elevation at this location and would not be likely to affect levee embankment or foundation stability over the accreditation period, provided it was installed as per the design and permit documents.

A site visit was conducted in November 2018 to visually observe the condition of the levee at the four utility crossings. No signs of distress to the levee were observed that would indicate underlying distress, or damage to the utilities. Based on the available information and assessments in 2010, 2015, and 2018, the utility penetrations in Segment 3 are not anticipated to affect levee embankment or foundation stability within the accreditation period provided that they continue to be monitored, inspected, and maintained in good operating condition in accordance with the provisions of the O&M Manual.

Liquefaction and Seismic Evaluation

The USACE document EC 1110-2-6067 titled, "Certification of Levee Systems for the National Flood Insurance Program (NFIP)", provides guidance for liquefaction and seismic stability evaluations of levee systems in regions that experience strong ground motions from earthquake activity. The document states that the peak ground acceleration (PGA) should be determined for the 10% in 50-year earthquake from the United States Geologic Survey (USGS) ground motion database. If the PGA is less than 0.15 g, no further evaluation of liquefaction potential and seismic stability is required. For the Feather River Segment 3 levee alignment, the PGA as determined from the USGS database is less than 0.15g, so a liquefaction and seismic stability evaluation was not required based on USACE levee certification protocols.

Hydrocompaction and Heave Potential

Hydrocompaction occurs when soils with a loose open structure, such as loosely deposited silts or sands, with low moisture content become saturated upon wetting and consolidate under their own weight, or under the application of additional loads. This type of phenomena usually occurs in arid regions with windblown sand or silt deposits. Over the last 100 years, the silt and sand materials along the Feather River East Segment 3 levee have been exposed to numerous floods, including floods that have reached the design capacity of the levee system, so the potential for additional hydrocompaction to occur along the levee alignment is considered low.

Heave potential of the clayey foundation soils in the levee was also estimated to be low, based on the relatively high moisture content of the near surface foundation soils and the relatively high levee embankment loads above the foundation soils. Groundwater conditions in the Feather River East Levee Segment 3 area are generally within 10 to 20 feet of levee foundation grade, so it is unlikely that the in-situ moisture content of the shallow foundation soils under the levee would vary significantly from the wet to dry season.

2.4.6 Feather River East Levee Segment 2

The embankment and foundation stability assessment for the Feather River East Levee Segment 2 included seepage and stability evaluations as presented in Volumes 2 and 3 of the January 2008 Feather River Setback Levee Design Report, and in Addendum No. 1 of the Feather River Setback Levee Design Report, dated April 2008. Based on the findings of the seepage and stability assessment, the levee was designed and constructed with a soil-bentonite cutoff wall tied to a homogeneous earthfill levee and with placement of relief wells along the landside toe in selected reaches of the setback levee alignment. Two separate sections of the levee did not require a cutoff wall or other seepage mitigation measure. Stability berms were constructed in reaches of the levee alignment underlain by softer foundation soils where increased end-of-construction stability and/or mitigation of potential differential settlement was required.

In December 2008, a sensitive cultural site was identified in the levee foundation at the southern end (south tie-in) of the setback levee alignment. The presence of the cultural site required modifications to the design of the south tie-in, including a widened embankment over soft foundation soils. The modified levee design section was re-evaluated and confirmed for embankment and foundation stability. The findings of this re-evaluation are presented in a supplemental design package titled,

Feather River Setback Levee, Design Modifications of South Tie-in for Cultural site CA-YUB-1677, dated August 2009.

Details about the construction activities for the setback levee project, including seepage and stability mitigation features and south tie-in modifications are presented in the April 2010 Draft Construction Completion Report for the Feather River Setback Levee, Segment 2.

Stability Evaluation

The minimum dimensions of the setback levee, as required by the Central Valley Flood Protection Board (Reclamation Board) permit and the USACE document titled, SOP-EDG-03, are tabulated below:

Crown Width	20 feet
Patrol Road Width (on Crown)	12 feet
Waterside Slope (horizontal: vertical)	3H:1V
Landside Slope (horizontal: vertical)	3H:1V

Stability of the embankment cross-section (both landside and waterside slopes) and underlying foundation materials was verified for end-of-construction (no flood with undrained conditions), steady-state seepage (subjected to the water surface from a 1:200 annual chance flood), and rapid-drawdown stability cases for 17 design sections. Three of the 17 design sections were also evaluated for the 1957 design water surface.

Detailed confirmatory slope stability analyses were performed using the selected cross-section geometries and site-specific strength properties for foundation and embankment materials. The steady-state seepage case was evaluated assuming a fully developed phreatic surface through the embankment because the duration of the flood hydrograph is influenced by large upstream reservoirs and could be several weeks. The results of the stability analyses performed for the setback levee are summarized in Section 5 and Appendix E, Stability Calculations, of the January 2008 Feather River Setback Levee Design Report, and the April 2008 Feather River Setback Levee Design Report Addendum No. 1.

The analyses confirmed that the setback levee meets or exceeds the required minimum safety factors detailed in EM 1110-2-1913, Design and Construction of Levees, Table 6-1b. In reaches where the levee crosses recent alluvial deposits, the safety factors would have been less than the minimum safety factor for the end–of-construction condition due to the presence of softer soil deposits in the levee foundation. In order to attain an adequate factor of safety, stability berms were placed on the landside and/or waterside slopes of the levee as follows:

- A landside stability berm was placed on a 300-foot long section of levee
- A landside and waterside stability berm was placed on the a 2,700-foot long section of levee
- A waterside stability berm was placed on a 1,600-foot long section of levee

The stability berms were 5 to 10 feet in height, 30 to 60 feet in width, and were constructed with compacted fill material. The berms extended to adjacent design sections where the end-of-construction safety factor was adequate. Stability berms were also incorporated in the levee for

mitigation of differential settlement, as discussed in Section 2.5.4 of this report. These stability berms included an internal drainage system.

In order to reduce the potential for unstable foundation conditions during construction, all areas to receive embankment or stability berm fill (except within the limits of the cultural site) had vegetation and organic soil removed to a minimum depth of six inches. Trees removed from the levee foundation area had their root systems removed. Roots greater than 1.5 inches were removed to a depth of 3 feet as a minimum. All drains, ditches and abandoned conduits were removed from the levee foundation and backfilled with low-permeability soil.

The embankment cross section at the cultural site area was re-evaluated for slope stability based on the modified south tie-in embankment geometry and foundation conditions. Stability of the modified embankment cross-section (both landside and waterside slopes) and underlying foundation materials was verified for end-of-construction, steady-state seepage, and rapid-drawdown. The re-evaluation confirmed that the modified embankment configuration at the cultural site area meets or exceeds the required minimum safety factors detailed in detailed in EM 1110-2-1913. The modified design was approved by the USACE.

Seepage Evaluation

Seepage analyses of the Segment 2 levee and its foundation were based on the assumption that steady-state conditions have developed for the peak stage of the design flood event. Seepage analyses computed the distribution of hydraulic heads within the levee and its foundation, both in the pervious foundation strata as well as in the less pervious upper stratum on which the levee is founded. The need for seepage control measures was triggered by (1) an uplift gradient at the setback levee toe (defined as the difference in hydraulic head across the less pervious upper layer divided by the layer's thickness) in excess of 0.5, and/or (2) an exit gradient in excess of 0.5 at the setback levee toe, both computed with water at the design water surface elevation.

To evaluate seepage into the drainage ditch landside of the setback levee, the allowable exit gradient ranged from 0.5 at the bottom of the ditch where the ditch is located adjacent to the landside levee toe to 0.8 where the ditch is located 150 feet from the levee toe. For intermediate positions between the landside levee toe and 150 feet landward of the landside levee toe, the maximum allowable exit gradient at the bottom of the ditch was determined by linear interpolation between 0.5 and 0.8. Seepage gradients were also evaluated in transitional areas such as the ends of cutoff walls and where potential seepage blocks on the landside of the levee may be present due to changes in subsurface stratigraphy.

The detailed methodology and results of the seepage analysis are described in Section 5 and Appendix D, Seepage Calculations, of the January 2008 Feather River Setback Levee Design Report. Underseepage mitigation measures were required along most of the setback levee alignment and consisted of a soil-bentonite slurry cutoff wall extending through the permeable foundation soil layers. The exceptions were two portions of the levee, 2,100 and 2,800-feet long respectively, with relatively thick low-permeability soil layers in the foundation, where underseepage mitigation was not necessary to meet gradient design criteria. Per USACE requirements, the design thickness of the cutoff wall was adopted as 3 feet. The wall was designed to tie into a low-permeability layer.

Relief wells were provided along the edge of the Pump Station No. 3 intake sump to meet the required seepage gradient. The maximum allowable exit gradient between relief wells was taken as 0.5. Additional relief wells were provided as a redundant seepage control measure near the south end of the levee in portions of the levee foundation containing gravel layers within recent alluvium deposits. A total of 26 relief wells were installed in a single line along the landside levee toe. The Segment 2 relief wells have undergone redevelopment and pump testing in 2015. Details regarding relief well performance and redevelopment testing is provided in the report titled *Due Diligence Review - 2019 FEMA Accreditation - Bear River North Setback Levee and Feather River East Levee Segments 1, 2 and 3*, March 2019. The relief wells appear to be functioning adequately,

An inspection trench, with a depth of 6 feet or greater and a bottom width of 12 feet or greater, was excavated in the foundation along the entire length of the Segment 2 levee. The purpose of the inspection trench was to expose or intercept any undesirable underground features such as old irrigation pipes, animal burrows, buried logs, layers of unsuitable material, or other debris. In addition, the backfilling of the trench with tight, compacted, backfill was intended to disrupt shallow seepage paths that may exist directly under the base of the embankment. In the south tie-in area, inspection trench excavation was performed outside the delineated limit of the cultural site. Where a soil-bentonite slurry cutoff wall was installed, the inspection trench was integrated with the cutoff wall and was located under the waterside levee slope.

Utility Penetrations

All known pipes that crossed the levee foundation were removed within the levee footprint. The pipe ends outside of the removal limits were capped. Existing road crossings, ditches, buried tanks and septic systems, debris piles and building foundations in the levee footprint were also removed prior to foundation preparation and placement of levee embankment fill.

Near the south end of the levee, four 36-inch-diameter HDPE discharge pipes were installed up and over the levee as part of the construction for the Pump Station No. 3 relocation. The trenches for the outfall pipes were backfilled with low-permeability fill materials. Near the north end of the levee, two 36-inch-diameter HDPE pipes were installed up and over the levee to provide a levee crossing for the RD 784 Pump Station No. 10 discharge pipelines. The trenches for the outfall pipes were backfilled with controlled low-strength material. All penetrations crossing the levee were constructed in accordance with sound engineering practices, and are not anticipated to affect embankment or foundation stability of the Setback Levee.

In 2015, an additional assessment of the utility penetrations along Segment 2 was performed with the purpose of assessing whether the penetrations posed a hazard to levee integrity California Department of Water Resources' Urban Levee Design Criteria. Video inspections were performed for all Pump Station No. 3 and Pump Station No. 10 discharge pipelines. Findings of the 2015 assessment are presented in the memorandum titled *Assessment of Levee Encroachment Penetrations and Closures, RD 784 200-year ULDC Compliance Determination, Feather River East Levee (Segment 2)*, October 30, 2015. The overall observed condition of the pipelines was good at both pump stations.

A site visit was conducted in November 2018 to visually observe the condition of the levee at the utility crossings. No signs of distress to the levee were observed that would indicate underlying distress or damage to the utilities.

Based on the available information and assessments in 2015 and 2018, the existing utility penetrations are not anticipated to affect embankment or foundation stability of the Feather River East Levee Segment 2 within the accreditation period provided that they continue to be monitored, inspected, and maintained in good operating condition in accordance with the provisions of the O&M Manual.

Liquefaction and Seismic Evaluation

The USACE document EC 1110-2-6067 titled, "Certification of Levee Systems for the National Flood Insurance Program (NFIP)", provides guidance for liquefaction and seismic stability evaluations of levee systems in regions that experience strong ground motions from earthquake activity. The document states that the peak ground acceleration (PGA) should be determined for the 10% in 50-year earthquake from the United States Geologic Survey (USGS) ground motion database. If the PGA is less than 0.15 g, no further evaluation of liquefaction potential and seismic stability is required. For the Feather River setback levee alignment, the PGA as determined from the USGS database was less than 0.15g, so a liquefaction and seismic stability evaluation was not required based on USACE levee certification protocols.

Hydrocompaction and Heave Potential

Hydrocompaction occurs when soils with a loose open structure, such as loosely deposited silts or sands with low moisture content become saturated upon wetting and consolidate under their own weight, or under the application of additional loads. This type of phenomena usually occurs in arid regions with windblown sand or silt deposits. Loose, open structure silt and sand materials are not present in the alluvial foundation soils or levee embankment materials for the Segment 2 levee, so the potential for hydrocompaction to occur along the setback levee alignment is very low.

Heave potential of the clayey foundation soils in the levee was also estimated to be low, based on the relatively high moisture content of the near surface foundation soils (typically greater than 20 percent), and the relatively high levee embankment loads above the foundation soils (typically 2,400 to 3,500 pounds per square foot). Groundwater levels along the setback levee alignment are typically within 5 to 20 feet of levee foundation grade, and it is not anticipated that the in-situ moisture content of the shallow foundation soils under the levee would vary significantly from the wet to dry season.

2.4.7 Feather River East Levee Segment 1

The embankment and foundation stability assessment by GEI for the Feather River East Levee Segment 1 included seepage and stability evaluations as presented in Volumes 1 and 3 of the March 2007 Phase 4 Feather River Repair Project Design Report and Addendum 1 dated May 2007. Levee improvement (repair) features, summarized below, were designed and constructed based on the findings of the seepage and stability assessment. Stability mitigation measures were not required. Seepage mitigation features were required at select reaches of Segment 1, including two sections of soil-cement-bentonite cutoff wall through the levee embankment, one section of soil-bentonite cutoff wall through the waterside toe of the levee embankment, a waterside low-permeability blanket, and installation of relief wells. Details about the construction activities for the levee repair project are presented in the June 2009 Feather River Levee Segments 1&3 Construction Completion Report.

Stability Evaluation

The dimensions of the existing levee as required by the Central Valley Flood Protection Board and the USACE are tabulated below:

Crown Width	20 feet minimum
Patrol Road Width (on Crown)	12 feet minimum
Waterside Slope (horizontal: vertical)	3:1 maximum
Landside Slope	2:1 maximum (based on a good history of landside slope performance and minimal potential for destabilizing seepage forces during design flood events)

Stability of the embankment cross-sections (both landside and waterside slopes) and underlying foundation materials was computed for steady-state seepage and rapid-drawdown stability cases. The end of construction condition was not analyzed because new berms or embankments were not planned as repair features. Detailed confirmatory slope stability analyses were performed using the selected cross-section geometry and site-specific strength properties for foundation and existing embankment materials. The steady-state seepage case was evaluated assuming a fully developed phreatic surface through the embankment because the duration of the flood hydrograph is influenced by large upstream reservoirs and could be several weeks.

The results of the stability analyses performed for the levee are summarized in Section 4 and Appendix G of the March 2007 Phase 4 Feather River Levee Repair Project Design Report. The analyses indicated that the existing levee meets or exceeds the required minimum safety factors detailed in EM 1110-2-1913, Design and Construction of Levees, Table 6-1b.

Seepage Evaluation

Seepage analyses of the Segment 1 levee and its foundation were based on the assumption that steady-state conditions have developed for the peak stage of the design flood event. Seepage analyses computed the distribution of hydraulic heads within the existing levee and its foundation, both in the pervious foundation strata as well as in the less pervious upper stratum on which the levee is founded. The seepage evaluation also included an assessment of previously installed seepage mitigation features, which consisted of 1,700- and 2,600-foot-long landside seepage berms, a 3,600-foot-long soil-cement-bentonite cutoff wall, and a system of relief wells, located within separate reaches of the Feather River East Levee Segment 1.

The need for additional seepage remedial features was triggered by at least one of the following criteria:

- An uplift gradient (defined as the difference in hydraulic head across the less pervious upper layer divided by the layer's thickness) in excess of 0.5 when computed with water at the design water surface elevation.
- An exit gradient in excess of 0.5, also computed with water at the design water surface elevation.
- A determination that a potential exists for levee through seepage based on embankment soil conditions observed in borings performed through the levee embankment.

The detailed methodology and results of the seepage analysis are described in Section 4 and Appendix F of the March 2007 Phase 4 Feather River Levee Repair Project Design Report and its May 2007 Addendum 1. Constructed seepage repair features included the following:

- Two separate sections of soil-cement-bentonite cutoff walls through the levee embankment with lengths of 2,220 and 3,150 feet.
- Low-permeability waterside blankets totaling 4,300 feet in length for those reaches with existing landside seepage berms that required additional through-seepage mitigation.
- Sixteen additional relief wells split spaced between wells previously installed by the USACE.
- A 2,600-foot long soil-bentonite cutoff wall through the waterside toe of the levee embankment.

Construction of the soil-cement-bentonite cutoff wall involved degrading the levee crown to provide a work platform necessary for equipment to construct the wall. The wall tied into a low-permeability layer in the levee foundation. Soils from the cutoff wall trench excavation and levee degrade were used in the soil-cement-bentonite backfill. Following construction of the cutoff wall, the levee embankment was reconstructed to design crown elevations.

The waterside blanket was constructed by excavating the existing waterside levee slope a depth of 5 feet, and reconstructing it by placing and compacting low-permeability fill to the original 3 horizontal to 1 vertical slope grade.

The relief wells were designed as fully penetrating the pervious stratum, with a maximum allowable exit gradient between relief wells of 0.5. Relief wells were constructed along the landside toe of the levee adjacent to an existing concrete ditch. The wells were installed about midway between the previously installed wells. The Segment 1 relief wells have undergone performance testing in 2013 and 2018 and have also been observed to operate during high water river events between the spring of 2011 and winter of 2019. Details regarding relief well performance and redevelopment testing are provided in the report titled *Due Diligence Review - 2019 FEMA Accreditation - Bear River North Setback Levee and Feather River East Levee Segments 1, 2 and 3*, March 2019. The relief wells appear to be functioning adequately.

Construction of the soil-bentonite cutoff wall involved excavating a wedge of the existing waterside slope of the levee and excavating a 12-foot wide by 3-foot deep key trench to provide a sound foundation for construction of the cutoff wall and to encapsulate the wall-embankment contact. The wall was constructed to tie into a low-permeability layer. Soil from the trench excavation was used in the soil-bentonite backfill. Following construction of the cutoff wall, the levee embankment was reconstructed to the design crown elevations. Per USACE requirements, the design thickness of the cutoff wall was 3 feet.

In September 2008, after completion of the soil-bentonite cutoff wall, a 550-foot long longitudinal crack was observed on the landside slope of the levee. Additional field investigations and slope stability analyses indicated that excavation of the slurry trench for the soil-bentonite wall (prior to backfilling) induced a temporary condition of reduced stability located within softer soil zones of the levee foundation. The condition of reduced stability stopped after the trench was backfilled, and lateral deformations in the foundation soils gradually diminished. Crack repairs consisted of excavating a 650-foot wedge of the landside slope of the levee to remove the upper portion of the

crack, placing a sand blanket on the excavated landside slope and foundation surface, and reconstructing the landside portion of the levee to the pre-existing geometry using material from the excavation. Additional details about the landside crack evaluation are presented in the report titled Phase 4 Feather River Levee Repair Project, Technical Memorandum, Assessment of Levee Along New Soil-Bentonite Wall, Stations 220+00 to 246+00, and Proposed Remedial Measures for Cracked Reach, Stations 220+75 to 226+50, dated April 17, 2009. Details of repair construction and as-built drawings are presented in the December 2009 Feather River Levee Segments 1&3 Construction Completion Report, Addendum No. 1.

In 2013, an erosion protection berm was constructed in Segment 1, extending from approximate Station 128+00 to 135+00. The erosion protection berm was designed and constructed ULDC for stability. The berm consists of earthfill placed above a one-foot thick sand filter/drainage layer on the landside slope and toe of the levee. This filter/drainage layer intercepts seepage that exits on the landside slope and discharges it safely away from the erodible silty sand lens on the landside slope. Past performance of the levee at this location had not exhibited any problems with through-seepage, raveling, or slope instability. In addition, the evaluations conducted for this levee reach in 2006 indicated this area did not exhibit any criteria exceedance that would affect FEMA certification for embankment or foundation stability of the levee.

Utility Penetrations

Utility penetrations through the levee that were no longer needed were removed. Those that remain in service were evaluated and reconstructed if appropriate. Near the north end of Segment 1, two Plumas Mutual HDPE pipes crossing up and over the levee were removed and replaced with 30-inch and 22-inch-diameter HDPE pipes. The pipe removal and replacement was necessary in order to construct a soil-bentonite cutoff wall in this area. In addition, two abandoned 36-inch-diameter steel pipes and two concrete wing walls were removed within the foundation of the levee at the crossing area. After removal of the pipeline materials, the excavated levee was backfilled to existing grade using impervious fill materials. Details of the pipe crossing removal and replacement are presented in the June 2009 Feather River Levee Segments 1&3 Construction Completion Report.

In addition, a former 4-inch-diameter steel pipe crossing was removed from the landside slope of the levee. The depth of the pipe was approximately 7 feet below the levee crown, and the pipe alignment did not extend past the levee crown. The pipe removal excavation on the landside slope was backfilled with compacted in-situ material.

The construction of the modified Plumas Mutual outfall crossing and pipe removals were performed in accordance with sound engineering practices, and are not anticipated to affect embankment or foundation stability of the Feather River East Levee Segment 1. There were four utility penetrations located within Segment 1 that were not removed or modified. The four utility penetrations are as follows:

- A single concrete gravity-discharge culvert at Pump Station No. 2 that penetrates the Segment No. 1 levee foundation at approximately Station 49+00.
- Three HDPE pressure discharge pipes at Pump Station No. 2 that are placed up and over the 100-year flood elevation of the Segment No. 1 levee.

In the Fall of 2009, GEI performed an assessment of these utility penetrations as presented in the memorandum titled, "Assessment of Levee Utility Penetrations- RD 784 Levee Accreditation, Segments 1 and 3", dated January 2010. The purpose of the assessment was to evaluate the condition and integrity of existing utility crossings that were not modified as part of the Phase 4 Feather River Levee Repair Project. Activities associated with the assessment included (1) a review of available information pertaining to the utilities, (2) discussions about utility construction, performance and maintenance with an RD 784 representative and the contractor that constructed Pump Station No. 2, (3) site observations of the Pump Station No.2 area, and (4) a visual walk-through inspection of the interior of the Pump Station No. 2 gravity-discharge culvert.

In 2015, an additional assessment of the utility penetrations along Segment 1 was performed for the purpose of assessing whether the penetrations posed a hazard to levee integrity under the 200-year design water surface elevation for ULDC. Findings of the 2015 assessment are presented in the memorandum titled Assessment of Levee Encroachment Penetrations and Closures, RD 784 200-year ULDC Compliance Determination, Feather River East Levee (Segments 1 and 3), dated October 30, 2015. The overall condition of the pipelines was observed to be good at the various facilities.

In November 2018 a site visit was performed to visually observe the condition of the levee at the utility crossings. No signs of distress or alterations to the levee were observed that would indicate underlying damage to the utilities.

Based on the available information and assessments performed in 2010, 2015 and 2018, the existing utility penetrations are not anticipated to affect embankment or foundation stability of the Feather River East Levee Segment 1 within the accreditation period provided that they continue to be monitored and maintained in good operating condition in accordance with the O&M Manual.

Liquefaction and Seismic Evaluation

The USACE document EC 1110-2-6067 titled, "Certification of Levee Systems for the National Flood Insurance Program (NFIP)", provides guidance for liquefaction and seismic stability evaluations of levee systems in regions that experience strong ground motions from earthquake activity. The document states that the peak ground acceleration (PGA) should be determined for the 10% in 50-year earthquake from the United States Geologic Survey (USGS) ground motion database. If the PGA is less than 0.15 g, no further evaluation of liquefaction potential and seismic stability is required. For the Feather River Segment 1 levee alignment, the PGA as determined from the USGS database is less than 0.15g, so a liquefaction and seismic stability evaluation was not required based on USACE levee certification protocols.

Hydrocompaction and Heave Potential

Hydrocompaction occurs when soils with a loose open structure, such as loosely deposited silts or sands, with low moisture content become saturated upon wetting and consolidate under their own weight, or under the application of additional loads. This type of phenomena usually occurs in arid regions with windblown sand or silt deposits. Over the last 100 years, the silt and sand materials along the Feather River Segment 1 levee have been exposed to numerous floods, including floods that have reached the design capacity of the levee system, so the potential for additional hydrocompaction to occur along the levee alignment is considered low.

Heave potential of the clayey foundation soils in the levee was also estimated to be low, based on the relatively high moisture content of the near surface foundation soils and the relatively high levee embankment loads above the foundation soils. Groundwater conditions in the Feather River East Levee Segment 1 area are generally within 10 to 20 feet of levee foundation grade, so it is unlikely that the in-situ moisture content of the shallow foundation soils under the levee would vary significantly from the wet to dry season.

2.4.8 Bear River North Setback Levee

The embankment and foundation stability assessment by GEI for the Bear River Setback levee included seepage and stability evaluations as presented in Volumes 2 and 3 of the July 2006 Bear River Setback Levee Final Design Report. Based on the findings of the seepage and stability assessment, the setback levee was designed and constructed with a soil-bentonite cutoff wall tied to a homogeneous earthfill setback levee, with placement of relief wells along the landside toe in selected reaches of the setback levee alignment. Details about the construction activities for the setback levee project, including seepage mitigation features are presented in the May 2007 Bear River Setback Levee Construction Completion Report.

Stability Evaluation

The minimum dimensions of the setback levee, as required by the Central Valley Flood Protection Board (Reclamation Board) permit and the USACE document titled, SOP-EDG-03, are tabulated below:

Crown Width	20 feet
Patrol Road Width (on Crown)	12 feet
Waterside Slope (horizontal: vertical)	3H:1V
Landside Slope (horizontal: vertical)	3H:1V

Stability of the embankment cross-section (both landside and waterside slopes) and underlying foundation materials was verified for end-of-construction, steady-state seepage, and rapid-drawdown stability cases. Detailed confirmatory slope stability analyses were performed using the selected cross-section geometry and site-specific strength properties for foundation and embankment materials. The steady-state seepage case was evaluated assuming a fully developed phreatic surface through the embankment because the duration of the flood hydrograph is influenced by large upstream reservoirs and could be several weeks. The results of the stability analyses performed for the setback levee are summarized in Section 4 and Appendix G, Stability Calculations, of the July 2006 Bear River Setback Levee Final Design Report. The analyses confirmed that the setback levee meets or exceeds the required minimum safety factors detailed in EM 1110-2-1913, Design and Construction of Levees, Table 6-1b.

In order to reduce the potential for unstable foundation conditions during construction, all areas to receive fill had vegetation and organic soil removed to a minimum depth of six inches. Trees removed from the levee foundation area had their root systems removed. Roots greater than 1.5 inches were removed to a depth of 3 feet as a minimum. All drains, ditches and abandoned conduits were removed from the levee foundation and backfilled with low-permeability soil.

Seepage Evaluation

Seepage analyses of the levee and its foundation were based on the assumption that steady-state conditions have developed for the peak stage of the design flood event. Seepage analyses computed the distribution of hydraulic heads within the levee and its foundation, both in the pervious foundation strata as well as in the less pervious upper stratum on which the levee is founded. The need for seepage control measures was triggered by (1) an uplift gradient (defined as the difference in hydraulic head across the less pervious upper layer divided by the layer's thickness) in excess of 0.5, and/or (2) an exit gradient in excess of 0.5, both computed with water at the design water surface elevation. The detailed methodology and results of the seepage analysis are described in Section 4 and Appendix F, Seepage Calculations, of the July 2006 Bear River Setback Levee Final Design Report

An inspection trench, with a depth of 6 feet or greater and a bottom width of 12 feet or greater, was excavated in the foundation along the entire length of the levee. The purpose of the inspection trench was to expose or intercept any undesirable underground features such as old irrigation pipes, animal burrows, buried logs, layers of unsuitable material, or other debris. In addition, the backfilling of the trench with tight, compacted, backfill was intended to disrupt shallow seepage paths that may exist directly under the base of the embankment.

Where a soil-bentonite cutoff wall was installed, the inspection trench was integrated with the cutoff wall and was located under the waterside levee slope. Per USACE requirements, the design thickness of the cutoff wall was adopted as 3 feet. The wall was designed to tie at least into a low-permeability layer. Where a low-permeability layer did not exist within a practical depth (80 feet), or if a lateral cutoff could not be made for constructability reasons, relief wells were included in the design and construction.

Relief wells were designed and constructed as a single row of wells about 5 feet landside of the levee toe, partially to fully penetrating the pervious stratum. The maximum allowable exit gradient between relief wells was taken as 0.5. The maximum relief well spacing was selected to be 200 feet on-center. The relief wells have undergone performance testing in 2013 and 2018. In 2015, two of the relief wells (RW-B09 and RWB14) were retrofitted with an inner casing, screen and filter pack material to reduce the production of fine sand and silt into the wells that was observed during redevelopment and pump testing. Details regarding relief well performance, redevelopment testing and modifications are provided in GEI's report titled *Due Diligence Review- 2019 FEMA Accreditation- Bear River North Setback Levee and Feather River East Levee Segments 1, 2 and 3*, March 2019. The relief wells appear to be functioning adequately, including the two wells that were retrofitted in 2015.

Liquefaction and Seismic Evaluation

The USACE document EC 1110-2-6067 titled, "Certification of Levee Systems for the National Flood Insurance Program (NFIP)", provides guidance for liquefaction and seismic stability evaluations of levee systems in regions that experience strong ground motions from earthquake activity. The document states that the peak ground acceleration (PGA) should be determined for the 10% in 50-year earthquake from the United States Geologic Survey (USGS) ground motion database. If the PGA is less than 0.15 g, no further evaluation of liquefaction potential and seismic stability is required. For the Bear River setback levee alignment, the PGA as determined from the USGS database is less than

0.15g, so a liquefaction and seismic stability evaluation was not required based on USACE levee certification protocols.

Hydrocompaction and Heave Potential

Hydrocompaction occurs when soils with a loose open structure, such as loosely deposited silts or sands, with low moisture content become saturated upon wetting and consolidate under their own weight, or under the application of additional loads. This type of phenomena usually occurs in arid regions with windblown sand or silt deposits. Loose, open structure silt and sand materials are not present in the alluvial foundation soils or levee embankment materials for the Bear River Setback levee, so the potential for hydrocompaction to occur along the setback levee alignment is very low.

Heave potential of the clayey foundation soils in the setback levee was also estimated to be low, based on the relatively high moisture content of the near surface foundation soils (average of 25 percent), and the relatively high setback levee embankment loads above the foundation soils (2,500 to 3,500 pounds per square foot). Groundwater conditions in the setback levee area are within 5 to 10 feet of levee foundation grade, so it is unlikely that the in-situ moisture content of the shallow foundation soils under the levee would vary significantly from the wet to dry season.

2.4.9 Upper Bear North Levee (Setback Levee to WPIC), WPIC West Levee, and ODB Ring Levee

The embankment and foundation stability assessment for the Upper Bear River north levee between the setback levee and the WPIC, the WPIC west levee, and the ODB ring levee included seepage and stability evaluations as presented in the 2004 Problem Identification Report and the 2006 Basis of Design Report. Levee improvement features, summarized below, were designed and constructed based on the findings of the seepage and stability assessment. Seepage mitigation features included soil-cement-bentonite cutoff walls and seepage berms along select portions of the subject levees to address both through-seepage and underseepage deficiencies. Details about the construction activities for the levee repair project, including slope stability and seepage mitigation features, are presented in the 2007 Construction Documentation Report.

Analyses for the WPIC 200-Year Standard Project, constructed in 2016-2017, are summarized in the 2014 Geotechnical Alternatives Analysis and 2014 Geotechnical Basis of Design Reports. Levee improvement features were designed and constructed based on the findings of the seepage and stability assessment. Seepage mitigation features included a soil-cement-bentonite cutoff wall, soil-bentonite cutoff walls, landside low area filling, and a drained berm along select portions of the subject levee to address both through-seepage and underseepage deficiencies for the 200-year water surface elevation. Stability mitigation features included a stability berm along select portions of the subject levee to address stability for the 200-year water surface elevation. Details about the construction activities for the WPIC 200-year Standard Project, including slope stability and seepage mitigation features, are presented in the 2018 Construction Documentation Report.

Stability Evaluation

The dimensions of the existing levees meet or exceed the criteria tabulated below as required by the Central Valley Flood Protection Board and the USACE:

Crown Width	20 feet minimum for main levees 12 feet minimum for tributary levees
Patrol Road Width (on Crown)	12 feet minimum
Waterside Slope (horizontal: vertical)	3H:1V maximum
Landside Slope (horizontal: vertical)	2H:1V maximum (based on a good history of landside slope performance and minimal potential for destabilizing seepage forces during design flood events)

Stability of the existing embankment cross-sections (both landside and waterside slopes) and underlying foundation materials was computed for steady-state seepage, rapid-drawdown, and seismic (see below) stability cases. Detailed confirmatory slope stability analyses were performed using the selected cross-section geometry and site-specific strength properties for foundation and existing embankment materials. The steady-state seepage case was evaluated assuming a fully developed phreatic surface through the embankments. The results of the stability analyses performed for the levees are summarized in the 2004 Problem Identification Report and 2006 Basis of Design Report. The analyses confirmed that the levee meets or exceeds the required minimum safety factors detailed in EM 1110-2-1913, Design and Construction of Levees, Table 6-1b.

For the WPIC 200-year Standard Project, the stability of the existing embankment cross-sections (both landside and waterside slopes) and underlying foundation materials was computed for steady-state seepage and rapid-drawdown cases in the 2014 Alternatives Analysis Report. Constructed stability repair features included 1,900 feet of stability berm. Construction of the stability berm included clearing and stripping the footprint area of the stability berm, including the removal of deleterious materials, and the placement of a sandy layer under semi pervious fill to the design grades.

No stability analysis was performed on the ODB ring levee in the 2004 Problem Identification Report. The ring levee was constructed with similar materials as the WPIC levee and at flatter slopes, thus it was assumed that the levee would be stable under similar loading conditions. Stability analysis was performed on the ODB ring levee in the 2014 Alternative Analysis Report and in the 2015 ODB Technical Memorandum for the WPIC 200-Year Standard Project. The analyses confirmed that the ODB ring levee meets or exceeds the required minimum safety factors detailed in EM 1110-2-1913, Design and Construction of Levees, Table 6-1b.

As-built drawings and details of the construction activities for the seepage mitigation features are presented in the 2007 Construction Documentation Report and the 2018 Construction Documentation Report for the WPIC 200-Year Standard Project.

Seepage Evaluation

Seepage analyses of these levee segments and their foundation were based on the assumption that steady-state conditions have developed for the peak stage of the design flood event. Seepage analyses computed the distribution of hydraulic heads within the existing levee and its foundation, both in the pervious foundation strata as well as in the less pervious upper stratum on which the levee is founded.

The need for additional seepage remedial features was triggered by at least one of the following criteria:

- An uplift gradient (defined as the difference in hydraulic head across the less pervious upper layer divided by the layer's thickness) in excess of 0.5 when computed with water at the design water surface elevation.
- An exit gradient in excess of 0.5, also computed with water at the design water surface elevation.
- A determination that a potential exists for levee through-seepage based on embankment soil conditions observed in borings performed through the levee embankment.

The detailed methodology and results of the seepage analyses are described in the 2004 Problem Identification Report, 2005 Geotechnical Design Memorandum, and 2006 Basis of Design Report. Constructed seepage repair features for the Bear River north levee included 825 feet of seepage berm between 50- and 100-feet-wide and replacement of shallow sand strata in the foundation with levee embankment material. Constructed seepage repair features for the WPIC west levee included 1,500 feet of soil-cement-bentonite cutoff wall through portions of the existing levee embankment extending to an average depth of approximately 35 to 44 feet below the levee crest and filling of a landside ditch in some portions of the levee. No repairs were required for the ODB ring levee.

For the WPIC 200-year Standard Project, the seepage analyses are described in the 2014 Alternatives Analysis Report. Constructed seepage repair features included 1,500 feet of soil-cement-bentonite cutoff wall, 3,300 feet of soil-bentonite cutoff wall, 2,572 feet of drained berm, and 1,800 feet of landside filling to thicken the blanket.

Construction of the soil-cement-bentonite and soil-bentonite cutoff walls involved degrading the levee crown to provide a working platform necessary for equipment to construct the wall. Soils from the cutoff wall trench excavation and levee degrade were used in the soil-cement-bentonite backfill. Following construction of the cutoff wall, the levee embankment was reconstructed to design crown elevations, revegetated with native grasses, and aggregate base along the levee crown.

Construction of the seepage berm included clearing and stripping the footprint area of the seepage berm, including the removal of deleterious materials, and the placement of semipervious fill to the design grades to address seepage pressures. The top of the berm was revegetated with native grasses similar to the reconstructed levee embankment.

Construction of the drained berm included clearing and stripping the footprint area of the drained berm, including the removal of deleterious materials, and the placement of a sand layer under semi pervious fill to the design grades. Aggregate base was placed on the top of the berm.

Construction of the landside fill areas included clearing and stripping the footprint area of the landside fill areas, including the removal of deleterious materials, and the placement of semi pervious fill to the design grades. In some areas an access road was constructed above the landside fill areas and the other areas were revegetated with native grasses.

As-built drawings and details of the construction activities for the seepage mitigation features are presented in the 2007 Construction Documentation Report and the 2018 Construction Documentation Report for the WPIC 200-YearStandard Project.

Utility Penetrations

There were three utility penetrations located within the Upper Bear North Levee. There are no utility penetrations in the WPIC West Levee. There are two utility penetrations in the ODB Ring Levee. The five utility penetrations are as follows:

- Four 42 inch HDPE pressure discharge pipes at Pump Station No. 6 that are placed up and over the levee (Bear North Levee Station 140+75)
- A single 8 foot by 6 foot concrete gravity discharge culvert (concrete box culvert) at Pump Station No. 6 that penetrates the levee foundation (Bear North Levee Station 140+75)
- A single 4 inch PVC Sprint fiber optics line connected to the Union Pacific Railroad crossing at the levee (Project Station 168+00)
- A single 8 foot by 5 foot concrete gravity discharge culvert (concrete box culvert) at the ODB Pump Station that penetrates the levee foundation (ODB Ring Levee Station 0+60)
- Four 36 inch steel pressure discharge pipes at the ODB Pump Station are placed up and over the levee (ODB Ring Levee Station 1+50)

In 2007, MBK performed an inventory of these utility penetrations. This inventory is presented in the memorandum titled, "Inventory of Levee Utility Penetrations- RD 784 Levee Accreditation, Yuba River South Levee (WPRR to Simpson Lane), Bear River North Levee (Setback Levee to the WPIC), WPIC West Levee, and the ODB Ring Levee", dated April 7, 2010. The purpose of the inventory was to obtain information on the location and elevation of the utility, identify any historic problems at the utility penetration, and to obtain information on the maintenance and the condition and integrity of the utility penetrations located within this levee reach. Activities associated with the inventory included (1) a review of available information pertaining to the utilities and (2) discussions about utility maintenance and performance with utility engineers and RD 784 representatives.

Based on the available information, the existing utility penetrations are not anticipated to affect embankment or foundation stability of the Upper Bear River north levee between the setback levee and the WPIC and the ODB ring levee within the accreditation period provided that they continue to be monitored and maintained in good operating condition.

Liquefaction and Seismic Evaluation

The USACE document EC 1110-2-6067 titled, "Certification of Levee Systems for the National Flood Insurance Program (NFIP)", provides guidance for liquefaction and seismic stability evaluations of levee systems in regions that experience strong ground motions from earthquake activity. The document states that the peak ground acceleration (PGA) should be determined for the 10% in 50-year earthquake from the United States Geologic Survey (USGS) ground motion database. If the PGA is less than 0.15g, no further evaluation of liquefaction potential and seismic stability is required. Seismic stability analysis was performed on the Upper Bear River North Levee and the WPIC West Levee using an approximated PGA of 0.20g in the 2004 Problem Identification Report. The results showed that with this higher PGA, the calculated factor of safety for slope stability exceeded the recommended criteria for seismic stability, which reinforces the language presented in EC 1110-2-6067.

Hydrocompaction and Heave Potential

Hydrocompaction occurs when soils with a loose open structure, such as loosely deposited silts or sands, with low moisture content become saturated upon wetting and consolidate under their own weight, or under the application of additional loads. This type of phenomena usually occurs in arid regions with windblown sand or silt deposits. Over the last 100 years, the silt and sand materials along the Upper Bear River north levee between the setback levee and the WPIC, the WPIC west levee, and the ODB ring levee have been exposed to numerous floods, including floods that have reached the design capacity of the levee system, so the potential for additional hydrocompaction to occur along the levee alignment is considered low.

Heave potential of the clayey foundation soils in the levee was also estimated to be low, based on the relatively high moisture content of the near surface foundation soils and the relatively high levee embankment loads above the foundation soils. Groundwater conditions in the Upper Bear River north levee between the setback levee and the WPIC, the WPIC west levee, and the ODB ring levee area are generally within 10 to 20 feet of levee foundation grade, so it is unlikely that the in-situ moisture content of the shallow foundation soils under the levee would vary significantly from the wet to dry season.

2.5 SETTLEMENT [44 CFR § 65.10(B)(5)]

TRLIA's consultants evaluated the potential for settlement over the length of the RD 784 Levee System. The evaluation was performed as follows:

- GEI evaluated the Feather River east levee and the Bear River north setback levee.
- HDR/Kleinfelder evaluated the Yuba River South Levee, the Upper Bear north levee (from the setback levee to the WPIC), the Western Pacific Interceptor Canal (WPIC) west levee, and the Olivehurst Detention Basin ring levee.
- ENGEO assessed the Goldfields 100-Year Embankment.

The evaluation was conducted in accordance with the 44 CFR § 65.10(b)(5). This section states the following:

> *Engineering analyses must be submitted that assess the potential and magnitude of future losses of freeboard as a result of levee settlement and demonstrate that freeboard will be maintained within the minimum standards set forth in paragraph (b)(1) of this section. This analysis must address embankment loads, compressibility of embankment soils, compressibility of foundation soils, age of the levee system, and construction compaction methods. In addition, detailed settlement analysis using procedures such as those described in the COE manual, "Soil Mechanics Design – Settlement Analysis" (EM 1110-2-1904) must be submitted.*

The engineers evaluated the settlement potential at sections of the RD 784 levee system that are considered more likely to settle than others due to construction of either significant levee raises or new setback levees. The engineers' settlement evaluation of their respective reaches indicates that up to 1.8 feet of settlement could occur along the new setback levee reaches within the RD 784 levee system, and much smaller amounts for levee sections where raises or berms have been constructed.

The new setback levees currently have at least 6 feet of freeboard above the base flood, which is at least 3 feet more than the 3 feet of freeboard required for the base flood. Because the 3 feet of additional freeboard in all cases significantly exceeds the estimated potential settlement, it is engineers' opinions that the estimated settlement over the next 50 years will not reduce the freeboard for the base flood below the required minimum.

Engineer's Opinions for the RD 784 levee system, signed by a Licensed Professional Engineer, are included in Appendix E of this Certification Summary document. A general description of settlement evaluations and associated reference reports is provided below for each RD 784 levee reach

2.5.1 Goldfields 100-Year Embankment

Construction of the Goldfields 100-Year Embankment consisted of placement of fill along an existing dredge tailing mound. This work did not result in significant increases in load on the existing embankment or underlying foundation soils, which are predominately granular. Therefore, a settlement evaluation was not performed for this segment of levee. Due to the granular nature of the Yuba Goldfields deposits, post-construction settlement of the 100-Year Embankment is considered negligible.

2.5.2 Yuba River South Levee (Simpson Lane to the Goldfields)

The levee repair measures for Upper Yuba Levee Improvement Project included the construction of a landside stability/seepage berm, installation of a cutoff wall, and geometry corrections. A settlement evaluation of the seepage berm construction indicates that up to 1.5 inches of settlement could occur. This is less than the construction tolerances for the seepage berm and this potential amount of seepage is insignificant with respect to grading tolerances for the project embankment. The potential settlement of the seepage berm will not reduce the freeboard of the levee embankment below the minimum required for the base flood. The detailed methodology and results of the settlement analysis are described in Section 5.5 and Appendix N of the June 11, 2010 Revised Geotechnical Basis of Design report, Upper Yuba Levee Improvement Project, Yuba River South Levee Evaluation, Reclamation District 784, Yuba County, California (Kleinfelder).

2.5.3 Yuba River South Levee (UPRR to Simpson Lane)

The levee repair measures for the Yuba River South Levee between UPRR and Simpson Lane included the construction of a small landside corner seepage berm, installation of a cutoff wall, and minimal reshaping of the levee crown. These completed repairs did not result in significant increases in load on the existing levee and underlying foundation soils, which have been preloaded by the existing levee embankment and would thus not be susceptible to additional consolidation. Therefore, a settlement evaluation was not performed for this segment of levee.

2.5.4 Yuba River South Levee (WPRR to UPRR)

The levee repair measures for the Yuba River South Levee between the WPRR and UPRR included the construction of a landside combination seepage and stability berm, installation of a cutoff wall, and minimal reshaping of the levee crown. The landside berm ranged in width from 90 to 300 feet with a

maximum height of 5 feet and was constructed of volcanic sands from a local source. As noted in the December 2006 Basis of Design Report, these completed repairs did not result in significant increases in load on the existing levee and underlying foundation soils and would thus not induce settlement and detailed analysis are not necessary. The Yuba River South Levee between WPRR and Highway 70 did not include any levee remediation features and there was no additional load placed on the foundation, so settlement would not be an issue.

2.5.5 Feather River East Levee Segment 3

The levee repair measures for Feather River Segment 3 included the construction of a landside stability berm, installation of a cutoff wall, waterside slope flattening, and reshaping of the levee crown. A settlement evaluation was performed for the landside stability berm, which involved the placement of approximately 6 to 8 feet of additional embankment over the existing levee landside slope and foundation soils. Settlement analyses were completed at three section locations in the reach of the stability berm repair to estimate post-construction settlements. Levee settlement was estimated as described in Section 4 and Appendix G of the March 2007 Phase 4 Feather River Levee Repair Project Design Report. The crown settlement of the existing levee due to the stability berm was estimated to be less than ½ of an inch. The computed differential settlement between the levee crown and the point of maximum settlement under the stability berm ranged from about 2 to 3.5 inches. Defensive measures to address the computed differential settlement included visual observation and periodic inspection of the levee for evidence of cracking, as detailed in the Local Addendum. No cracking has been observed since the completion of the stability berm in 2008.

The waterside slope flattening and cutoff wall construction did not result in significant increases in load on the existing levee and underlying foundation soils. Likewise, the crown reshaping of the existing levee resulted in the addition of less than 1 foot of fill, which was considered to be a negligible increase in load on the existing foundation and underlying foundation soils. Therefore, a settlement evaluation was not performed for levee areas that underwent these repair measures.

2.5.6 Feather River East Levee Segment 2

Settlement analyses were performed at approximately 500-foot intervals along the Segment 2 levee alignment to estimate post-construction settlements. Levee settlement was estimated as described in Section 5 and Appendix F, Settlement Calculations, of the January 2008 Feather River Setback Levee Final Design Report. The estimated post-construction settlement along the proposed levee ranged from less than one inch to about 13 inches. The levee freeboard was increased to account for foundation settlement. The levee was designed and constructed with camber (overbuild) consistent with the estimated settlement (up to 1 foot), but not less than 0.3 feet per Central Valley Flood Protection Board permit requirements.

The potential for adjacent areas of the levee foundation to settle at different rates or amounts under the embankment load (differential settlement) was addressed, particularly where the levee alignment crossed over alluvial formations of different ages. Settlement mitigation measures were included in the design and construction for two 1,100- and 1,200-foot-long reaches of the setback levee. The mitigation measures included placement of landside berms with cohesionless filter and drain layers to collect seepage and prevent piping, as well as settlement monitoring and visual observation for evidence of cracking.

In the cultural site area described in Section 2.4.4, foundation settlements were evaluated to assess the potential impact of the widened levee in the south tie-in area. Post construction settlements of up to about 18 inches are expected in this area. The settlement mitigation measures included in the original design of the levee (overbuilding of the levee crown to compensate for long-term settlement, and placement of a landside stability berm to mitigate for differential settlement), were still applicable and were used to mitigate the effects of the settlement induced by the widened levee section. The camber of the levee crown provided for this area ranges from 12 to 18 inches to compensate for the greater magnitude of post-construction settlement. This evaluation is presented in the document titled, *Feather River Setback Levee- Design Modifications of South Tie-in for Cultural Site CA-YUB-1677*, dated August 13, 2009.

Post-construction settlement monitoring of the levee was performed between January 2010 and January 2019 and the results are summarized in the report by GEI titled *Due Diligence Review- 2019 FEMA Accreditation - Bear River North Setback Levee and Feather River East Levee Segments 1, 2 and 3,* March 2019. The levee crown has not settled below the design elevation at any of the survey monument locations.

2.5.7 Feather River East Levee Segment 1

The levee repair measures for Feather River Segment 1 included the installation of relief wells, cutoff walls and waterside blankets. The waterside blanket repair consisted of excavation of the existing levee slope materials, and replacement to original levee grade with a low-permeability fill. The levee crown reshaping of the existing levee resulted in the addition of less than 1/2 foot of fill, which was considered to be a negligible increase in load on the existing foundation and underlying foundation soils. Since the levee repair measures in Segment 1 did not include significantly raising of existing levee embankment grades or placement of significant berms over levee slope and foundation areas, there was no increase in loading on the existing levee and underlying foundation soils. Therefore, it was concluded that the settlement potential for the Feather River East Levee Segment 1 would be negligible.

2.5.8 Bear River North Setback Levee

The construction of the Bear River Setback Levee caused and will continue to cause settlement of the ground surface along the levee alignment and at the Feather River Levee and Bear River Levee where the setback levee ties into these pre-existing levees. GEI completed settlement analyses at 27 section locations along the setback levee alignment to estimate post-construction settlements. Levee settlement was estimated as described in Section 4 and Appendix H, Settlement Calculations, of the July 2006 Bear River Setback Levee Final Design Report. The estimated post-construction settlement along the proposed levee ranged from 0 to 22 inches.

The potential for adjacent areas of the levee foundation to settle at different rates or amounts under the embankment load (differential settlement) was addressed, particularly where the levee alignment crossed over alluvial formations of different ages. Defensive measures consisting of landside berms with cohesionless filter and drain layers, as well as settlement monitoring and visual observation for evidence of cracking, were included in the design, construction, and operation plan for the levee for the reaches of the alignment where relatively high differential settlements were estimated. The as-

constructed freeboard also accounted for levee foundation settlement. The levee was designed with camber (overbuild) consistent with the estimated settlement but not less than 0.3 feet per Central Valley Flood Protection Board permit requirements.

Post-construction monitoring of the levee was performed between December 2006 and June 2016, and the results are summarized in the report by GEI titled *Due Diligence Review - 2019 FEMA Accreditation - Bear River North Setback Levee and Feather River East Levee Segments 1, 2 and 3*, March 2019. The levee crown has not settled below the design elevation at any of the survey monument locations.

2.5.9 Upper Bear North Levee (Setback Levee to WPIC), WPIC West Levee, and ODB Ring Levee

The levee repair measures for the Upper Bear River north levee from the setback levee to WPIC included the construction of a waterside impervious zone, placement of rip rap revetment, and full and partial reconstruction of the levee embankment, including levee raises up to about 2 feet. The levee repair measures for the WPIC west levee included areas with levee raises up to about 1.3 feet, placement of rip rap revetment, and construction of cutoff walls. As noted in the 2006 Basis of Design Report, these completed repairs did not result in significant increases in load on the existing levee and underlying foundation soils and would thus not induce settlement. The additional load due to levee raises up to about 2 feet would induce minimal settlement on the order of 0.1 feet, which would not impact the design freeboard of the subject levees.

For the WPIC 200-year Standard Project, the levee repair measures included construction of cutoff walls, a drained berm, a stability berm, and landside filling to thicken the blanket. These levee repair measures did not result in significant increases in load on the existing levee and underlying foundation soils. Analyses for the WPIC 200-Year Standard Project that was constructed in 2016-2017 are summarized in the 2014 Geotechnical Alternatives Analysis and 2014 Final Geotechnical Basis of Design Reports

The ODB Ring Levee was constructed of low plasticity soils on semi-consolidated material that was already preloaded with an existing levee embankment. According to the 2005 Geotechnical Design Memorandum, the foundation material was relatively stiff so a limited settlement of about 1 inch was expected. This minor settlement will not adversely impact the design freeboard for the ODB ring levee.

2.6 INTERIOR DRAINAGE [44 CFR § 65.10(B)(6)]

The RD 784 Levee System has a series of interior drainage components that function to evacuate stormwater from the interior drainage areas through the line of protection to the Feather and Bear Rivers and to the WPIC. The interior drainage system consists of a series of stormwater pump stations, detention basins, channels and canals. A detailed Interior Drainage Study for the RD 784 Levee System has been prepared by MHM, Incorporated in accordance with 44 CFR § 65.10 (b)(6) which states the following:

> *An analysis must be submitted that identifies the source(s) of such flooding, the extent of the flooded area, and, if the average depth is greater than one foot, the water-*

> *surface elevation(s) of the base flood. This analysis must be based on the joint probability of interior and exterior flooding and the capacity of facilities (such as drainage lines and pumps) for evacuating interior floodwaters.*

An Engineer's Opinion, signed by a Licensed Professional Engineer, is included in Appendix F of this Certification Summary document. Reports titled, *Interior Drainage Study, RD 784 Levee and Flood Control System, FEMA Accreditation Project, Three Rivers Levee Improvement Authority,* March 12, 2010 and *Interior Drainage Study – PAL Area Extension LOMR Application Narrative – East Linda Extension, FEMA Accreditation Project, Three Rivers Levee Improvement Authority,* August 10, 2010 (and revised on September 17, 2010) are incorporated by reference and provided separately.

3 OPERATIONS PLANS AND CRITERIA [44 CFR § 65.10(C)]

The majority of the RD 784 Levee System has been operated and maintained under an existing set of instructions developed by the USACE as the SRFCP was completed in the RD 784 area. The basic manuals are the Corps' *Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project* (May 1955), the Corps' *Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 145-Part No. 1,* last revised December 2016, and the Corps' *Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 149, South Levee of Yuba River Maintenance Area No. 8,* last revised December 2016. More recently (2019), the USACE has completed a revised supplement that combines the Unit 145 and Unit 149 supplements into a single supplemental manual. This revised supplement is currently in the process of being transferred to the State of California.

In addition to the USACE manuals, TRLIA and RD784 have been developing a "Local Addendum" that provides more detailed information, instructions, history, etc. This Local Addendum is a living document that continues to be developed as improvements are completed.

Unlike the remainder of the levee system, the Goldfields 100-Year Embankment is not a federally or State authorized flood control feature. The Goldfields 100-Year Embankment is also not maintained by RD 784, but is instead maintained by TRLIA. For these reasons, the Goldfields 100-Year Embankment has its own O&M Manual: *Three Rivers Levee Improvement Authority, Goldfields 100-YerYear Interim Flood Risk Reduction Project Operations, Maintenance, and Emergency Actions Requirements*, September 23, 2016.

Regulations regarding operation plans and criteria required by FEMA are covered in 44 CFR §65.10(c). This section states the following:

> *Operation plans and criteria. For a levee system to be recognized, the operational criteria must be as described below. All closure devices or mechanical systems for internal drainage, whether manual or automatic, must be operated in accordance with an officially adopted operation manual, a copy of which must be provided to FEMA by the operator when levee or drainage system recognition is being sought or when the manual for a previously recognized system is revised in any manner. All operations must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP.*

It is MBK Engineers' opinion that the existing SRFCP Operation and Maintenance Manual, along with the Supplemental Manual, the Local Addendum, and the Goldfields O&M Manual collectively meet the requirements for an operation plan as outlined in 44 CFR § 65.10(c). An Engineer's Opinion signed by a Licensed Professional Engineer is included in Appendix G of this Certification Summary document. The 2016 O&M supplements and the Goldfields O&M Manual are incorporated by reference and provided separately.

The following sections discuss specific FEMA regulations governing operation plans, point by point, and provide references to the sections in the manuals that satisfy the requirements.

3.1 CLOSURES [44 CFR § 65.10(C)(1)]

As described in Section 2.2 above, the RD 784 Levee system contains two closure structures; the UPRR structure on the Yuba River South Levee and the UPRR (WPRR) structure in Feather Segment 3. The UPRR (WPRR) structure does not have to be closed to provide protection from the base flood. Section 44 CFR § 65.1O(c)(1) states that operation plans for closures must include those items outlined as follows:

3.1.1 FLOOD WARNING SYSTEM [44 CFR § 65.10(C)(1)(I)]

Section 44 CFR § 65.1O(c)(1)(i) requires that the operation plan must include:

> *Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and demonstration that sufficient flood warning time exists for the completed operation of all closure structures, including necessary sealing, before floodwaters reach the base of the closure.*

Section 9 of the Local Addendum describes how to access real-time information and flood forecasts from the US National Weather Service River Forecast Center at the California Department of Water Resources gage at Yuba City on the Feather River. These sections specify elevations on the gages that would require notification of railroad personnel about potential closures of the two closure structures, when to activate actual closures, and when to reopen the closures.

Water surface elevations at both closure structures are greatly influenced by the operations of Oroville Reservoir on the Feather River. This results in slow rising and well predicted flood elevations until the reservoir exhausts flood storage space which occurs at approximately the 125-year flood occurrence. The use of conservative flood elevations to initiate closure actions allows ample time to notify railroad personnel about closures, to actually close the gates, and to seal around the gate closures.

3.1.2 FORMAL PLAN OF OPERATION [44 CFR § 65.10(C)(1)(II)]

Section 44 CFR § 65.1O(c)(1)(ii) requires that the operation plan must include:

> *A formal plan of operation including specific actions and assignments of responsibility by individual name or title.*

A description of the UPRR (WPRR) closure structure is contained in Section 9 of the Local Addendum. Theses sections also contain instructions for implementing the closures and who is responsible for making railroad notifications and for actually closing the structures. Closures are simple to implement and once railroad notification is made, involve unlocking the secured open gates, swinging the gates closed, and sealing the gates.

3.1.3 PERIODIC OPERATION [44 CFR § 65.10(C)(1)(III)]

Section 44 CFR § 65.1O(c)(1)(iii) requires that the operation plan must include:

> *Provisions for periodic operation, at not less than one-year intervals, of the closure structure for testing and training purposes.*

The requirement for periodic inspection and operation of these railroad closure structures is included in Section 10 of the Local Addendum. Because of the disruption to traffic on these active and busy rail lines, closure structures are to be inspected annually to guard against vandalism and each structure is exercised every 3 years. Because of the traffic on the railroads, sand bag placement is not a part of the periodic operation. RD 784 has training every year in the filling and placement of sand bags and placement at the closure structures is no different than placement at other points.

3.2 INTERIOR DRAINAGE SYSTEMS [44 CFR § 65.10(C)(2)]

Section 44 CFR § 65.1O(c)(2) contains regulatory requirements for operation plans as they pertain to interior drainage systems. Interior drainage systems are defined and requirements summarized as follows:

> *Interior drainage systems. Interior drainage systems associated with levee systems usually include storage areas, gravity outlets, pumping stations, or a combination thereof. These drainage systems will be recognized by FEMA on NFIP maps for flood protection purposes only if the following minimum criteria are included in the operation plan:*

The RD 784 Levee System interior drainage system includes:

- Five pumping stations at the line of protection (levees) (PS 9, PS 3, PS 2, PS 6 and ODB)
- Three gravity drains at the line of protection (PS 2, PS 6 and ODB) The community of West Linda Drains via the Olivehurst Interceptor Canal directly into Reeds Creek
- Seven interior pumping stations (PS 1, PS 4, PS 5, PS 7, PS 8, PS 10, and Montross PS)
- Appurtenant interior drainage facilities (75 Miles of Drainage Channels and 14 Detention Basins)

More detailed descriptions on the interior drainage system are given in the interior drainage study report. Operation plan requirements for interior drainage systems are outlined as follows:

3.2.1 FLOOD WARNING SYSTEM [44 CFR § 65.10(C)(2)(I)]

Section 44 CFR § 65.10(c)(2)(i) requires that the operation plan must include:

> *Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and demonstration that sufficient flood warning time exists to permit activation of mechanized portions of the drainage system.*

As noted above, in Section 9 of the Local Addendum describes how to access real-time information and flood forecasts from the US National Weather Service River Forecast Center at the California Department of Water Resources gage at Yuba City on the Feather River. Interior drainage operation is not predicated on river flood elevations. RD 784 does monitor the river gage, but the only interior drainage action taken due to high river stages is to close the positive closure gates at the gravity drains at PS 2, PS 6, and the ODB PS. Even though flap gates exist on these gravity drains, this action is taken to ensure that high river levels do not flow back through the drains and thus increase interior flood elevations or add additional flow to be pumped. These positive closure valves are closed when river flood elevations prevent gravity flow, which is approximately when the water reaches the toe of the levee at the pump stations. Pump activation is automatic and is initiated by preset interior water elevations in the PS sumps.

3.2.2 Formal Plan of Operation [44 CFR § 65.10(c)(2)(ii)]

Section 44 CFR § 65.10(c)(2)(ii) requires that the operation plan must include:

> *A formal plan of operation including specific actions and assignments of responsibility by individual name or title.*

PS 2 was reconstructed by the USACE in 2004. PS 6 and the ODB PS were reconstructed by TRLIA in 2006, and PS 3 was reconstructed by TRLIA in 2009. Each of these reconstructed pump stations include multiple pumps and have automatic monitoring systems installed which monitor interior water surface elevations at the pump station and the electrical and mechanical conditions at the pump station. This system sends information to RD 784 and to the RD 784 District Engineer. RD 784 is responsible for assuring that the pump stations are operating as designed. The stations also include automatic programs which initiates pumping at prescribed elevations, adds pumps if elevations continue to rise, and shuts off pumps as interior elevations fall. The pump start and stop operating conditions are given in the interior drainage study report. These programs also include routines to rotate the first pump to be used so that pump usage is spread over all of the pumps at the station. The plan of operation is programmed into the pump station software and operation is monitored at the RD 784 Office. During periods of high interior run off, RD 784 District personnel daily inspect the pump stations to be certain that conditions reported by the remote system match what is occurring. RD 784 contracts with the County of Yuba to operate and maintain the ODB pump station. PS 9 is an older station constructed in 1988 and its plan of operation is automatic as well. If necessary, storage at PS 9 can be routed to PS 6 if there is trouble with PS 9 or runoff would be better handled at PS 6.

3.2.3 Manual Backup [44 CFR § 65.10(c)(2)(iii)]

Section 44 CFR § 65.10(c)(2)(iii) requires that the operation plan must include:

> *Provision for manual backup for the activation of automatic systems.*

The reconstructed pump stations (PS 2, PS 3, PS 6, and ODB PS) are all powered by electricity. These pump stations have redundant pumps that can ensure pump station capacity if one pump is inoperative. These stations also include back up generator systems that can power the pump station and which will automatically be started through automatic transfer switches in the event of a power

outage. PS 9 does not have back up generator capacity but is equipped with a coupling which allows the pump to be run by an outside motor source, i.e. tractor. If a tractor is not available, runoff to this pump station can be diverted to PS 6. All pump stations are equipped with check valves to prevent backflow in the discharge pipes. Pump stations 2, 3, 6 and ODB are connected to a SCADA system which transmits conditions and activities at the pump station to the RD 784 Office. This SCADA system is also equipped to issue an emergency notice by phone to key personnel in the event that a problem is detected at a pump station.

3.2.4 PERIODIC OPERATION [44 CFR 65.10(C)(2)(IV)]

Section 44 CFR § 65.10(c)(2)(iv) requires that the operation plan must include:

> *Provisions for periodic inspection of interior drainage systems and periodic operation of any mechanized portions for testing and training purposes. No more than one year shall elapse between either the inspections or the operations.*

The requirement for periodic inspection of electrical and mechanical features of the pump stations is noted in the Local Addendum. Inspection and maintenance is to be in accordance with O&M manuals supplied by manufacturers of the pump station equipment. The climate in the Central Valley of California is Mediterranean and interior runoff is only available in the winter. Most winters do supply enough runoff to operate the pumps at least once a year. However, during dry years not all pump stations may function. Testing of pumps can only occur when runoff is available to be pumped. However, all equipment is serviced and inspected at least annually and kept in good working order.

3.3 OTHER OPERATION PLANS AND CRITERIA [44 CFR § 65.10(C)(3)]

Section 44 CFR § 65.10(c)(3) provides for the operation plan to include:

> *Other operation plans and criteria. Other operating plans and criteria may be required by FEMA to ensure that adequate protection is provided in specific situations. In such cases, sound emergency management practice will be the standard upon which FEMA determinations will be based.*

FEMA has not requested RD 784 to provide additional operating plans and criteria at this time. However, RD 784 in conjunction with the Yuba County Office of Emergency Services has developed a flood response plan and provisions for coordination between responsible parties to react in a way that will provide adequate protection to RD 784 in various flood situations.

4 MAINTENANCE PLANS AND CRITERIA [44 CFR § 65.10(D)]

As described previously, the majority of the RD 784 Levee System has been operated and maintained under the USACE's Standard O&M Manual for the SRFCP, and two supplements for Unit 145 and Unit 149. USACE has completed a revised supplement that combines the Unit 145 and Unit 149 supplements into a single supplemental manual and is currently in the process of transferring this manual to the State of California. RD784 also relies on a more detailed Local Addendum for its O&M.

As also described previously, TRLIA is responsible for O&M of the Goldfields 100-Year Embankment and uses a separate manual for this purpose.

Section 44 CFR §65.10(d) contains regulatory requirements for maintenance plans and criteria. This section states:

> *Maintenance plans and criteria. For levee systems to be recognized as providing protection from the base flood, the maintenance criteria must be as described herein.*
> *Levee systems must be maintained in accordance with an officially adopted maintenance plan, and a copy of this plan must be provided to FEMA by the owner of the levee system when recognition is being sought or when the plan for a previously recognized system is revised in any manner. All maintenance activities must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP that must assume ultimate responsibility for maintenance. This plan must document the formal procedure that ensures that the stability, height, and overall integrity of the levee and its associated structures and systems are maintained. At a minimum, maintenance plans shall specify the maintenance activities to be performed, the frequency of their performance, and the person by name or title responsible for their performance.*

Section 9 of the Local Addendum contains inspection and maintenance criteria for the majority of the levee system. Maintenance of the majority of the levee system is under the jurisdiction of DWR, and the inspection and maintenance plan is implemented by the local maintenance agency, RD 784. Table 4 specifies maintenance activities to be performed and the frequency of their performance, and who is responsible for performing these activities. In addition, DWR has a long standing and continuing program of levee inspection. The RD 784 Levee System is inspected twice a year (spring and fall) by Department of Water Resources' inspectors and a rating of acceptable, marginal acceptable, or unacceptable is assigned. The RD 784 Levee System has not received an unacceptable rating in the last five years. RD 784 personnel are responsible for performing two additional annual inspections (summer and winter) and reporting on remediation of any problems uncovered by State inspections and on the condition of the levee at the time of the RD 784 inspection. In addition to the annual levee inspections, DWR requires all local maintaining agencies to annually report on conditions for their levee system. This information is supplied through a web page and each agency is required to supply:

1) Information known to the Local Agency that is relevant to the condition or performance of the Project Levee,
2) Information identifying known conditions that might impair or compromise the level of flood protection provided by the Project Levee

3) A summary of maintenance performed by the Local Agency during the previous fiscal year'
4) A Statement of work and estimated cost for operation and maintenance of the Project Levee for the current fiscal year, as approved by the Local Agency, and
5) Any other readily available information contained in the records of the Local Agency relevant to the condition or performance of the Project Levee, as determined by the Central Valley Flood Protection Board or DWR.

The Goldfields O&M Manual contains inspection and maintenance criteria for the Goldfields 100-Year Embankment. The Goldfields 100-Year Embankment is not under the jurisdiction of DWR, but is under the jurisdiction of TRLIA, which performs the maintenance and inspection activities as described in the Goldfields O&M Manual.

It is MBK Engineers' opinion that the existing Standard O&M Manual for the SRFCP, along with the Supplemental Manual, the Local Addendum, and the Goldfields O&M Manual collectively meet the requirements for an operation plan as outlined in 44 CFR § 65.10(c). An Engineer's Opinion signed by a Licensed Professional Engineer is included in Appendix G of this Certification Summary document. A copy of the Local Addendum and the Goldfields O&M Manual are incorporated by reference and provided separately.

5 CERTIFICATION REQUIREMENTS [44 CFR § 65.10(E) & 65.2]

5.1 CERTIFICATION STATEMENT FOR FEMA ACCREDITATION

This certification is made in accordance with the requirements, definitions and descriptions in the Code of Federal Regulations, Title 44 – Emergency Management and Assistance, Part 65 – Identification and Mapping of Special Hazard Areas (44 CFR 65.10). This certification is made solely to the Federal Emergency Management Agency for purposes of obtaining accreditation of the RD 784 Levee System, and is further limited to the base flood protection (i.e., 1-percent chance flood). This certification is made with respect to the components of the RD 784 Levee System as specifically required by 44 CFR 65.10. All information, calculations, definitions, descriptions, restrictions, limitations, or other pertinent data contained in the overall submission form the basis of this certification.

Acting on behalf of TRLIA, and in accordance with paragraph (b) of 44 CFR 65.2, as supported by the information contained within this submission; this is to certify that:

1. *Certification of Data* – The data presented in this submission is accurate to the best of my knowledge.

2. *Certification of Analysis* – The analyses were performed in accordance with sound engineering practices.

3. *Certification of Structural Works* – The RD 784 Levee System is designed in accordance with sound engineering practices to provide protection from the base flood.

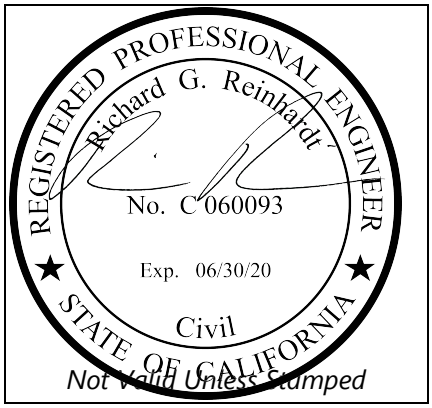
4. *Certification of As-Built Conditions* – The RD 784 Levee System has been built in substantial conformance with the construction plans, is in place, and is fully functioning.

Certified by:

Ric Reinhardt, P.E.
Program Engineer
Three Rivers Levee Improvement Authority
114 Yuba Street, Suite 218
Marysville, CA 95901

06/13/2019

Signature *Date*



5.2 DEFINITIONS AND CONDITIONS

5.2.1 DEFINITIONS

The meaning and context by which the term "Certification" was used in this document was derived from the definition provided in 44 CFR §65.2(b), which is repeated below.

> *…a certification by a registered professional engineer or other party does not constitute a warranty or guarantee of performance, expressed, or implied. Certification of data is a statement that the data is accurate to the best of certifier's knowledge. Certification of analysis is a statement that the analyses have been performed correctly and in accordance with sound engineering practices. Certification of structural works is a statement that the works are designed in accordance with sound engineering practices to provide protection from the base flood. Certification of "as built" conditions is a statement that the structure(s) has been built according to the plans being certified, is in place, and is fully functioning.*

Furthermore, it is assumed that "sound engineering practices" are practices that are performed in a manner consistent with the degree of skill and care ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions.

5.2.2 CERTIFICATION CONDITIONS

This certification made in Section 5.1 above shall expire, or become invalid, upon the earliest of any of the following events occurring:

1. As is consistent with current practice, this certification and the professional opinions of expected levee system performance upon which the certification is based, are valid for a maximum of 15 years from the date of the TRLIA's certification, at which time this certification shall become invalid.

2. Activities prescribed in the Operations and Maintenance (O&M) Manuals, referenced in the Certification Summary Report, are not performed in substantial conformance with the O&M Manuals.

3. Failure to perform ongoing monitoring activities for any component of the system, which has been identified in the O&M Manuals as needing continued observation; or failure to complete any capital improvement determined pursuant to the monitoring to be necessary to meet the system's continued protection relative to the 1% annual flood.

4. Discovery of any substantive defect in the condition of any component of the Levee System, which was not known at the time this certification was made, and which materially affects the system's ability to provide protection relative to the 1% annual flood.

5. Any finding by the USACE, the DWR, or other governmental agency having jurisdiction, that the Flood Protection System's rating has fallen to an unacceptable level, or has substantive defects, or that the system is for any reason placed in inactive status.

6. Any newly enacted governmental regulation, law, or policy that renders this certification obsolete or invalid because of lack of conformance to the new requirements for any reason, including, but not limited to, changes in technical standards in the Code of Federal Regulations.

6 QUALITY CONTROL

All of the design documents utilized for certification of the RD 784 Levee System underwent a rigorous quality control and assurance review as they were completed. This review was accomplished by the different consultants' in-house quality management teams. Additionally, these documents also underwent review by regulatory agencies include the USACE, CVFPB, and DWR, and in most cases by an independent panel of experts.

Quality control of the certification summary report was performed by Mr. Mike Kynett, P.E. of MBK Engineers. His certification is included in Appendix H of this Certification Summary document. In addition, as part of this final certification process, TRLIA tasked an independent panel of experts to perform a review of this Certification Summary Report. The independent panel of experts is comprised of Dr. Faiz Makdisi, Mr. Donald Babbitt, and Dr. David Williams; all of whom are recognized experts in flood protection projects and geotechnical engineering (Makdisi, Babbitt) and hydrologic and hydraulic engineering (Williams). 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. The members of the panel have no conflicts of interest with respect to the TRLIA repair projects.

This independent review was requested to ensure that the certification being offered for the RD 784 Levee System is adequately supported by appropriate engineering analysis, results, and recommendations.

The selected panel also served as an independent panel of experts for implementation of TRLIA's levee improvement program. Therefore, the panel members have received and reviewed the record of evidence that has been developed by TRLIA over the last decade. For this effort, the panel's review included a "refresher" review of design and construction documents for all of the work that TRLIA is seeking to certify, as well as the construction completion report for the work to assure that the work had been constructed according to the plans and specifications issued for construction. The panel made the following findings:

- The design teams had followed the current standards of engineering practice required for design and construction of the repairs implemented in the RD 784 Levee System.
- Adequate and appropriate information had been gathered to perform the analyses needed to support the repairs implemented.
- The analyses performed were appropriate and were conducted in accordance with the State of California Urban Levee Design Criteria (2012), and with USACE Engineering Manuals and Guidelines.
- While the IPE had limited involvement in construction activities of the project, the Construction Completion Documentation Reports (signed and stamped by California-registered Engineers of Record) indicate that the repairs had been constructed in accordance with the plans and specifications issued for construction and satisfy the intent of the design.
- The references cited in the draft Certification Summary Report support the Engineers' Opinion letters, and provide the appropriate and adequate information to support those opinions.

The panel's report on their review is included in Appendix H of this Certification Summary document.