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SUTTER BASIN PILOT FEASIBILITY FINAL REPORT—FINAL ENVIRONMENTAL IMPACT REPORT/SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT APPENDICES

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY, CIVIL WORKS, THE DEPARTMENT OF DEFENSE

TRANSMITTING

A FINAL ENVIRONMENTAL IMPACT REPORT ON THE SUTTER BASIN PROJECT IN SUTTER AND BUTTE COUNTIES, CALIFORNIA

PART 1 OF 2

NOVEMBER 12, 2014.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

AUG 20 2014

Honorable John A. Boehner
Speaker of the House
of Representatives
U.S. Capitol Building, Room H-232
Washington, DC 20515-0001

Dear Mr. Speaker:

In partial response to the authority provided in section 209 of the Flood Control Act of 1962, the Secretary of the Army recommends the Sutter Basin Project in Sutter and Butte Counties, California, for the purpose of flood risk management. The proposal is described in the enclosed report of the Chief of Engineers, dated March 12, 2014, which includes other reports and pertinent documents. The report includes a Final Environmental Impact Statement. The views of the Environmental Protection Agency are set forth in the enclosed communications. The project was authorized in section 7002(2)8 of the Water Resources Reform and Development Act of 2014. The Secretary of the Army plans to implement the project at the appropriate time, considering National priorities and the availability of funds.

The recommended plan consists of strengthening approximately 41.4 miles of the existing Feather River West Levee from Thermalito Afterbay in the northern end of the basin to Laurel Avenue near the southern end. The project would reduce expected average annual flood damages along the Feather River by about 64 percent. The annual exceedance probability for flooding in the basin's urban communities would be reduced from approximately four to eight percent (depending on location) to approximately 0.2 percent. Unavoidable environmental impacts would be mitigated by improving 85 acres of riparian forest, improving 2.6 acres of oak woodland, transplanting and planting elderberry shrubs for threatened valley elderberry longhorn beetles on 20.4 acres, purchasing commercial mitigation credits for endangered giant garter snakes on 10.6 acres, and purchasing commercial mitigation credits on 3.4 acres to mitigate for impacts to jurisdictional waters under section 404 of the Clean Water Act. The recommended plan deviates from the National Economic Development (NED) Plan and is the Locally Preferred Plan (LPP). I approved a policy exception on May 7, 2013, that allowed the report to recommend the LPP, with the additional cost above the NED Plan at 100 percent non-Federal cost.

The estimated total project first cost is $688,930,000 based on October 2013 price levels. The estimated first cost of the NED Plan is $391,840,000, and in accordance with section 103 of the Water Resources Development Act of 1986, as amended, the estimated Federal share for the NED Plan and the recommended plan is approximately $255,270,000 (37 percent of the recommended plan). The non-Federal sponsors, Sutter Butte Flood Control Agency and the Central Valley Flood Protection Board, have agreed to be responsible for the remainder of the costs of the recommended flood risk management features above the NED Plan, resulting in a non-Federal cost share estimated at about $433,660,000 (63 percent). The sponsors would provide all required lands, easements, rights-of-way, relocations, and excavated material disposal areas, a cost currently estimated

to be $141,005,000. The sponsors would also be responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project after construction in accordance with section 103(j) of the WRDA of 1986, a cost estimated at $454,000 per year.

The sponsors intend to seek credit in accordance with section 104 of the WRDA of 1986 for the construction of a setback levee along the Feather River at Star Bend at a cost of $20,776,000. This in-kind work was approved for section 104 credit eligibility by the Assistant Secretary of the Army (Civil Works) on June 10, 2009. The feasibility report concludes that the setback levee is an acceptable substitute for the LPP measure that involves constructing a slurry wall in the existing levee. Credit would be limited to the cost of the setback levee or the slurry wall, whichever is less.

Also, the sponsors are currently improving the Feather River West Levee and will seek credit in accordance with section 221 of the Flood Control Act of 1970, as amended. The improvements are intended to reduce flood risks while waiting for implementation of the recommended Federal project. The feasibility report concludes the in-kind work is likely to be integral to the recommended project. The sponsors and the Corps executed an In-Kind Memorandum of Understanding on June 14, 2013, after release of the draft feasibility report for public review and prior to initiation of the local construction effort. The Corps granted a section 408 permit for the first construction contract on July 19, 2013. Credit will be limited to in-kind work determined to be integral to the recommended plan.

Based on a discount rate of 3.5 percent and a 50-year period of analysis, the total equivalent average annual cost, including OMRR&R, is approximately $33,000,000. The average annual benefit for reducing flood damages is about $87,000,000, which provides net average annual benefits estimated at $54,000,000 and a benefit-to-cost ratio of about 2.6 to 1. The average annual residual flood damages would be about $50,000,000.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress and concludes that the report recommendation is consistent with the policy and programs of the President. OMB also advises that the project would need to compete with other proposed investments in future budgets. A copy of OMB's letter, dated August 8, 2014, is enclosed. I am providing a copy of this transmittal and the OMB letter to the Subcommittee on Water Resources and Environment of the House Committee on Transportation and Infrastructure, and the Subcommittee on Energy and Water Development of the House Committee on Appropriations. I am providing an identical letter to the President of the Senate.

Very truly yours,

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

Enclosures

5 Enclosures

1. Report of the Chief of Engineers, March 12, 2014
2. Environmental Protection Agency (EPA) letter, December 19, 2013
3. Corps of Engineers response to EPA, March 10, 2014
4. OMB Clearance Letter, August 8, 2014
5. Record of Decision
6. Feasibility Final Report - Final Environmental Impact Report / Supplemental Environmental Impact Statement, October 2013 (DVD)

DEPARTMENT OF THE ARMY
CHIEF OF ENGINEERS
2600 ARMY PENTAGON
WASHINGTON, DC 20310-2600

DAEN

MAR 1 2 2014

SUBJECT: Sutter Basin, California

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on flood risk management for the Sutter Basin, California. It is accompanied by the report of the district and the division engineers. This report was undertaken in partial response to the authority contained in Section 209 of the Flood Control Act of 1962, Public Law 87-874, 76 Stat. 1180, 1196, for the study of flood risk management and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, California. The non-federal sponsors for this project are the state of California Department of Water Resources and the Sutter Butte Flood Control Agency. Pre-construction engineering and design activities for the Sutter Basin, California Flood Risk Management Project will continue under the authority cited above.

2. The reporting officers recommend authorizing a plan to reduce flood risk by strengthening approximately 41 miles of the existing Feather River West Levee from the Thermalito Afterbay to Laurel Avenue. The recommended plan would reduce adverse flooding effects, including risks to public and life safety, in the northern portion of the basin as well as in Yuba City. The primary method of strengthening the existing levee is the construction of soil-bentonite cutoff walls of various depths. Non-structural measures would be implemented in conjunction with the recommended plan. These measures include preparation of an emergency evacuation plan, identification of flood fight pre-staging areas, updates to the floodplain management plan, and flood risk awareness communication.

3. The recommended plan would reduce flood risk within the Sutter Basin. The proposed project would reduce Expected Annual Damages (EAD) within the Sutter Basin by 64 percent, with a residual EAD of approximately $50,000,000. This residual EAD is primarily a result of existing flooding from the lower end of the Feather River and the Sutter Bypass within the southern portion of the basin, which is largely agricultural land and rural homes. Residual flooding also exists for the entire basin in the form of Feather River levee overtopping from events less frequent than the 0.5 percent (1/200) Annual Chance Exceedance (ACE) event. Annual Exceedance Probabilities (AEP) for flooding within Sutter Basin's existing urban communities would be reduced from approximately 4 percent-8 percent (depending on location) to approximately 0.2 percent.

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4. All consultations with the U.S. Fish and Wildlife Service and the U.S. National Marine Fisheries Service necessary for construction of the project have been completed, in order to mitigate for the detrimental effects of the flood risk management features of the recommended plan on fish and wildlife habitat. Environmental effects resulting from the construction of the recommended plan would cause some direct effects on riparian habitat and special status species habitats that cannot be avoided. The mitigation recommendations of the U.S. Fish and Wildlife Service (FWS) contained in the Final Fish and Wildlife Coordination Act Report are concurred in and are included in the recommended plan. The recommended plan includes a Fish and Wildlife Mitigation and Monitoring plan to compensate for adverse effects on fish and wildlife resources and to ensure the success of mitigation features. Other mitigation measures have been adopted to minimize the impact of construction on water quality, noise and vibration, and air quality. Endangered Species Act consultation with the FWS, in coordination with the non-federal sponsors, remains to be completed concerning the operations and maintenance of the project after construction, which is the responsibility of the non-federal sponsors under federal law. Cultural resource effects have been identified and coordinated with consideration of historical sites and structures in the Yuba City area and some prehistoric sites near the existing levee areas. The recommended plan would be in full compliance with the vegetation guidelines of Engineering Technical Letter 1110-2-571, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams and Appurtenant Structures (Vegetation ETL) and maximum potential effects have been disclosed. During the preconstruction engineering and design (PED) phase, all options then available for compliance with the Vegetation ETL will be considered and consultation with resource agencies will be completed in coordination with the non-federal sponsors.

5. The first cost was estimated on the basis of October 2013 price levels and amounts to $688,930,000. Estimated average annual costs of $33,000,000 were based on a 3.50 percent discount rate, a period of analysis of 50 years, and construction ending in 2023. The cost of lands, easements, rights-of-way , relocations, and dredged or excavated material disposal areas (LERRD) is estimated at $141,005,000. The Sutter Butte Flood Control Agency would be responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project after construction, a cost currently estimated at about $454,000 per year, an increase of $22,000 over existing costs from existing OMRR&R commitments of the existing levee.

6. The recommended plan encompasses two separable elements: the National Economic Development (NED) Plan, which will be cost shared with the non-federal sponsors, and a Locally Preferred Plan (LPP) increment, which will be funded 100 percent by the non-federal sponsors. The cost of the NED Plan is estimated to be $391,840,000, with an estimated federal cost of $255,270,000 and an estimated non-federal cost of $136,570,000. The cost of the separable element constituting the LPP increment is estimated to be $297,090,000. Since the non-federal sponsors would be responsible for the extra cost of the LPP increment, the non-federal cost share will increase from an estimated $136,570,000 for the non-federal share of the

NED Plan to an estimated total non-federal cost of $433,660,000 for the entire recommended plan. The LPP increment reduces the vulnerability of a larger population that is economically disadvantaged including an elderly population with limited mobility that are subject to sudden and unpredictable failures with minimal warning time. The plan increment provides more evacuation routes relative to the NED Plan and improves the reliability of critical infrastructure exposed to the same flood risk while reducing substantial economic flood damages.

7. Local interests have completed construction of the Star Bend setback levee to replace a section of the right bank of the Feather River levee to address critical underseepage and flow constriction issues. Prior to initiation of construction, local interests requested and by letter dated June 10, 2009, the ASA(CW) approved Section 104 credit consideration for the levee construction. Construction of the setback levee was completed in 2010 at an estimated cost of $20,776,349. The locally constructed setback levee is compatible to the recommended plan as an acceptable substitute. The Section 104 approval will allow design and construction dollars invested by the local sponsor to be considered for use as credit towards meeting the non-federal cost-share requirements for the project recommended by this feasibility study, if authorized.

8. Based on a 3.50 percent discount rate and a 50-year period of analysis, the total equivalent average annual costs of the project are estimated to be $33,000,000, including OMRR&R and interest during construction. The selected plan is estimated to be 97 percent reliable in providing flood risk management from a flood which has a one percent chance of occurrence in any year (100-year flood) for the communities of Biggs, Gridley, Live Oak, Yuba City and rural Butte County while only 22 percent reliable in reducing those risks for rural Sutter County south of Yuba City. The recommended plan would reduce average annual flood damages by approximately 64 percent and would leave average annual residual damages estimated at $50,000,000. The population at risk within the 1 percent ACE floodplain for the No Action Alternative is 94,600. The recommended plan would reduce the population at risk to approximately 6,600. Average annual economic benefits are estimated to be $87,000,000; net average annual economic benefits are $54,000,000. The benefit-to-cost ratio is 2.6 to 1.

9. The recommended plan is similar to an alternative considered in the Final Environmental Impact Statement (FEIS), filed by U.S. Army Corps of Engineers (USACE) with the Environmental Protection Agency (EPA) on June 7, 2013, and Record of Decisions (dated July 19, 2013 and September 13, 2013) for Section 408 approval for the alteration of federal project levees under the Feather River West Levee Project (FRWLP). The Sutter Basin Flood Risk Management Project (SBFRMP) and FRWLP affect the same general area, have similar flood risk management objectives, and share potential measures and effects. As a consequence, National Environmental Policy Act compliance for the SBFRMP was accomplished by supplementation of the Section 408 FRWLP FEIS to address the environmental effects of the

features of the SBFRMP that differ from the FRWLP. The Final Feasibility Report, Final Environmental Impact Statement, and Supplemental Environmental Impact Statement focuses on the additional effects that would result from the SBFRMP, incorporating by reference, where appropriate, information, analyses, and conclusions contained in the FRWLP FEIS.

10. The goals and objectives included in the Campaign Plan of the USACE have been fully integrated into the Sutter Basin Pilot Feasibility study process. The recommended plan has been designed to avoid or minimize environmental impacts while maximizing future safety and economic benefits to the community. The recommended plan uses environmentally sustainable design of fix-in-place levee construction that was in coordination with a local community coalition to integrate project objectives and public concerns.

11. In accordance with the Engineering Circular on review of decision documents, all technical, engineering and scientific work underwent an open, dynamic and vigorous review process to ensure technical quality. This included an Agency Technical Review (ATR), an Independent External Peer Review (IEPR) (Type I), and USACE Headquarters policy and legal review. All concerns of the ATR have been addressed and incorporated into the final report. The IEPR was completed by Battelle Memorial Institute with all comments documented. The panel had 19 comments, one of which they considered significant, 15 were medium significance and 3 were low significance. The comments pertained to hydrology and hydraulic engineering, geotechnical engineering, civil engineering, economics and environmental concerns. In summary, the panel felt that the engineering, economics and environmental analysis were adequate and the additional sensitivity analysis and clarifications needed to be properly documented in the final report. The IEPR review comments resulted in no significant changes to the plan formulation, engineering assumptions, and environmental analyses that supported the decision-making process and plan selection. The final report/environmental impact statement also underwent state and agency review. The state and agency comments received during review of the final report/programmatic environmental impact statement provided no additional comments than those provided on the draft report that were incorporated into the final report. All comments from the above referenced reviews have been addressed and incorporated into the final documents as appropriate. Overall the reviews resulted in improvements to the technical quality of the report including the enhanced communication of risk and uncertainty. A safety assurance review (IEPR Type II) will be conducted during the design phase of the project.

12. Washington level review indicates that the project recommended by the reporting officers is technically sound, environmentally and socially acceptable, and economically justified. The plan complies with all essential elements of the U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Land related resources implementation studies and complies with other administrative and legislative policies and guidelines. Also, the views of interested parties, including federal, state and local agencies have been considered.

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13. I concur in the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that the plan to reduce flood risk in the Sutter Basin area including Yuba City, California, be authorized in accordance with the reporting officers' recommended plan at an estimated cost of $688,930,000 with such modifications as in the discretion of the Chief of Engineers may be advisable. My recommendation is subject to cost sharing, financing, and other applicable requirements of federal and state laws and policies, including Section 103 of Water Resources Development Act of 1986, as amended (33 U.S.C. 2213). The non-federal sponsor would provide the non-federal cost share and all LERRDs. Further, the non-federal sponsor would be responsible for all OMRR&R. This recommendation is subject to the non-federal sponsors agreeing to comply with all applicable federal laws and policies, including but not limited to:

a. Provide the non-federal share of total project costs, including a minimum of 35 percent but not to exceed 50 percent of total costs of the NED Plan, as further specified below:

(1) Provide 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

(2) Provide, during construction, a contribution of funds equal to 5 percent of total project costs;

(3) Provide all lands, easements, rights-of -way (LER), including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on LER to enable the disposal of dredged or excavated material all as determined by the government to be required or to be necessary for the construction, operation, and maintenance of the project;

(4) Provide, during construction, any additional funds necessary to make its total contribution equal to at least 35 percent of total costs of the NED Plan;

(5) Provide 100 percent of all costs of the LPP increment.

b. Shall not use funds from other federal programs, including any non-federal contribution required as a matching share, therefore, to meet any of the non-federal obligations for the project unless the federal agency providing the federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized.

c. Not less than once each year, inform affected interests of the extent of protection afforded by the project.

d. Agree to participate in and comply with applicable federal flood plain management and flood insurance programs.

e. Comply with Section 402 of the WRDA of 1986, as amended (33 U.S.C. 701b-12), which requires a non-federal interest to prepare a flood plain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the project.

f. Publicize flood plain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project.

g. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project LER or the addition of facilities which might reduce the level of protection the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function.

h. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 Code of Federal Regulations (CFR) Part 24, in acquiring LER required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

i. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the federal government.

j. Give the federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project.

k. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors.

l. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 CFR Section 33.20.

m. Comply with all applicable federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable federal labor standards requirements including, but not limited to, 40 U.S.C. 3141 - 3148 and 40 U.S.C. 3701 - 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*).

n. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation, and maintenance of the project. However, for lands that the federal government determines to be subject to the navigation servitude, only the federal government shall perform such investigations unless the federal government provides the non-federal sponsor with prior specific written direction, in which case the non-federal sponsor shall perform such investigations in accordance with such written direction.

o. Assume, as between the federal government and the non-federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under LER that the federal government determines to be required for construction, operation, and maintenance of the project.

p. Agree, as between the federal government and the non-federal sponsor, that the non-federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA.

q. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the WRDA of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

14. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a

DAEN
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proposal for authorization and implementation funding. However, prior to transmittal to Congress, the sponsor, the state, interested federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

THOMAS P. BOSTICK
Lieutenant General, USA
Chief of Engineers

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

Dec 19, 2013

Theodore A. Brown
Headquarters
U.S. Army Corps of Engineers
CECW-P (SA)
7701 Telegraph Road
Alexandria, Virginia 22315-3860

Subject: Sutter Basin Pilot Feasibility Report Final Environmental Impact Statement (EIS), Butte and Sutter Counties, California [CEQ #20130352]

Dear Mr. Brown:

The U.S. Environmental Protection Agency (EPA) has reviewed the above referenced document. Our review and comments are provided pursuant to the National Environmental Policy Act (NEPA), the Council on Environmental Quality's NEPA Implementation Regulations at 40 CFR 1500 - 1508, and our review authority under Section 309 of the Clean Air Act.

EPA appreciates that information has been added to the Final EIS in response to our comments on the Supplemental Draft EIS. We note that the Final EIS includes the Clean Water Act Section 404(b)(1) alternatives analysis, which identifies Alternative SB-8 (the locally preferred plan) as the least environmentally damaging practicable alternative. We recommend that, in the future, the U.S. Army Corps of Engineers include the 404(b)(1) alternatives analyses in draft EISs so that agencies and the public have a more meaningful opportunity to evaluate impacts and provide relevant and timely feedback to inform these analyses and the Corps' decisions.

In our comments on the Supplemental Draft EIS, we commented that the Sutter Basin Pilot Feasibility Report Mitigation and Monitoring Plan (MMP) did not identify specific restoration measures, success criteria, or monitoring commitments for 3.099 acres of waters of the U.S. that would be temporarily affected by the project, and recommended that the Final EIS and MMP include this information to ensure successful restoration of these resources. We were unable to find this information in either the Final EIS or the MMP, and recommend that the Corps ensure that this information is included in the MMP.

The Corps Regulatory Program Uniform Performance Standards for Compensatory Mitigation Requirements (Version 8/9/2012, SPD QMS 12505.1) requires that permittees ensure equal or greater than 80 percent survivorship for vegetation and monitor annually until a minimum of two years of success post-irrigation. The MMP (Appendix D5, p.5-4) states that irrigation will be required for plant establishment and survival and should be applied with the goal that plants will become self sufficient by the end of the third growing season. Elsewhere, however, the MMP (p.

4-1) states that a minimum survival rate of at least 80% must be maintained throughout the first two years of the monitoring period, rather than monitoring annually until a minimum of two years of success *post-irrigation*. Given that successful plant establishment may require irrigation for several years, we recommend that the success criteria in the Sutter Basin MMP be revised to require, for a minimum of two years of success post-irrigation, at least 80 percent vegetation survivorship and annual monitoring.

We appreciate the opportunity to review this Final EIS. Please send a copy of the Record of Decision to this office (mailcode CED-2) when it is signed. If you have any questions, please call me at (415) 972-3521 or contact Jeanne Geselbracht, our lead NEPA reviewer for this project, at geselbracht.jeanne@epa.gov or (415) 972-3853.

Sincerely,

/s/

Kathleen Martyn Goforth, Manager
Environmental Review Office

cc: Brad Johnson, U.S. Army Corps of Engineers, Sacramento
Mike Inamine, Sutter Butte Flood Control Agency

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

Planning and Policy Division

Ms. Kathleen Martyn Goforth
Environmental Review Office (CED-2)
U.S. Environmental Protection Agency, Region IX
75 Hawthorne Street
San Francisco, CA 94105

Dear Ms. Goforth:

This letter is in response to your comments on the final integrated feasibility report and Environmental Impact Statement for the Sutter Basin Feasibility Study provided in a letter dated December 19, 2013. We acknowledge that circulating the 404(b)(1) evaluation with the draft report for public comment as recommended by Environmental Protection Agency (EPA) would provide additional opportunity for public input. As you know, the Corps governing planning regulation, Engineering Regulation (ER) 1105-2-100, implementing the Principles and Guidelines that have governed the evaluation of proposed water resource development projects since 1983, requires that formulation and screening of alternatives leading to the identification of the recommended plan be carried out in accordance with the accounts set out in the Principles and Guidelines. In accordance with the Clean Water Act, the ER also directs that such feasibility planning reports include documentation necessary to demonstrate that the recommended plan complies with Section 404(b)(1) guidelines for evaluation of the discharge of dredged or fill material into waters of the United States. As you indicate, this has been done with regard to the final integrated feasibility report and EIS for this project.

We have addressed your comments concerning the project's proposed Mitigation and Monitoring Plan (MMP). Your comment concerning inclusion of specific restoration measures, success criteria, and monitoring commitments for about 3.1 acres of temporarily affected waters of the United States has been addressed. The Corps understands your comment regarding weaning plants from irrigation to show that plants are self sustaining at the end of the monitoring period without the need for supplemental irrigation. To address this comment, the MMP has been revised to state a minimum of two years of post-irrigation success and at least 80 percent vegetation canopy coverage survivorship with annual monitoring. The specific changes to the MMP made to address your comments are shown in the attached document.

We will provide the Record of Decision to your office upon its execution as you requested. We will continue to coordinate with the EPA as the project moves forward. We trust that the

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above information sufficiently addresses your concerns. If you would like to discuss these issues further, please contact Mr. Scott Nicholson at (202) 761-7770.

Sincerely,

Theodore A. Brown

Theodore A. Brown, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

August 8, 2014

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington, DC 20310-0108

Dear Ms. Darcy:

As required by Executive Order 12322, the Office of Management and Budget has reviewed an August 2013 Army Corps of Engineers (Corps) feasibility study recommending construction of the Sutter Basin, CA, flood mitigation project with a first cost of $688,930,000 (October 2013 price level).

The Office of Management and Budget has concluded that this project is consistent with the program and policies of the President. We would like to continue discussions with you regarding the way in which the Army Corps implements crediting and in-kind contributions provided by non-Federal sponsors in relation to Sections 104 and 902 of the Water Resources Development Act of 1986 and Section 221 of the Flood Control Act of 1970.

The Office of Management and Budget does not object to your submitting the Sutter Basin, CA Pilot Feasibility Report to Congress. However, when you do so, please advise the Congress that the project will need to compete with other proposed investments for funding in future budgets.

Sincerely,

John Pasquantino
Deputy Associate Director
Energy, Science and Water Division

RECORD OF DECISION

SUTTER BASIN, CALIFORNIA

The Final Integrated Feasibility Report and the Environmental Impact Report/Supplemental Environmental Impact Statement (FR/EIR/SEIS), dated October 2013, and the report of Chief of Engineers, dated March 12, 2014, address flood risk management opportunities in Sutter and Butte Counties, California. Based on these reports, the views of other Federal, State and local agencies, input from the public, and the review by my staff, I find the Sutter Basin Flood Risk Management Project (SBFRMP) to be technically feasible, economically justified, in accordance with environmental statutes, and in the public interest. Thus, I approve the SBFRMP for construction.

The FR/EIR/SEIS documents the evaluation of alternatives to reduce flood risk to the Sutter Basin which includes the communities of Yuba City, Gridley, Live Oak and Biggs. The plan recommended for implementation is the locally preferred plan (LPP), Alternative SB-8, Fix-in-Place Feather River Levees, Thermalito Afterbay to Laurel Avenue, which consists of the following features:

- Strengthening of about 41.4 miles of the existing Feather River West Levee;
- Realignment of 2.2 miles of levee;
- Relocation of 1,540 feet of the Sutter Butte Canal;
- Construction of 88 acres of compensatory mitigation for impacts to forested habitat;
- Purchase of conservation bank credits for the giant garter snake;
- Purchase of mitigation bank credits for impacts to wetlands;
- Implementation of a monitoring and adaptive management plan.

In addition to the no-action plan, two alternatives, the LPP and the National Economic Development (NED) plan, were included in the final array of alternatives. All the alternatives are fully described and evaluated in the FR/EIR/SEIS, which is incorporated herein by reference. The LPP provides protection to a larger number of communities than the NED plan, and best addresses residual flood risks and life safety risks in the study area. All practicable means to avoid, minimize, and compensate for adverse effects on environmental resources have been incorporated into the recommended plan.

The NED plan is the environmentally preferable alternative because it minimizes impacts to riparian forest, wetlands, and threatened and endangered species habitat while meeting the flood risk management project purpose. The NED plan was not selected as the recommended plan because it did not adequately address the flood risk to the communities of Gridley, Live Oak and Biggs.

The U.S. Fish and Wildlife Service provided a biological opinion outlining adverse effects to the valley elderberry longhorn beetle, the giant garter snake and their respective habitats. The recommended plan will implement all reasonable and prudent measures and the terms and conditions of the biological opinion. Potentially significant increases in airborne emissions would be mitigated through payments to the applicable air quality mitigation program. Potential adverse effects to noise levels caused by construction traffic, temporary loss of recreation access and increased greenhouse gases would be reduced to a less than significant level through project design, construction practices, regulatory requirements and best management practices.

Technical and economic criteria used in the formulation of alternative plans were those specified in the Water Resource Council's 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies. All applicable laws, executive orders, regulations and guidelines were considered in evaluation of alternatives and the selection of the recommended plan. Based on review of these evaluations, I find that the flood risk management benefits gained by construction of the recommended plan serve the public interest and outweigh any adverse effects. This Record of Decision completes the National Environmental Policy Act process.

Aug. 20, 2014
Date

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

SUTTER BASIN PILOT FEASIBILITY FINAL REPORT—FINAL ENVIRONMENTAL IMPACT REPORT / SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

PREPARED BY:

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US Army Corps of Engineers ®

October 2013

FINAL
PILOT FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT REPORT/ SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT
For
Sutter Basin Pilot Feasibility Study
Sutter & Butte Counties, California

This Feasibility Report (FR) includes an integrated Environmental Impact Report/Supplemental Environmental Impact Statement (EIR/SEIS) with sections required for compliance with the National Environmental Policy Act and California Environmental Quality Act noted by an asterisk (*) in the Table of Contents.

Responsible Agencies: The responsible Federal lead agency is the U.S. Army Corps of Engineers (USACE), Sacramento District. The Sutter Butte Flood Control Agency (SBFCA) is the responsible State lead agency and non-federal cost sharing partner for the study. There are no Cooperating Agencies as defined in 40 Code of Federal Regulation 1508.5 and no agency was requested to be a Cooperating Agency.

Abstract: The purpose of the Sutter Basin Pilot Feasibility Study (SBPFS) is to investigate and determine the extent of Federal interest in plans that reduce flood risk to the Sutter Basin in Sutter and Butte Counties. This report: (1) assesses the risk of flooding; (2) describes a range of alternatives formulated to reduce flood risk; and (3) identifies a Recommended Plan (RP) for implementation. The RP consists of levee improvements to existing levees of the Sacramento River Flood Control Project extending along approximately 41 miles of the Feather River. The RP would provide higher levels of flood risk management to local communities.

Following public and governmental agency review, this final report will be finalized and submitted to Headquarters, USACE, for review and approval, then transmitted to Congress for recommended project authorization. Federal project construction would be dependent upon Congressional appropriation of funding for the Federal share of the project.

Following release of the draft FR/EIR/SEIS for public comment in June 2013, SBFCA initiated construction of the Feather River West Levee Project (FRWLP), which is similar to the recommended plan. The non-federal costs incurred by SBFCA and the State of California in implementing the FRWLP are eligible for credit as non-federal cost share toward potential future USACE construction of recommended plan features.

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Acronyms and Abbreviations

ACE	Annual Chance Exceedance
ACHP	Advisory Council on Historic Preservation
APE	areas of potential effects
ASA(CW)	Office of the Assistant Secretary of the Army for Civil Works
ASTs	aboveground storage tanks
ATR	Agency Technical Review
Basin Plan	Sacramento and San Joaquin River Basins
BCAQMD	Butte County Air Quality Management District
BCR	benefit-to-cost ratios
BFE	base flood elevation
BMPs	Best Management Practices
BRCP	Butte Regional Conservation Plan
BSSCP	bentonite slurry spill contingency plan
CAA	Clean Air Act
CAR	Coordination Act Report
CARB	California Air Resources Board
CDFW	Department of Fish and Wildlife
Central Valley RWQCB	Central Valley Regional Water Quality Control Board
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CNRFC	California Nevada River Forecast Center
CRS	Community Rating System
CVFBP	Central Valley Flood Protection Board
CVFPA	Central Valley Flood Protection Act
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CVHM	Central Valley Hydrologic Model
CVIFMS	Central Valley Integrated Flood Management Study
CWA	Clean Water Act
dbh	diameter at breast height
DPM	diesel-fueled engines
DQC	District Quality Control
DWR	California Department of Water Resources
EFH	Essential Fish Habitat

EIP	Early Implementation Program
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EM	2004 Engineering Manual 1110-1-400
EO	Executive Order
ER	Ecosystem Restoration
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FIRMs	Flood Insurance Rate Maps
Flood Board	California Flood Protection Board
FMMP	Farmland Mapping and Monitoring Program
FPPA	Farmland Protection Policy Act
fps	feet per second
FR	Federal Register
FRAQMD	Feather River Air Quality Management District
FRM	flood risk management
FRWA	Feather River Wildlife Area
FRWL	Feather River West Levee
FRWLP	Feather River West Levee Project
FSM	Feasibility Scoping Meeting
GGS	giant garter snake
GIS	geographic information system
HCP	habitat conservation plan
HPTRM	High Performance Turf Reinforced Mat
HTRW	hazardous toxic radioactive wastes
ICF	ICF International
IEPR	Independent External Peer Review
LD	Levee Districts
LERRDs	lands, easements, right of ways, relocations, and disposal areas
LPP	Locally Preferred Plan
LST	Levee Screening Tool
MAs	Maintenance Areas
MBTA	Migratory Bird Treaty Act
MCACES	Micro Computer-Aided Cost Engineering System
MLD	most likely descendant
MMP	mitigation and monitoring plan
MOU	memorandum of understanding
NAAQS	National Ambient Air Quality Standards
NAVD88	North American Vertical Datum of 1988
NCCP	natural community conservation plan
NED	National Economic Development
NEPA	National Environmental Policy Act

NFIP	National Flood Insurance Program
NGOs	non-governmental organizations
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOD	Notice of Determination
NOI	Notice of Intent
NOP	Notice of Preparation
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NTUs	Nephelometric turbidity units
NWS	National Weather Service
O&M	operations and maintenance
OMB	Office of Management and Budget
OMRR&R	operation and maintenance, repair, replacement, and rehabilitation
OS	open space
OSE	Other Social Effects
OWA	Oroville Wildlife Area
P&G	Principles and Guidelines
PA	programmatic agreement
PDT	Project Deliver Team
PED	Preconstruction, Engineering & Design
PPA	Project Partnership Agreement
PRC	Public Resources Code
RD	Reclamation District
Reclamation Board	California Central Valley Flood Protection Board
RED	Regional Economic Development
ROD	Record of Decision
ROW	Right-of-Way
RP	Recommended Plan
RWQCB	Central Valley Regional Water Quality Control Board
SB	Senate Bill
SB 5	California Senate Bill 5
SBCA	Star Bend Conservation Area
SBFCA	Sutter Butte Flood Control Agency
SBMC	Sutter Butte Main Canal
SBPFS	Sutter Basin Pilot Feasibility Study
SEIS	Supplemental Environmental Impact Report
SHPO	State Historic Preservation Officer
SMAQMD	Sacramento Metropolitan Air Quality Management District
SPCCP	spill prevention, control, and counter-measure plan
SPFC	State Plan of Flood Control

SRA	Shaded Riverine Aquatic
SRFCP	Sacramento River Flood Control Project
State Water Board	State Water Resources Control Board
SWIF	System Wide Improvement Framework
SWPPP	stormwater pollution prevention plan
TRLIA	Three Rivers Levee Improvement Authority
TSP	tentatively selected plan
TSS	total settleable solids
UAIC	United Auburn Indian Community
UFRR	Urban Flood Risk Reduction
USACE	U.S. Army Corps of Engineers
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
USTs	underground storage tanks
valley	Sacramento Valley
VE	Value Engineering
Vegetation ETL	Guidelines for Landscape Plantings and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures
VELB	valley elderberry longhorn beetle
VFZ	Vegetation-Free- Zone
WDRs	waste discharge requirements
WRDA	Water Resources Development Act
Yuba-Sutter NCCP/HCP	Yuba-Sutter Natural Community Conservation Plan and Habitat Conservation Plan

This report serves three functions. It assesses the risk of flooding in the Sutter Basin, it describes a range of potential projects (called "alternatives") formulated to reduce flood risk, and it identifies a Recommended Plan (RP) for implementation. This report constitutes both a final Feasibility Report that describes the U.S. Army Corps of Engineers (USACE) "pilot" planning process that was followed to identify the RP, and a final Environmental Impact Report/Supplemental Environmental Impact Statement (EIR/SEIS) that is required to comply with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). Following public and governmental agency review, this final report will be submitted to Headquarters USACE, the Assistant Secretary of the Army for Civil Works (ASA[CW]), and the Office of Management and Budget for review and approval. Following approval, a Chief of Engineers Report will be sent to Congress recommending authorization of the Sutter Basin Flood Risk Management project.

ES.1 Purpose and Need

The primary purpose of the Sutter Basin Project is to reduce overall flood risk to the Sutter Basin study area consistent with the project goals. Recent geotechnical analysis and evaluation of historical performance during past floods indicate the existing project levees within the study area do not meet USACE levee design criteria and are at risk of failure. Approximately 26,783 structures throughout the study area are at risk of flooding in a 1% Annual Chance Exceedance (ACE) flood event (100-year event).

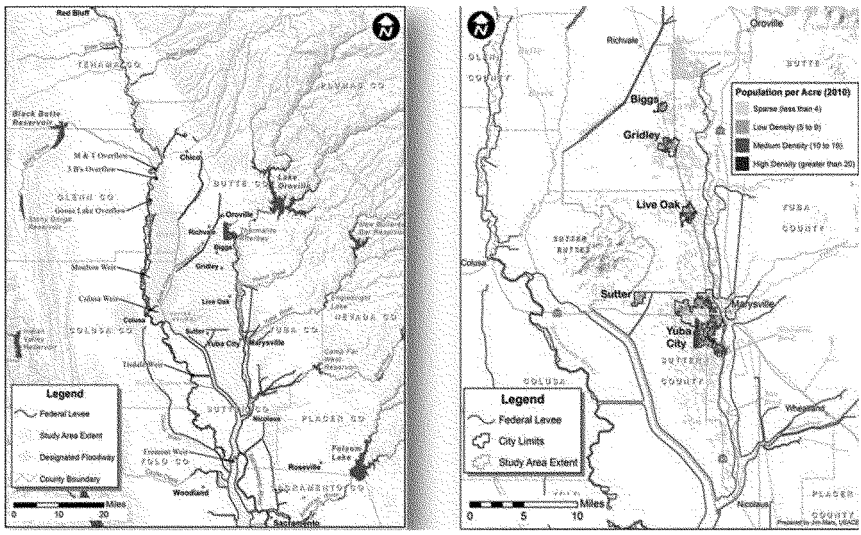
ES.2 Study Area and Need for Action

USACE initiated the Sutter Basin, California, Feasibility Study in 2000 at the request of Sutter County through the California Central Valley Flood Protection Board (formerly the Reclamation Board). The Sutter Butte Flood Control Agency (SBFCA) is a joint powers agency formed in 2007 by the Counties of Butte and Sutter; the Cities of Biggs, Gridley, Live Oak and Yuba City; and Levee Districts 1 and 9. SBFCA became a joint non-federal sponsor with the Central Valley Flood Protection Board (CVFBP) of the Feasibility Study in 2007, and the study area was redefined from the political boundaries of Sutter County to the hydraulic boundaries of Sutter Basin, which includes portions of both Sutter and Butte Counties.

The Sutter Basin is a 326-square-mile area located in northern California on the west bank of the Feather River, as shown on Figure ES-1. The study area is mostly encircled by project levees of the Sacramento River Flood Control Project (SRFCP), which was initially authorized by the Flood Control Act of 1917.

The Gold Rush of 1849 greatly accelerated European settlement in California's Central Valley, including the Sutter Basin. The population surge induced agricultural development and the establishment of the new communities of Marysville on the east bank of the Feather River and Yuba City, Biggs, Gridley, and Live Oak on the west bank. Initial local levee construction was based upon historic high water levels; however, competing levees on either side of the river constrained the flood carrying capacity of the river, as did upstream hydraulic mining that washed large amounts of sediment into the rivers and raised their natural beds. As a result, levees were overtopped, failed, and then rebuilt to a higher elevation. This cycle continued through the late 1800s, when the "Sawyer Decision" by the Ninth Circuit Court in San Francisco put an end to hydraulic mining and

the California Debris Commission proposed a comprehensive plan consisting of levees, weirs, and bypasses to reduce the risk of flooding in the Sacramento Valley. The plan was formally adopted by the State of California in 1911 and the California Reclamation Board was empowered to approve plans for the construction of levees along the Sacramento River, its tributaries, and within any of the overflow basins. By the time the SRFCP was authorized by Congress in the Flood Control Act of 1917, more than 400 miles of river levees had already been constructed. USACE, the State, and local communities continued to extend the system's levees and improve the existing levees to required grade and section. In 1938, USACE rebuilt the Feather River west bank levee from Shanghai Bend to Yuba City in accordance with the established design criteria.



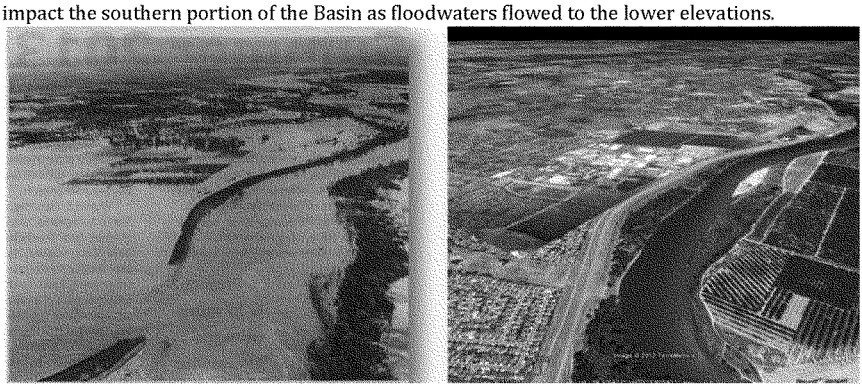
(See the *Figures* folder on the CD for full-sized images.)

Figure ES-1. Sutter Basin Study Area (left) and Sutter Basin Urbanized Areas (right)

The construction of large reservoirs on the Sacramento, Feather, and Yuba Rivers offered additional flood risk reduction by regulating flood discharge flows. However, the Sutter Basin is still at serious risk of flood, not from levee overtopping, but from geotechnical failure as a result of under-seepage. Since 1950 extensive flood fighting has occurred in the study area during 19 events. The flood of 1955 (see Figures ES-2 and ES-3) resulted in 38 deaths. Catastrophic and deadly failures occurred in 1997 on the Feather River East Levee and the Sutter Bypass West Levee. Both of these incidents, which reduced the Feather River water surface elevation, relieved pressure on the Sutter Basin levees and likely prevented further flooding and loss of life within the study area.

The Sutter Basin topography provides for broad and shallow floodplains with a northeast to a southwest flow toward the deeper southern basin (See Figure ES-4). Floodplain modeling of existing conditions clearly shows that the leveed study area, excluding the highlands of the Sutter Buttes, has a high level of flood risk and significant public and life safety risk (See Figure ES-4). Potential levee breaches on the eastern side of the Basin along the Feather River north of Yuba City would flood

most of the northern basin, including the communities of Live Oak, Gridley, and Biggs, and would impact the southern portion of the Basin as floodwaters flowed to the lower elevations.



Before After

Figure ES-2. Yuba City Flooding (1955) and Present Conditions

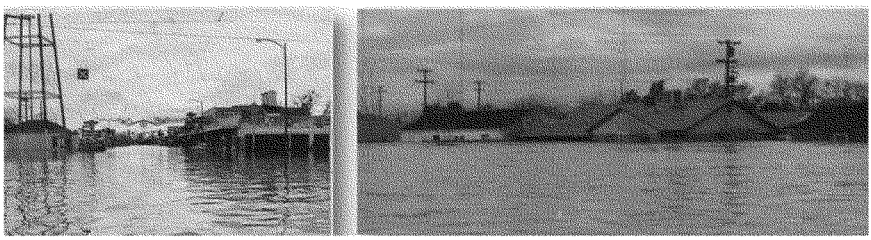


Figure ES-3. Yuba City Flooding (1955)

The residents, businesses, and local governments of Sutter Basin are keenly aware of the flood risk, which led them to create SBFCA, assess taxes specifically for reducing the flood risk, and formally seek partnership, in the form of a continuing feasibility study, with CVFPB and the Federal Government to address the flood risk. When USACE's National Pilot Program for planning modernization was initiated in 2011 to develop a new risk-informed planning process paradigm, both SBFCA and CVFPB readily supported and signed on to be part of the fast-moving pilot program.

A further example of local sponsor focus on expediting flood risk–reduction efforts is SBFCA's progress on the Feather River West Levee Project (FRWLP). SBFCA has requested and received approval under 33 United States Code Section 408 for certain levee improvement work in the study area. SBFCA's stated intent is to begin construction of the FRWLP to address the most critical sections of the existing levee and, in so doing, advance construction of the Federal project expected to result from this Sutter Basin Pilot Feasibility Study (SBPFS). SBFCA intends to seek in-kind credit for completing portions of the FRWLP that are determined to be integral to the Federal project. As described in Section ES.4, the environmental impact analysis contained in this final integrated pilot feasibility report and EIR/SEIS supplements the Final EIS prepared by USACE for the FRWLP and focuses on the additional impacts of the SBPFS.

The SBPFS and associated environmental documentation present a multi-objective pilot plan formulation process that has resulted in a RP that best addresses the study objectives of reducing flood risk and associated damages, and reducing the public and life safety risk in the Sutter Basin.

The local project sponsors contend that numerous unique flood-related problems, listed below, warrant a continued Federal investment in Sutter Basin public safety.

- **Sudden and unpredictable levee failures.** Numerous historic events confirm that Feather River levees most often fail because of under-seepage. This failure mode is characterized by minimal warning time, which renders evacuation plans ineffective and potentially hazardous.
- **Limited evacuation routes.** The unique geography, small number of transportation corridors, and population distribution necessitate the protection and augmentation of limited evacuation options. During past flood events, such as in 1955 and 1997, evacuation routes and available safe zones proved to be ineffective or hazardous.
- **Vulnerability to winter storms.** Flooding historically has occurred during the months of December through February with air temperatures of 38 to 55°F and water temperatures of 45 to 55°F. These temperatures significantly increase risk of death by exposure.
- **Vulnerable senior population.** Both Butte County (15.6%) and Sutter County (13.0%) are above the state average (11.7%) for percentage of persons at least 65 years of age.
- **Economically disadvantaged community.** The median household income for the study area ranges from $36,563 (Gridley) to $48,830 (Yuba City), well below the median in California. Unemployment is also high, with rates of 14.7%, 8.4%, and 9.3% in Biggs, Gridley and Yuba City, respectively (U.S. Census Bureau 2010).
- **Adoption of wise use of floodplain policies.** Local land use planning policies sustain agricultural land use in the southern portion of the basin, which is subject to deep flooding, while allowing limited growth adjacent to the four communities in the shallower northern portions.
- **Overwhelming support for risk-reduction measures.** In 2010, during the depths of the economic recession, Sutter Basin property owners voted to assess themselves $6.65 million per year to study and implement a project to reduce flood risks. This voting margin (72% to 28%) for one of the highest per-home assessment rates in California by an economically disadvantaged community represents a resounding public endorsement for the critical public and life safety aspects of the project.

ES.3 Study Authority

The authority for USACE to study Flood Risk Management (FRM) and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962, Public Law No. 87-874, Section 209, 76 Stat. 1180, 1196 (1962).

The existing project levees of the Sutter Basin provide FRM as part of the more comprehensive SRFCP, which was authorized by the Flood Control Act of 1917.

ES.4 Scope of NEPA and CEQA Impact Analysis

USACE as the NEPA lead agency and SBFCA as the CEQA lead agency have prepared this integrated document as a joint CEQA and NEPA document, an Environmental Impact Report/Supplemental Environmental Impact Statement (EIR/SEIS). In December 2012, USACE and SBFCA released for public comment a Draft EIS/EIR for the FRWLP. Following release of the Draft EIS/EIR, the NEPA and CEQA processes were separated and a stand-alone EIS and a stand-alone EIR were prepared. SBFCA has since certified and adopted its final EIR and filed a Notice of Determination. The Final EIS has been approved by USACE and a Record of Decision (ROD) was signed on July 19, 2013 covering levee work proposed for construction in 2013 and then a second ROD on September 13, 2013 covering the entire remaining project.

Because the FRWLP Final EIS analyzed a project with similar features and environmental impacts to those of the SBPFS, the actions proposed in the FRWLP Final EIS have been supplemented to include work associated with the SBPFS, including an additional reach of levee improvements and impacts on vegetation. Consequently, this final document supplements the analyses and conclusions reached by USACE in the FRWLP Final EIS. Further, this document incorporates by reference the FRWLP Final EIS where applicable.

ES.5 Pilot Study Program

The SBPFS was one of the first studies selected for inclusion in the National Pilot Program in February 2011. The pilot initiative provides an opportunity to test and develop principles of modernizing the USACE Civil Works Planning Program to better address the many water resource challenges facing the nation. The pilot study paradigm envisions a more predictable and efficient planning process that significantly lessens the time and level of information required to complete a feasibility study. This new process required regular involvement and alignment from the South Pacific Division and Headquarters-assigned personal (Vertical Team) throughout the plan formulation process. The pilot process emphasized multi-objective planning, early identification of the Federal interest, use of available information and data, professional judgment, and risk-informed planning and decisions.

ES.6 Existing Conditions of Levees and Flooding Characteristics

Existing conditions are those at the time the study is conducted and form the basis for extrapolation to other conditions. Existing conditions within the study area are discussed below.

ES.6.1 Topography

As shown in Figure ES-4, the floodplain elevations (excluding the high ground of Sutter Buttes) range from 110 feet in the northeast to 30 feet in the southwest.

ES.6.2 Geotechnical Levee Performance

History, initial information, and modeling during plan formulation indicate that the primary risk of flooding in the Sutter Basin is the result of geotechnical failure of the existing levees, not hydrologic or hydraulic factors that result in levee overtopping. Recent geotechnical analysis and evaluation of historical performance during past floods have resulted in a revision of the criteria used for the evaluation of under-seepage. The risk of levee failure cannot be attributed to design deficiency or

lack of maintenance of the existing levees, but rather to a better understanding of the mechanics of under-seepage. The project levees within the study area do not meet current USACE levee design standards and are at risk of breach failure at stages considerably less than levee crest elevations. This was evidenced by historical boils and heavy seepage at Feather River stages less than authorized design flows. Under-seepage failures are sudden and unpredictable, resulting in minimal warning time and ineffective evacuation plans. The risk of unexpected levee failure coupled with the consequence of flooding presents a continued threat to public and life safety, property, and critical infrastructure. Modeling indicated that a levee could fail for seepage-related reasons even when the water surface is at a 20% level (meaning the event has a 1 in 5 chance of occurring in any year) along the Feather River. During a 10% event (1/10), the probability of failure is 10–20%. For a 1% event (1/100), the probabilities of failure are 30–45%, depending upon the location along the river.

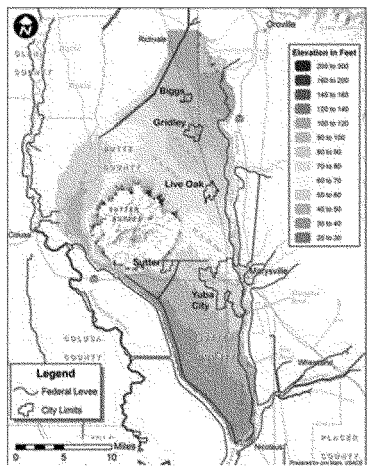


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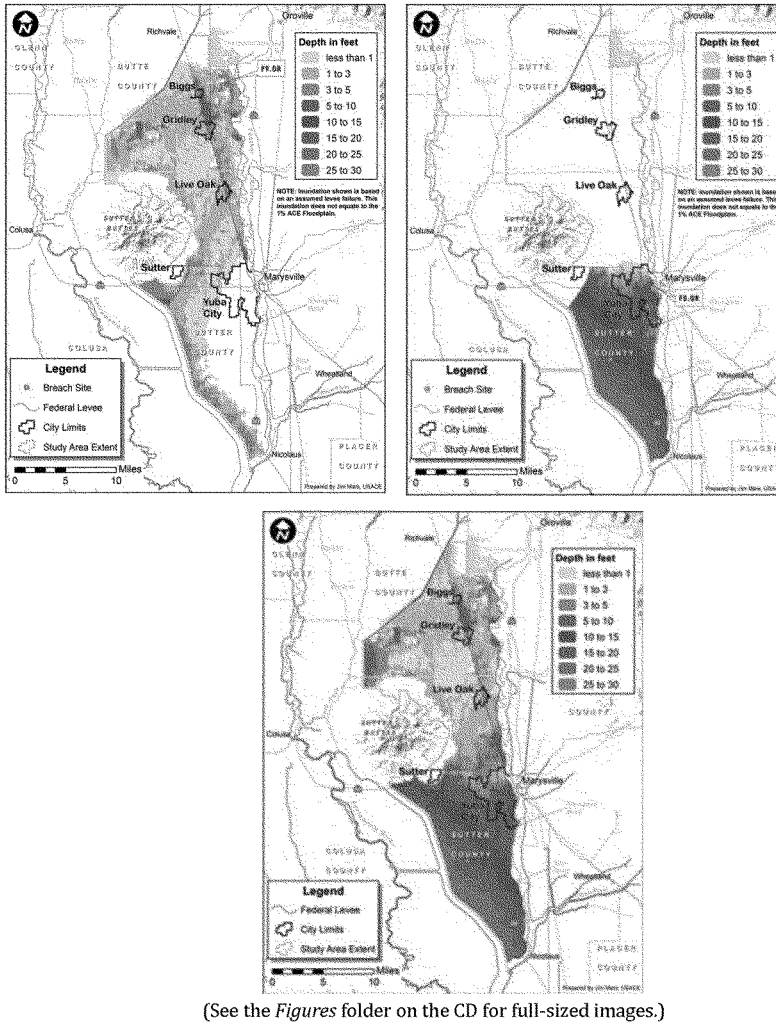
Figure ES-4. Sutter Basin Topography

ES.6.3 Hydraulics

Multiple levee breach scenarios were modeled along the Feather River and Sutter Bypass to assist in the analysis of the study alternatives. Floodplains resulting from levee breaches differ significantly in nature depending on the location of the breach, as illustrated in Figure ES-5. Simulated breaches along the northern portion of the Feather River flood the northern basin in a shallow (up to 6 feet) northeast to southwest flooding flow. Breaches from the Sutter Bypass and southern most portion of the Feather River only flood the deeper (up to 25 feet) southern basin area and do not impact the northern portion of the basin. The velocity of floodwaters varies depending on the proximity to the breach location. Within 1,000 feet of a breach, the velocity could be great enough to knock structures off of their foundations. This high-risk velocity area would consist mainly of the small portion of Yuba City within 1,000 feet of the river and would see velocities greater than 6 feet per

second (fps). The majority of Yuba City and all of Biggs, Gridley and Live Oak are outside this area and could expect to see flood velocities of 2–3 fps.



(See the *Figures* folder on the CD for full-sized images.)

Figure ES-5. Northern Feather River Levee Breach Scenario, 1% ACE Floodplain (upper left), Yuba City Feather River Breach Scenario, 1% ACE Floodplain (upper right), and Composite 1% ACE Floodplain for Sutter Basin (bottom).

Various without-project levee breach scenarios were developed and evaluated for the study area to determine the inundation area for flood events of various magnitudes. Figure ES-5 shows the 1% ACE floodplain for two breach scenarios, one near Biggs in the northern portion of the basin and the other near Yuba City. Figure ES-5 also shows a summary, or composite, of the 1% (1/100) ACE inundation areas for the entire study area from all evaluated breach locations that have less than a 90% reliability for a given mean annual exceedence event (in this case 1%). While this floodplain is larger than would likely be seen in a single flood/breach event, it is meant to represent the relative residual risk for the area from all remaining breach locations.

ES.7 Plan Formulation

ES.7.1 Pilot Plan Formulation Approach and Multi-Objective Planning

During the feasibility study, the Federal planning process for development of water resource projects was followed to identify a recommended plan for implementation. Following definition of flood-related problems and opportunities, specific planning objectives and planning constraints were identified. A broad array of management measures consisting of FRM, associated ecosystem restoration, and associated recreation opportunities was developed to achieve the planning objectives and avoid the planning constraints. These measures were based on existing reports and studies, local sponsor information, public input, risk assessment, and professional judgment, as discussed in Section 3-1, *Flood Risk–Management Measures.*

A parallel effort of plan formulation was also conducted by SBFCA for the FRWLP. Alternatives considered in detail in the Final EIS for the FRWLP are discussed in this document (Chapter 4, *Affected Environment and Environmental Consequences*) because this integrated document supplements the FRWLP Final EIS, as discussed in Section ES.4, *Scope of NEPA and CEQA Impact Analysis.*

Verification of the geotechnical levee issues and hydraulic modeling scenarios focused the FRM measures and alternatives to two basic approaches: fix the existing Feather River West Levee or construct new setback levees. Setback levees address FRM issues objectives and also provide opportunities at the new waterside areas lands created by the setback of the levee footprint for ecosystem restoration and recreation. These setback waterside lands would be connected to the active floodplain and river, but also to the extensive existing riparian and agricultural lands that provide habitat and recreation connectivity to the river. Fix-in-place measures do not have associated or conjunctive ecosystem or recreational opportunities, because the levee footprint is relatively the same as the existing levee and, therefore, is not creating or providing any new areas for potential ecosystem restoration or recreation connectivity. Thus, any proposed ecosystem restoration and recreation would need to be independent of the FRM fix-in-place place measures. The Feather River levees are already set back hundreds of feet from the river channel, with the connected floodplain area consisting of remnant riparian, fallow, and agriculture areas. These existing remnant riparian and fallow areas provide opportunities for ecosystem restoration and recreation that can be pursued independently from the study.

A combined Value Engineering (VE) Study and Planning Charette (workshop) screened and evaluated the conceptual alternatives developed during the initial management measurement efforts. VE methodology was incorporated into the planning process to compare, refine, and optimize alternatives based on multiple criteria to ensure a robust array of alternatives was evaluated. The VE Study/Charette process also provided an opportunity to validate the array of

conceptual alternatives and to ensure that significant alternatives had not been overlooked. The process resulted in a draft array of eight alternatives as described in Chapter 3, *Plan Formation*.

- Alternative SB-1: No Action
- Alternative SB-2: Minimal Fix-in-Place Feather River Levees: Sunset Weir to Star Bend
- Alternative SB-3: Yuba City Ring Levee
- Alternative SB-4: Little J-levee
- Alternative SB-5: Fix-in-Place Feather River Levees: Thermalito Afterbay to Star Bend
- Alternative SB-6: Fix-in-Place Feather River, Sutter Bypass, and Wadsworth Canal Levees
- Alternative SB-7: Fix-in-Place Feather River Levees: Sunset Weir to Laurel Avenue
- Alternative SB-8: Fix-in-Place Feather River Levees: Thermalito Afterbay to Laurel Avenue

A multi-objective evaluation strategy was used to narrow the draft array of eight alternatives into a final array of three alternatives. The multi-objective evaluation process first screened alternatives using the federal planning criteria that identified efficiency (economics/cost efficiency) and completeness (best meeting study objectives). The next step was screening based on the "planning accounts" of National Economic Development (NED) for efficiency and Other Social Effects (OSE) for completeness.

ES.7.2 Identification of Final Array of Alternatives

Alternative SB-7, which would maximize net benefits, was identified as the NED Plan. This alternative consists of strengthening approximately 27 miles of the existing Feather River West Levee from Sunset Weir to Laurel Avenue. The NED Plan would reduce adverse flooding effects, but benefits would be primarily centered in Yuba City. The NED Plan would not address the significant flooding risks in the communities of Biggs, Gridley, and Live Oak. Therefore, the NED Plan does not fully address the planning objectives.

Using the evaluation metrics and multi-objective analysis, the alternative that best balances the study objectives of reducing flood risk and damages and reducing risk to public and life safety within the entire study area was determined to be Alternative SB-8 (See Table ES-1). Alternative SB-8 is supported by the local sponsors as a locally preferred plan (LPP), and can be considered in a multi-objective planning context to be a more comprehensive and complete Federal plan.

The LPP consists of strengthening approximately 41.4 miles of the existing Feather River West Levee from Thermalito Afterbay to Laurel Avenue. The LPP would reduce adverse flooding effects, including risks to public and life safety, in the northern portion of the basin as well as in Yuba City. See Figure ES-6.

With the confirmation of an LPP, A final array of alternatives was established.

- Alternative SB-1: No Action
- Alternative SB-7: Fix-in-Place Feather River Levees: Sunset Weir to Laurel Avenue (NED Plan)
- Alternative SB-8: Fix-in-Place Feather River Levees: Thermalito Afterbay to Laurel Avenue (LPP)

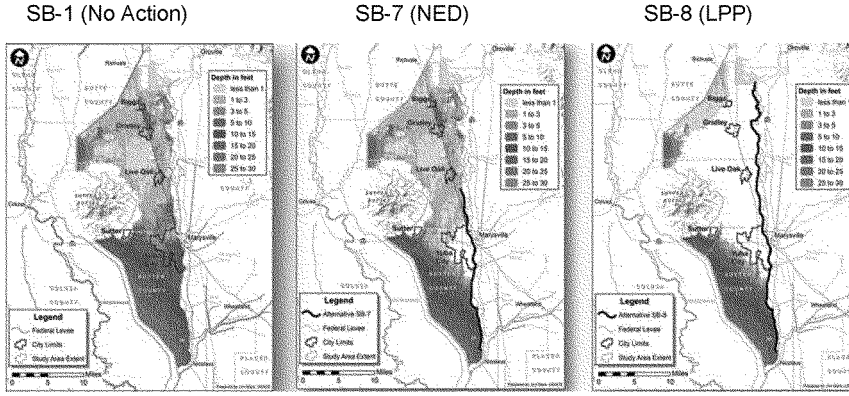
Table ES-1. Net Benefits (Mean, Standard USACE Practice) – Final Array of Alternatives Using October 2013 Prices (Values in Millions) and 3.5% Discount Rate

Economic Category	Alternative SB-1: No Action	Alternative SB-7: NED Plan	Alternative SB-8: LPP
Total First Cost [a]	N/A	390	686
IDC	N/A	38	94
OMRR&R	N/A	0.28	0.45
Annual Cost	N/A	18	33
Annual Benefits	N/A	79	87
Annual Net Benefits	N/A	61	54
Benefit to Cost Ratio	N/A	4.4:1	2.6:1

NED = National Economic Development.
IDC = Interest during construction.
OMRR&R = Operations and maintenance, repair, replacement and rehabilitation.
[a] Cultural resources data recovery costs ($1.6 million for SB-7 and $3.0 million for SB-8) are not included in economic costs per Corps policy (ER 1105-2-100, Appendix E, paragraph E-63.f.(5)),

ES.7.3 Management of Residual Risk

The LPP (Alternative SB-8) is the multi-objective/criteria alternative that is both cost effective and best reduces flooding and residual risk to public and life safety in the Sutter Basin. Alternative SB-8 includes Alternative SB-7 and would fix-in-place the northern Feather River levees from Sunset Weir up to Thermalito Afterbay. The total first cost, which is the sum of all initial expenditures to construct a project, of the LPP is estimated at $688,930,000. The LPP would provide annual net benefits of $54 million.



(See the *Figures* folder on the CD for full-sized images.)

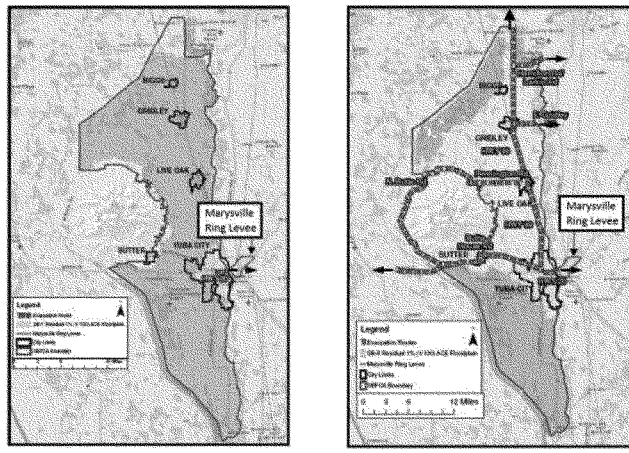
Figure ES-6. Final Array of Alternatives Comparison (Residual 1% ACE Floodplains)

The additional investment of $297,090,000 in project cost (Alternative SB-8 first cost minus the NED Plan cost) would buy down the residual risk of the NED Plan, provide additional annual benefits ($8 million), and provide significant nonmonetized benefits in the reduction of public and life safety risk reduction. The population at risk of flooding from a 1% ACE flood event would decrease from 38,200 under the NED Plan to 6,600 under the LPP. In addition, critical infrastructure at risk would be reduced from 11 facilities under the NED Plan to one under the LPP. Significantly, the number of evacuation routes for the entire Sutter Basin would increase from one under NED Plan to five under the LPP (See Table ES-1, Table ES-2, and Figure ES-7).

Table ES-2. Final Array: Summary of Life Safety Metrics for Residual Risk

		Alternative		
Evaluation Metric		**SB-1: No Action**	**SB-7: NED Plan**	**SB-8: LPP**
Population at Risk	People	94,600	38,200	6,600
Critical Infrastructure	Facilities	28	11	1
Evacuation Routes	Number of Routes	0	1	5
Potentially Developable Floodplains	Acres	71,800	88,200	100,200

In significantly reducing the residual risk of the NED Plan to public and life safety and still providing additional annual benefits and a positive total benefit to cost ratio, Alternative SB-8 is supported by the local sponsors as the LPP, and can be considered in a multi-objective planning context to be a more comprehensive and complete Federal plan. Alternative SB-8 is recommended as the RP.



NED **LPP**

(See the *Figures* folder on the CD for full-sized images.)

Figure ES-7. Evacuation Routes Comparison of NED Plan and LPP

Strengthening the existing levees from Thermalito Afterbay to Laurel Avenue would reduce the risk of sudden geotechnical levee failure. The remaining flood risk would be from infrequent large flood

flows that would result in levee overtopping. However, as discussed in Section 4.2.2.5.2., flood events of this magnitude would be preceded by a flood warning issued 5 days in advance. A more accurate warning of potential levee overtopping would likely be made 24 to 36 hours in advance.

ES.8 Recommended Plan

The multi-objective comparison and assessment between the NED Plan and the LPP showed both the NED Plan and LPP provide significant benefits that exceed their costs. While the NED Plan is more efficient than the LPP (greater net benefits), both plans are efficient (annual benefits exceed annual costs).

ES.8.1 Description

The RP would strengthen about 41.4 miles of existing project levees along the west bank of the Feather River from the vicinity of Laurel Avenue, just south of Yuba City, to Thermalito Afterbay at the northern end of the Sutter Basin. The RP is the LPP; however, Federal cost sharing would be capped at 65% of the cost of the NED Plan. Under the RP, existing levees would be strengthened to reduce the risk of geotechnical failure modes associated with under-seepage. The existing levees would not be raised. The RP would provide FRM benefits to the northern communities of Biggs, Gridley, and Live Oak, as well as to Yuba City, at an estimated cost of $688,930,000 (see Figure ES-8). The RP is justified and has a benefit to cost ratio of 2.6 to 1. In a multi-objective context that emphasizes flood risk management and residual risk to life safety objectives across all accounts and criteria, the LPP (Alternative SB-8) is a more comprehensive FRM solution at a NED level of Federal cost share participation. A policy exception waiver from the ASA(CW) has been approved to allow the Federal government to recommend the LPP over the NED Plan.

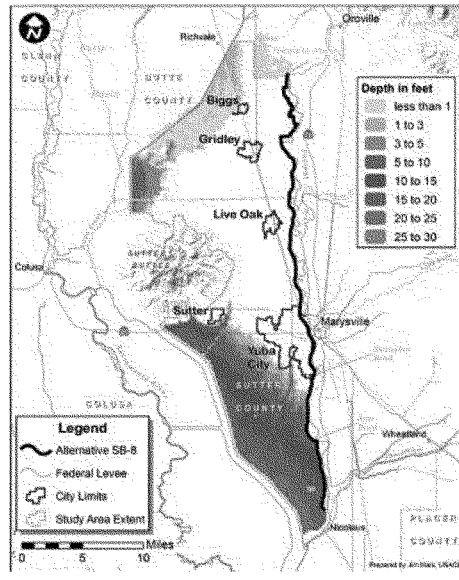


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Figure ES-8. Recommended Plan (Residual 1% ACE Floodplain)

The RP is a fix-in-place design to strengthen the existing levee along the west bank of the Feather River from a point 2,250 feet south of Laurel Avenue (Station 180+00) to Thermalito Afterbay (Station 2368+00). The proposed design features for the RP include primarily soil-bentonite levee cutoff walls of various depths. The RP also includes erosion control at two sections where initial overtopping will most likely occur for less frequent extreme flood events. A total of about 1.5 miles of erosion protection would be provided to increase the resiliency of the initial overtopping sections, which would increase the flood warning and evacuation time prior to overtopping failure.

The RP assumes all vegetation, except grasses, will be removed from the levee and within 15 feet of the levee toe in compliance with Engineering Technical Letter (ETL) 1110-2-571, *Guidelines for Landscape Plantings and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures* (Vegetation ETL). This assumption discloses the maximum potential impacts of the RP resulting from vegetation removal. During the design phase of the project, other options with lesser impacts, including a formal Vegetation ETL variance application to allow woody vegetation on the waterside of the levee, might be available and will be considered.

Nonstructural measures to be implemented in conjunction with the RP are preparation of an emergency evacuation plan, preparation of flood fight pre-staging areas, updates to the floodplain management plan, and flood risk–awareness communication.

ES.8.2 RP Economics and Cost Sharing

The project first cost, estimated on the basis of October 2013 price levels, is $688,930,000. Estimated average annual costs are $33 million based on a 3.5% interest rate, a period of analysis of

50 years, and construction ending in 2023. The total average annual flood damage reduction benefits would be $87 million for a benefit-cost ratio of 2.6 to 1.

The ASA(CW) has approved an exception to the policy that requires USACE to recommend the NED Plan. The LPP costs $297,090,000 more than the NED Plan. The non-federal sponsors would be responsible for the entire extra cost, which would increase the non-federal cost share from $136,570,000 for the NED Plan to $433,660,000 for the LPP. The Federal cost share of $255,270,000 is the same for both the NED Plan and the LPP. A summary of cost sharing responsibilities is presented in Table ES-3.

The non-federal sponsors, SBFCA and CVFPB, fully support the RP and have agreed to fund the determined cost of the RP.

Table ES-3. Summary of Cost Sharing Responsibilities for the Recommended Plan ($1,000) [a] [b]

MCACES Account [c]	Account	Federal	Non-Federal	Total
	NED Plan			
1	Land and Damages	$0	$42,390	$42,390
2	Relocations [d]	$0	$28,542	$28,542
6	Fish and Wildlife	$4,797	$1,241	$6,038
11	Levees and Floodwalls	$190,596	$49,326	$239,922
18	Cultural Resources	$493	$127	$620
30	Preconstruction, Engineering, and Design	$41,086	$8,633	$51,719
31	Construction Management	$16,664	$4,312	$20,976
	Add Data Recovery	$1,633	$0	$1,633
	Percentage	65%	35%	100%
	Total First Cost (NED)	$255,270	$136,570	$391,840
	LPP Increment from NED Plan to LPP			
1	Land and Damages	$0	$11,156	$11,156
2	Relocations[d]	$0	$58,917	$58,917
6	Fish and Wildlife	$0	$1557	$1,557
11	Levees and Floodwalls	$0	$172,933	$172,933
18	Cultural Resources / Data Recovery	$0	$1,853	$1,853
30	Preconstruction, Engineering, and Design	$0	$35,831	$35,831
31	Construction Management	$0	$14,843	$14,843
	Total Incremental Increase	$0	$297,090	$297,090
	Total First Cost (LPP)	**$255,270**	**$433,660**	**$688,930**

Notes:

[a] Based on October 2013 price levels.

[b] Planning, Engineering, and Design costs incurred after completion of the Feasibility Report will be cost shared between the Federal Government and the project sponsors in accordance with a Design Agreement. Upon initiation of project construction, all costs incurred under the Design Agreement will be included as part of the total project costs and subject to the project cost sharing requirements in accordance with the Project Partnership Agreement, which will be executed prior to award of the first construction contract.

[c] Micro Computer-Aided Cost Engineering System (MCACES) is the software program and assorted format used by USACE in developing cost estimates. Costs are divided into various categories identified as "accounts." Detailed costs estimates are presented in Appendix C, part 4, Cost Engineering.

[d] Relocations estimate includes construction cost, design cost, and construction management cost associated with required relocations.

ES.8.3 Operations and Maintenance, Repair, Replacement and Rehabilitation

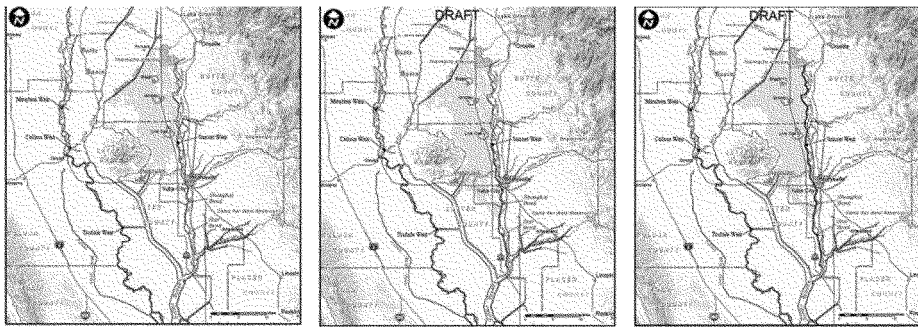
Local non-federal interests are responsible for the existing project levees and have continuing operations and maintenance, repair, replacement, and rehabilitation (OMRR&R) obligations in accordance with established operations and maintenance manuals and agreements. The local sponsors have coordinated with the responsible OMRR&R districts and agencies of the RP levees. Annual OMRR&R cost of the levees after implementation of the RP is estimated to be $454,000, an increase of $22,000 from existing OMRR&R commitments. Amended manuals and new agreements would be prepared upon construction completion.

ES.8.4 Potential Developable Floodplain Effects of the RP

Executive Order (EO) 11988 (May 24, 1977) requires a Federal agency, when taking an action, to avoid short- and long-term adverse effects associated with the occupancy and the modification of a floodplain.

The wise use of floodplains concept, as described in EO 11988, was incorporated as a life safety evaluation metric for this study. The metric, termed "potentially developable floodplain" was used in the pilot study multi-objective planning process for evaluation, screening, and comparison. Potentially developable floodplain is developable land within the 1% ACE floodplain that would flood to a depth of less than 3 feet. This metric approach was based on pilot study objectives of applying qualitative rather than quantitative analysis, use of existing data/inventory, and professional team judgment.

Maps were prepared and acreages were calculated for the No Action, NED Plan, and RP with the baseline 0.2% ACE floodplain. These maps do not forecast future growth. Rather, they measure potentially developable acreage using high-level screening criteria of the metric (See Figure ES-9).



(See the *Figures* folder on the CD for full-sized images.)

Figure ES-9. Potentially Developable Floodplain of the No Action Alternative (left), NED Plan (center) and RP (right)

- The NED Plan would result in an additional 16,000 acres of potentially developable floodplain consisting of 5,000 acres in the Yuba City urban area and 11,000 acres in the Sutter County rural area surrounding Yuba City.
- The additional increment to implement SB-8 (RP) would result in an additional 12,000 acres of potentially developable floodplain consisting of 500 acres in the urban areas of Yuba City, Biggs, Gridley, and Live Oak; 2,700 acres in the Sutter County rural area; and 8,800 acres in the Butte County rural area. This would be in addition to the 16,000 acres under the NED Plan.

The eight-step EO 11988 process was completed for the RP, which was demonstrated to be in compliance with the intent of the EO (see Section 7.1.9 for detailed analysis). Local and state programs and laws also are in place to limit development in Sutter Basin floodplains. SBFCA's position is that Sutter Basin is a model of wise use of the floodplain for the following reasons.

- The agricultural-based economy of Sutter Basin sustains low hazard land uses.
- The agricultural-based economy (and resultant wise use of the floodplain) depends on economically sustainable small communities in the north.
- Existing communities have low growth rates.
- The northern basin communities were developed on the shallower portion of the floodplain.
- No urbanization is planned for the deeper southern basin.

ES.8.5 Areas of Controversy and Issues to be Resolved

Based on the comments received during the scoping period and the public comments received on the FRWLP EIS/EIR, the projected areas of controversy associated with the study are those listed here.

- Construction-related effects.
- Property acquisition.
- Levee encroachments and vegetation.
- Climate change and sea-level rise.
- River access for recreation.

The most controversial concern is the USACE policy contained in the Vegetation ETL that restricts woody vegetation on Federal project levees. Implementation of the policy has stirred public and scientific controversy. The SBPFS is subject to this guidance. With implementation of the proposed project, approximately 20 acres of riparian vegetation may require removal to comply with the policy, resulting in effects on fish and wildlife habitat and social values like recreation and aesthetics. This issue is discussed below and further described in Chapter 3, *Plan Formulation*, and under the effects discussions for vegetation, fish, wildlife, visual resources, and recreation in Chapter 4, *Affected Environment and Environmental Consequences*. The other potential areas of concerns are addressed also in Chapter 4.

ES.8.6 Environmental Impact Conclusions

Presented below is an overview of the impact analysis conclusions of this integrated feasibility report and EIR/SEIS. Table ES-5 presents the impact significance findings for Alternatives SB-8 and

SB-7 before and after consideration of mitigation measures. Due to its length, Table ES-5 is located at the end of the executive summary. As identified in Table ES-5, even though SB-7 would have less overall environmental impact than SB-8, both alternatives would have significant impacts on air quality, noise, vegetation, visual resources, and cultural resources.

The SBPFS RP (Alternative SB-8) is similar to the FRWLP's preferred alternative (Alternative 3) in that both propose fix-in-place levee design measures to the same levees. The SBPFS RP extends 2,250 linear feet farther south, has minor variations in staging and rights-of-way land requirements, and includes additional encroachment removal, including vegetation removal, to satisfy the USACE Levee Safety Vegetation Policy described in the Vegetation ETL. The permanent beneficial effects and adverse impacts of Alternatives SB-8 and SB-7 relative to the FRWLP preferred alternative are summarized in Table ES-4.

The SBPFS RP would provide a similar level of flood risk reduction as the FRWLP would provide, occupy roughly the same footprint, and have similar temporary impacts on air quality, noise, and recreation during construction. However, the RP would result in a greater impact on terrestrial habitats and wildlife resources than the FRWLP preferred alternative due to approximately 20 acres of additional vegetation removal to comply with the Vegetation ETL. USACE guidance (Federal Register, February 17, 2012) requires, "New federally authorized cost shared levee projects shall be designed to meet the current vegetation management standards."

The Vegetation ETL makes allowance for the issuance of variances in certain instances to further enhance environmental values or to meet state of Federal laws and/or regulations, provided that (a) safety, structural integrity, and functionality are retained, and (b) accessibility for maintenance, inspection, monitoring, and flood fighting are retained. During final project design, the existing levee system will be evaluated using current criteria for a possible variance to retain vegetation on the lower 2/3 of the waterside slope of the levee and within 15 feet of the waterside toe; all other woody vegetation would still be removed. It is possible that additional options for Vegetation ETL compliance, or variance consideration, may be established in the future. During the design phase, all available options and means for achieving Vegetation ETL compliance will be considered.

Project effects on fish and wildlife resources have been coordinated with the U.S. Fish and Wildlife Service (USFWS) under the Fish and Wildlife Coordination Act. In consultation with the USFWS and the California Department of Fish and Wildlife (CDFW), a fish and wildlife mitigation and monitoring plan (Appendix D) has been developed to compensate for impacts on fish and wildlife resources. It is anticipated that implementation of the proposed mitigation and monitoring plan and compliance with requirements of the Federal Endangered Species Act and California Endangered Species Act would avoid long-term significant impacts on fish and wildlife resources.

Table ES-4. Summary Comparison of the SBPFS Alternatives and the FRWLP Preferred Alternative Based on Key Characteristics and Environmental Effects

Environmental Effect or Project Characteristic	FRWLP Preferred Alternative	Alternative SB-8	Alternative SB-7	No Action Alternative
Proposed Levee Improvements	Approximately 41 miles, primarily cutoff wall construction. Includes 1.9 miles of seepage berms and 1.8 miles of canal dredging.	Approximately 41 miles, primarily cutoff wall construction. Includes 2.5 miles of seepage berms, 2.2 miles of levee relocation, 1.5 miles of landside levee slope erosion protection, and 0.29 miles of canal relocation.	Approximately 24 miles, primarily cutoff wall construction. Includes 1.3 miles of seepage berms and 1.1 miles of landside levee slope erosion protection. No canal or levee relocation.	Not applicable
Structures in Residual 1% (1/100) ACE Floodplain	1,670 structures	1,670 structures	7,569 structures	26,783 structures
Potentially Developable Floodplain	Removes flood risk as an obstacle to growth in 28,400 acres within the study area.	Same as FRWLP	Removes flood risk as an obstacle to growth in 12,000 acres within the study area.	Flood risk is not removed as an obstacle to growth
Water Quality and Soils				
Ground Disturbance (Footprint)	975 acres	1,031 acres	678 acres	Not Applicable
Soil Borrow Quantity	1.93 million cubic yards	1.62 million cubic yards	1.0 million cubic yards	Not Applicable
Air Quality				
Air Quality Effects of Construction Emissions	Significant effect: Exceeds local air quality management district daily emission thresholds after mitigation. Alternative demonstrates conformity.	Significant effect: Exceeds local air quality management district daily emission thresholds after mitigation. Alternative demonstrates conformity.	Significant effect: Exceeds local air quality management district daily emission thresholds after mitigation. Alternative demonstrates conformity.	Emergency response and clean up actions in the event of levee failures would result in increased emission; however, too speculative to assess magnitude and make a determination of significance.

Environmental Effect or Project Characteristic	FRWLP Preferred Alternative	Alternative SB-8	Alternative SB-7	No Action Alternative
Vegetation and Wetlands				
Wetlands and Other Jurisdictional Waters	0.43 acres of permanent impact 7.61 acres of temporary impact	5.79 acres of permanent impact 3.12 acres of temporary impact	1.76 acres of permanent impact 0.91 acre of temporary impact	Emergency response and clean up actions in the event of levee failures could result in fill or disturbance; however, too speculative to quantify.
Loss of Terrestrial Habitats (Riparian Forest, etc.)	Riparian Forest: 20.63 acres Riparian Scrub-Shrub: 3.09 acres Oak Woodland: 0.22 acres	Riparian Forest: 42.00 acres (without Vegetation ETL variance) to 32.28 acres (with Vegetation ETL variance). Riparian Scrub-Shrub: 0.50 acres (without Vegetation ETL variance) to 0.10 acres (with Vegetation ETL variance). Oak Woodland: 1.30 acres (without or with Vegetation ETL variance)	Riparian Forest: 24.40 acres (without Vegetation ETL variance) to 22.12 acres (with Vegetation ETL variance). Riparian Scrub-Shrub: 0.02 acres (without or with Vegetation ETL variance) Oak Woodland: 1.00 acre (without or with Vegetation ETL variance)	To comply with Federal and state levee operations and maintenance requirements, some removal of vegetation may occur as result of local levee maintenance actions. Emergency response and clean up actions in the event of levee failures could adversely affect habitats; however, too speculative to quantify.
Special Status Wildlife				
Effects on Valley Elderberry Longhorn Beetle and Giant Garter Snake	91 elderberry shrubs 0.004 acre of permanent impact on giant garter snake aquatic habitat	162 elderberry shrubs 3.54 acres of permanent impact on giant garter snake upland habitat	79 elderberry Shrubs 3.54 acres of permanent impact on giant garter snake upland habitat	Emergency response and clean up actions in the event of levee failures could adversely affect special status species habitats; however, too speculative to quantify.
Fisheries				
Effects on Special Status Fish Species	No significant effects. No in-river construction and no vegetation impacts would occur in critical habitat.	No significant effects. No in-river construction and no vegetation impacts would occur in critical habitat.	No significant effects. No in-river construction and no vegetation impacts would occur in critical habitat.	Potential for release of hazardous materials into the waterway in the event of levee breach but too speculative to assess.
Agriculture				
Permanent Conversion of Farmland	219.20 acres	49.4 acres	30.78 acres	No effect

ES.8.6.1 Significant and Unavoidable Effects of Alternatives SB-7 (NED Plan) and SB-8 (RP)

A significant and unavoidable effect or impact (the terms *environmental effect* and *environmental impact* are considered synonymous in this analysis) is one that would result in a significant or potentially significant adverse effect on the environment that could not be reduced to a less-than-significant level even with implementation of applicable feasible mitigation.

The following impacts of the NED Plan (Alternative SB-7) and the RP (Alternative SB-8) were found to be significant and unavoidable. Most of these impacts would be temporary and related to construction activities. Where feasible mitigation exists, it has been included to reduce these impacts; however, the mitigation would not be sufficient to reduce the impacts to a less-than-significant level. The following impacts are presented in the order they appear in Chapter 4, *Affected Environment and Environmental Consequences.*

- Effect AQ-2: Exceedance of Applicable Thresholds for Construction Emissions
- Effect NOI-1: Exposure of Sensitive Receptors to Temporary Construction-Related Noise
- Effect NOI-2: Exposure of Sensitive Receptors to Temporary Construction-Related Vibration
- Effect VEG-1: Disturbance or Removal of Riparian Trees
- Effect VEG-4: Potential Loss of Special-Status Plant Populations Caused by Habitat Loss Resulting from Project Construction
- Effect VIS-1: Result in Temporary Visual Effects from Construction
- Effect VIS-2: Adversely Affect a Scenic Vista
- Effect VIS-3: Substantially Degrade the Existing Visual Character or Quality of the Site and its Surroundings
- Effect CR-1: Effects on Identified Archaeological Sites Resulting from Construction of Levee Improvements and Ancillary Features
- Effect CR-2: Potential to Disturb Unidentified Archaeological Sites
- Effect CR-3: Potential to Disturb Human Remains
- Effect CR-4: Direct and Indirect Effects on Identified Historic Architectural/Built Environmental Resources Resulting from Construction Activities.

ES.8.6.2 Flood Risk Management and Geomorphology

Relative to existing and future without-project conditions, significant beneficial effects would result from the study alternatives due to reduced risk of flooding from levee failure. Proposed levee improvements would provide a levee that is more resistant to under-seepage, and erosion, and less susceptible to catastrophic breaches. The alternatives would not significantly alter the location, height, or alignment of the existing Feather River West Levee and, therefore, would not provide any increased or decreased flood storage or conveyance capacity. No significant adverse impacts on flood control and geomorphology are anticipated. Existing interior drainage patterns could be altered by levee improvements. This impact would be mitigated to a less-than-significant level by

coordinating with owners and operators, preparing drainage studies, and remediating effects through project design.

ES.8.6.3 Water Quality and Groundwater Resources

Construction activities would disturb existing vegetation cover and soils, would expose large areas of disturbed ground that then could be subject to rainfall and erosion, and could cause temporary discharges of sediment and other contaminants in stormwater runoff to drainage channels and the Feather River. Environmental commitments are included in the project to reduce potential temporary effects on surface water quality from construction-related turbidity to a less-than-significant level. Effects on groundwater were studied and cutoff walls were determined to have a negligible effect on groundwater levels. Results indicated that there would be a 3-foot increase in groundwater levels in the southern study area, and a negligible change in the northern study area along the Feather River. A 3-foot change in the groundwater levels in the southern area was determined unlikely to have any significant effect because the depth to groundwater in the southern area is 10 to 30 feet below the ground surface.

ES.8.6.4 Geology, Seismicity, Soils, and Mineral Resources

No significant adverse effects on geology, seismicity, soils, and mineral resources are anticipated from the project. Relative to existing conditions, the project would have a beneficial effect on levee stability. The ground-disturbing activities and vegetation clearing along levee slopes and 15 feet out from the waterside and landside levee toes could potentially cause soil erosion and sedimentation of local drainages and waterways. Alternative SB-8 would disturb the largest area because its construction footprint is substantially larger than Alternative SB-7's footprint. However, significant large-scale erosion and generation of runoff is unlikely because construction would be reduced or would not occur during the winter months, and the levees are generally located distant from the river. Site-specific measures to control erosion would be described in more detail in the required Stormwater Pollution Prevention Plan (SWPPP). With implementation of the SWPPP, erosion and sediment-related effects would be less than significant.

ES.8.7 Traffic, Transportation, and Navigation

Effects on traffic levels would result primarily from hauling of borrow material from borrow sites to the project area along highways and local roads, and from worker trips to and from the project site. Temporary increases in construction-related traffic, temporary road closures, emergency response times, and other traffic and transportation effects from project implementation were determined to be less than significant for both alternatives. Alternative SB-7 would have substantially less impact than SB-8 due to SB-7's smaller construction footprint. The action alternatives would have no effect on navigation.

ES.8.7.1 Air Quality

Emissions resulting from construction activities associated with study alternatives would have short-term impacts on local air quality and would have negligible impacts on regional air quality. Temporary construction-related emissions would be partially mitigated by reducing vehicle and equipment emissions and implementing a fugitive dust plan. Regardless of the mitigation measures, the temporary construction emissions produced would be significant and unavoidable.

ES.8.7.2 Agriculture, Land Use, Socioeconomics

The No Action Alternative would have significant adverse effects on land use if levee failures resulted in catastrophic flooding. Losses of property and agricultural production, and annual cost of insurance to offset the losses present a significant financial burden, especially to low income households. Under Alternatives SB-7 and SB-8, farmland in the direct footprint of the project would be permanently converted to nonagricultural use; however, the conversion of agricultural land would occur only in a narrow corridor adjacent to the existing levee. Overall, the project is intended to preserve existing land use and socioeconomic conditions, especially for agriculture. Construction activities would temporarily increase employment and personal income in the local area. Neither Alternative SB-7 nor Alternative SB-8 is anticipated to result in significant adverse impacts on agriculture, land use, or socioeconomics.

ES.8.7.3 Population, Housing, and Environmental Justice

Both Alternatives SB-8 and SB-7 would require displacement of existing housing units. Alternative SB-8 would affect more housing units than SB-7 because improvements would extend over a longer reach of levee. Permanent acquisition, relocation, and compensation services would be conducted in compliance with Federal and state relocation laws. In cases where project construction is temporarily disruptive to nearby residents, assistance and compensation would be provided for residents to relocate temporarily during construction activities. The alternatives being considered would not result in disproportionately high and adverse effects on minority populations and low-income populations from acquisition of homes because plenty of vacant homes exist within the study area to serve as replacement housing.

ES.8.7.4 Vegetation and Wetlands

Project implementation would result in permanent loss of vegetation and wetlands. Under Alternatives SB-8 and SB-7, as much as 42.00 acres and 24.40 acres of riparian woodland, respectively, could be removed to conform to the Vegetation ETL. The project would include a mitigation and monitoring plan to provide in-kind, offsite compensation for losses of vegetation and jurisdictional waters and wetlands with the goal of no net loss.

ES.8.7.5 Wildlife

Construction activities would result in the injury, mortality, or disturbance of special-status and common species, which could affect local populations. Implementation of mitigation measures and a mitigation and monitoring compensation plan to avoid a long-term loss of riparian habitat would minimize or avoid these impacts and reduce the effects to a less-than-significant level.

ES.8.7.6 Fish and Aquatic Resources

The project would have no effect on shaded riverine aquatic cover and critical habitat; however, due to loss of floodplain riparian vegetation, there may be effects on fish species protected under the Endangered Species Act. Vegetation loss would be minimized and all activities would occur above the ordinary high water mark on the waterside levee slopes and toe. Thus, the project is not expected to have significant effects on fish and aquatic resources.

ES.8.7.7 Visual Resources

Alternatives SB-8 and SB-7 could potentially result in significant visual effects in reaches with sensitive viewers. The effect mechanism is primarily vegetation removal. In Reaches 12–17 near Yuba City, about 220 trees would be removed to meet Vegetation ETL levee vegetation-free zone requirements. Temporary significant unmitigable impacts on visual conditions would also result from construction activities.

ES.8.7.8 Recreation

Access to recreational facilities along the Feather River would be restricted in areas where construction is occurring. However, limitations on the use of recreation facilities would be short-term and temporary. Vegetation removal may reduce visual values immediately along the levee, but the effect on recreation would be less than significant. A substantial permanent change or reduction in the availability of recreational opportunities would not occur as a result of either Alternative SB-7 or Alternative SB-8. Proposed habitat improvements at the Star Bend Conservation Area may enhance recreation opportunities in the local area. The alternatives would not have any significant permanent effects on recreation in the project area.

ES.8.7.9 Utilities and Public Services

Construction may damage drainage and irrigation systems and public utility infrastructure, resulting in temporary disruptions to service. Coordination with drainage and irrigation systems users, consultation with service providers, and implementation of appropriate protection measures would minimize the possibility of any significant effects.

ES.8.7.10 Public Health and Environmental Hazards

Project implementation has the potential to slightly increase risks to the public during construction through use of equipment and fuels, but the increased risk would be temporary. These risks would be minimized by implementation of a SWPPP and the best management practices it contains to control accelerated erosion, sedimentation, and other pollutants during and after project construction.

ES.8.7.11 Cultural Resources

Cultural resources are known to exist throughout the project area, including a number of resources that appear eligible for inclusion in the National Register of Historic Places. These resources eligible for listing or listed in the National Register of Historic Places are called historic properties. Cultural resources, including historic properties, would be disturbed and destroyed under Alternatives SB-8 and SB-7. While mitigation measures have been identified, the mitigation may not reduce the effects to less-than-significant levels.

ES.9 Public and Agency Review

The Draft Integrated Feasibility Report and EIR/SEIS was distributed for public and agency review and comment, in accordance with NEPA and CEQA requirements. The review period began on June 14, 2013 and closed on July 29, 2013. A public meeting was held during the review period in Yuba City on July 22, 2013 to present information and to accept comments. In addition, written comments

from the public, reviewing agencies, and stakeholders were accepted throughout the public comment period. These comments, along with the written responses to those comments, are contained in Appendix F, *Responses to Comments on the Draft Document*, of this Final Integrated Feasibility Report and EIR/SEIS. Corrections, revisions, additions, and/or deletions to the text are not shown in the final document as changes; the final document contains a clean reprint of the document.

This Final Integrated Feasibility Report and EIR/SEIS will be distributed for public and agency review and comment, in accordance with NEPA and CEQA requirements for a 30-day public review. After the CEQA review period, SBFCA will consider certifying the EIR if it is determined to be in compliance with CEQA. After the NEPA review period, USACE will issue a Record of Decision that will identify USACE's decision in recommending an alternative to Congress for authorization.

ES.10 Recommended Plan Recommendation

The Assistant Secretary of the Army for Civil Works has approved, by memorandum dated May 7, 2013, an exception to National Economic Development policy for the Federal government to recommend an LPP over the NED Plan, allowing recommendation of the LPP as the RP at the NED level of Federal cost share participation. The RP is supported by the local sponsors and can be considered, in a multi-objective planning context, a comprehensive and complete Federal plan for addressing flood risk and for the protection of public and life safety.

The recommendation of the District Engineer of Sacramento District, U.S. Army Corps of Engineers, is that the RP (Alternative SB-8) plan be authorized for implementation as a Federal project. The estimated first cost of the RP is $688,930,000 in October 2013 dollars. The estimated Federal cost is $255,2670,000 and the estimated non-federal cost is $433,660,000. Federal cost participation is limited to the Federal cost of the NED Plan (SB-7). OMRR&R cost is estimated to be $454,000, an increase of $22,000 over costs from existing OMRR&R commitments of the existing levees. The estimated fully funded first cost, based on projected inflations specified by USACE budget guidance, is $788,989,000, excluding cultural resources data recovery cost of $2,981,000.

The non-federal sponsors' portion of the estimated first cost is $433,660,000. The non-federal sponsors shall agree to provide all lands, easements, rights-of-way, relocations, and suitable borrow and disposal areas. The non-federal sponsors shall also assume continued responsibility for OMRR&R. The non-federal sponsors shall publicize floodplain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the floodplain.

Table ES-5. Summary of Effects and Mitigation Measures

Effect	Alternative	Significance before Mitigation	Mitigation Measure	Significance after Mitigation
Flood Risk Management and Geomorphic Conditions				
Effect FC-1: Change in Water Surface Elevations and Flood Safety Attributable to Project Design	SB-8 and SB-7	No effect	None required	No effect
Effect FC-2: Increase in Channel Bed Incision and Bank Erosion Attributable to Project Design	SB-8 and SB-7	No effect	None required	No effect
Effect FC-3: Decrease in Under-seepage	SB-8 and SB-7	Beneficial	None required	Beneficial
Effect FC-4: Decrease in Risk of Levee Failure as a Result of Erosion or Seepage	SB-8 and SB-7	Beneficial	None required	Beneficial
Effect FC-5: Change in Stream Energy and Modification of Floodplain Scour/Deposition	SB-8 and SB-7	No effect	None required	No effect
Effect FC-6: Alteration of the Existing Drainage Pattern of the Site or Area	SB-8 and SB-7	Significant	FC-MM-1: Coordinate with Owners and Operators, Prepare Drainage Studies as Needed, and Remediate Effects through Project Design	Less than significant
Effect FC-7: Increase in Levee Slope Stability	SB-8 and SB-7	Beneficial	None Required	Beneficial
Water Quality and Groundwater Resources				
WQ-1: Effects on Surface Water Quality from Excessive Turbidity or Total Suspended Solids	SB-8 and SB-7	Less than significant	None required	Less than significant
WQ-2: Release of Contaminants into Adjacent Surface Water Bodies from Construction-Related Hazardous Materials	SB-8 and SB-7	Less than significant	None required	Less than Significant
WQ-3: Effects on Groundwater or Surface Water Quality Resulting from Contact with the Water Table	SB-8 and SB-7	Significant	WQ-MM-1: Implement Provisions for Dewatering WQ-MM-2: Complete Phase I and Phase II (if Necessary) Environmental Site Assessment Investigations and Implement Required Measures	Less than significant
WQ-4: Effects on Groundwater Wells Due to Project Encroachment	SB-8 and SB-7	Less than significant	None Required	Less than significant

Effect	Alternative	Significance before Mitigation	Mitigation Measure	Significance after Mitigation
Geology, Seismicity, Soils and Mineral Resources				
Effect GEO-1: Beneficial Change in Levee Stability	SB-8 and SB-7	Beneficial	None required	Beneficial
Effect GEO-2: Increase Exposure of People or Structures to Hazards Related to Construction Vibrations	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect GEO-3: Cause Accelerated Erosion and Sedimentation Resulting from Construction-Related Ground Disturbance	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect GEO-4: Cause Structural Damage and Injury Resulting from Development on Expansive Soils	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect GEO-5: Cause Accelerated Erosion and Sedimentation Resulting from Use of Imported Borrow	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect GEO-6: Loss, Injury, or Death from Slope Failure at Borrow Sites	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect GEO-7: Cause the Loss of a Known Mineral Resource of Regional or Local Importance as a Result of Construction of Proposed Project	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect GEO-8: Cause the Loss of a Known Mineral Resource of Regional or Local Importance as a Result of Placement of Proposed Project	SB-8 and SB-7	Less than significant	None required	Less than significant
Traffic, Transportation, And Navigation (Findings for Preferred Alternative in FRWLP Final EIS Applicable to Study Alternatives)				
Effect TRA-1: Temporary Increase in Traffic Volumes from Construction-Generated Traffic	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect TRA-2: Temporary Road Closures	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect TRA-3: Increase in Safety Hazards Attributable to Construction-Generated Traffic	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect TRA-4: Increase in Emergency Response Times	SB-8 and SB-7	Less than significant	None required	Less than significant

Effect	Alternative	Significance before Mitigation	Mitigation Measure	Significance after Mitigation
Effect TRA-5: Inadequate Parking Supply to Meet Parking Demand for Construction Equipment and Construction Workers	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect TRA-6: Disruption of Alternative Transportation Modes as a Result of Temporary Road Closures	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect TRA-7: Temporary Changes to Navigation	SB-8 and SB-7	No Effect	None required	No Effect
Effect TRA-8: Damage to Roadway Surfaces during Construction of Facilities	SB-8 and SB-7	Less than significant	None required	Less than significant
Air Quality and Climate Change				
Effect AQ-1: Obstruction of an Applicable Air Quality Plan	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect AQ-2: Exceedance of Applicable Thresholds for Construction Emissions	SB-8 and SB-7	Significant	AQ-MM-1: Provide Advance Notification of Construction Schedule and 24-Hour Hotline to Residents AQ-MM-2: Implement Fugitive Dust Control Plan If Unmitigated Emissions Exceed PM_{10} or $PM_{2.5}$ Thresholds AQ-MM-3: Implement General Measures to Reduce Emissions AQ-MM-4: Implement Fleet-Wide Emission Reductions for Large Off-Road Equipment AQ-MM-5: Pay Required Fees to FRAQMD and BCAQMD to Offset Annual Construction NO_X Emissions to Net Zero (0)	Significant and unavoidable
Effect AQ-3: Exceedance of the Federal General Conformity Thresholds during Construction	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect AQ-4: Long-Term Operations and Maintenance Emissions of ROG, NO_X, and PM_{10}	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect AQ-5: Exposure of Sensitive Receptors to Toxic Air Emissions	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect AQ-6: Exposure to Objectionable Odors from Diesel Exhaust	SB-8 and SB-7	Less than significant	None required	Less than significant

Effect	Alternative	Significance before Mitigation	Mitigation Measure	Significance after Mitigation
Effect CC-1: Increase in GHG Emissions during Construction Exceeding Threshold	SB-8 and SB-7	Less than significant	CC-MM-1: Implement Measures to Minimize GHG Emissions during Construction	Less than significant
Effect CC-2: Conflict with an Applicable Plan, Policy, or Regulation Adopted for the Purpose of Reducing the Emissions of GHGs	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect CC-3: Failure to Address Changes in Flood Frequency and Floodwater Elevation Caused by Global Climate Change	SB-8 and SB-7	Less than significant	None required	Less than significant
Noise(Findings for Preferred Alternative in FRWLP Final EIS Applicable to Study Alternatives)				
NOI-1: Exposure of Sensitive Receptors to Temporary Construction-Related Noise	SB-8 and SB-7	Significant	NOI-MM-1: Employ Noise-Reducing Construction Practices	Significant and unavoidable
NOI-2: Exposure of Sensitive Receptors to Temporary Construction-Related Vibration	SB-8 and SB-7	Significant	NOI-MM-2: Employ Vibration-Reducing Construction Practices	Significant and unavoidable
Vegetation and Wetlands				
Effect VEG-1: Disturbance or Removal of Riparian Habitat as a Result of Project Construction	SB-8 and SB-7	Significant	VEG-MM-1: Compensate for the Loss of Woody Riparian Trees VEG-MM-2: Install Exclusion Fencing and/or K-rails along the Perimeter of the Construction Work Area and Implement General Measures to Avoid Effects on Sensitive Natural Communities and Special-Status Species VEG-MM-3: Conduct Mandatory Contractor/Worker Awareness Training for Construction Personnel VEG-MM-4: Retain a Biological Monitor	Significant and unavoidable (Short-term) Less than significant (Long-term after establishment of compensatory mitigation)
Effect VEG-2: Loss of Wetlands and Other Waters of the United States as a Result of Project Construction	SB-8 and SB-7	Significant	VEG-MM-2: Install Exclusion Fencing and/or K-rails along the Perimeter of the Construction Work Area and Implement General Measures to Avoid Effects on Sensitive Natural Communities and Special-Status Species VEG-MM-3: Conduct Mandatory Contractor/Worker Awareness Training for Construction Personnel VEG-MM-4: Retain a Biological Monitor VEG-MM-5: Compensate for the Loss of Wetlands and Other Waters	Less than significant

Effect	Alternative	Significance before Mitigation	Mitigation Measure	Significance after Mitigation
Effect VEG-3: Disturbance or Removal of Protected Trees as a Result of Project Construction	SB-8 and SB-7	Significant	VEG-MM-1: Compensate for the Loss of Woody Riparian Trees VEG-MM-2: Install Exclusion Fencing and/or K-rails along the Perimeter of the Construction Work Area and Implement General Measures to Avoid Effects on Sensitive Natural Communities and Special-Status Species VEG-MM-3: Conduct Mandatory Contractor/Worker Awareness Training for Construction Personnel VEG-MM-4: Retain a Biological Monitor	Less than significant
Effect VEG-4: Potential Loss of Special-Status Plant Populations Caused by Habitat Loss Resulting from Project Construction	SB-8 and SB-7	Significant	VEG-MM-2: Install Exclusion Fencing and/or K-rails along the Perimeter of the Construction Work Area and Implement General Measures to Avoid Effects on Sensitive Natural Communities and Special-Status Species VEG-MM-3: Conduct Mandatory Contractor/Worker Awareness Training for Construction Personnel VEG-MM-4: Retain a Biological Monitor VEG-MM-6: Retain Qualified Botanists to Conduct Floristic Surveys for Special-Status Plants during Appropriate Identification Periods VEG-MM-7: Avoid or Compensate for Substantial Effects on Special-Status Plants	Significant and unavoidable
Effect VEG-5: Introduction or Spread of Invasive Plants as a Result of Project Construction	SB-8 and SB-7	Less than significant	None required	Less than Significant
Effect VEG-6: Conflict with Provisions of an Adopted HCP/NCCP or Other Approved Local, Regional, or State Habitat Conservation Plan	SB-8 and SB-7	No effect	None required	No effect
Wildlife				
Effect WILD-1: Potential Mortality of or Loss of Habitat for Antioch Dunes Anthicid, Sacramento Anthicid, and Sacramento Valley Tiger Beetles	SB-8 and SB-7	Significant	WILD-MM-1: Fence and avoid habitat of Antioch Dunes Anthicid, Sacramento Anthicid, and Sacramento Valley Tiger Beetles and Implement Protective Measures	Less than significant

Effect	Alternative	Significance before Mitigation	Mitigation Measure	Significance after Mitigation
Effect WILD-2: Potential Mortality or Disturbance of VELB and its Habitat (Elderberry Shrubs)	SB-8 and SB-7	Significant	WILD-MM-2: Conduct VELB Surveys Prior to Elderberry Shrub Transplantation WILD-MM-3: Implement Measures to Protect VELB and its Habitat WILD-MM-4: Compensate for Effects on VELB and its Habitat	Less than significant
Effect WILD-3: Potential Mortality or Disturbance of Western Pond Turtle	SB-8 and SB-7	Significant	WILD-MM-5: Conduct Preconstruction Surveys for Western Pond Turtle and Monitor Construction Activities if Turtles are Observed	Less than significant
Effect WILD-4: Potential Disturbance or Mortality of and Loss of Suitable Habitat for Giant Garter Snake	SB-8 and SB-7	Significant	WILD-MM-6: Avoid and Minimize Construction Effects on Giant Garter Snake WILD-MM-7: Compensate for Permanent Loss of Suitable Giant Garter Snake Habitat	Less than significant
Effect WILD-5: Potential Loss or Disturbance of Nesting Swainson's Hawk and Loss of Nesting and Foraging Habitat	SB-8 and SB-7	Significant	WILD-MM-8: Conduct Vegetation Removal Activities outside the Breeding Season for Birds WILD-MM-9: Conduct Focused Surveys for Nesting Swainson's Hawk prior to Construction and Implement Protective Measures during Construction	Less than significant
Effect WILD-6: Potential Mortality or Disturbance of Nesting Special-Status and Nonspecial-Status Birds and Removal of Suitable Breeding Habitat	SB-8 and SB-7	Significant	WILD-MM-8: Conduct Vegetation Removal Activities outside the Breeding Season for Birds WILD-MM-10: Conduct Nesting Surveys for Special-Status and Nonspecial-Status Birds and Implement Protective Measures during Construction	Less than significant
Effect WILD-7: Potential Loss or Disturbance of Western Burrowing Owl and Loss of Nesting and Foraging Habitat	SB-8 and SB-7	Significant	WILD-MM-8: Conduct Vegetation Removal Activities outside the Breeding Season for Birds WILD-MM-11: Conduct Surveys for Western Burrowing Owl prior to Construction and Implement Protective Measures if Found WILD-MM-12: Compensate for the Loss of Occupied Western Burrowing Owl Habitat	Less than significant

Effect	Alternative	Significance before Mitigation	Mitigation Measure	Significance after Mitigation
Effect WILD-8: Potential Injury, Mortality or Disturbance of Tree-Roosting Bats and Removal of Roosting Habitat	SB-8 and SB-7	Significant	WILD-MM-8: Conduct Vegetation Removal Activities outside the Breeding Season for Birds WILD-MM-13: Identify Suitable Roosting Habitat for Bats and Implement Avoidance and Protective Measures	Less than significant
Effect WILD-9: Potential Injury, Mortality or Disturbance of Ringtail and Removal of Habitat	SB-8 and SB-7	Significant	WILD-MM-14: Identify Suitable Shelter and Denning Habitat for Ringtail and Implement Avoidance and Protective Measures	Less than significant
Effect WILD-10: Disturbance to or Loss of Common Wildlife Species and Their Habitats	SB-8 and SB-7	Significant	WILD-MM-8: Conduct Vegetation Removal Activities outside the Breeding Season for Birds WILD-MM-9: Conduct Focused Surveys for Nesting Swainson's Hawk prior to Construction and Implement Protective Measures during Construction WILD-MM-10: Conduct Nesting Surveys for Special-Status and Nonspecial-Status Birds and Implement Protective Measures during Construction	Less than Significant
Effect WILD-11: Potential Disruption of Wildlife Movement Corridors	SB-8 and SB-7	Less than significant	None required	Less than significant
Fish and Aquatic Resources				
Effect FISH-1: Loss or Degradation of Riparian and SRA Cover, including Critical Habitat	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect FISH-2: Construction-Related Erosion Resulting in Substantially Increased Sedimentation and Turbidity	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect FISH-3: Adverse Effects on Fish Health and Survival Associated with Potential Discharge of Contaminants during Construction Activities	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect FISH-4: Adverse Effects Caused by Construction Equipment Noise and Vibration	SB-8 and SB-7	Less than Significant	None required	Less than significant

Effect	Alternative	Significance before Mitigation	Mitigation Measure	Significance after Mitigation
Agriculture, Land Use, and Socioeconomics				
Effect AG-1: Temporary Conversion of Prime Farmland, Unique Farmland, or Farmland of Statewide Importance to Accommodate Construction Activities	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect AG-2: Irretrievable Conversion of Prime Farmland, Unique Farmland, or Farmland of Statewide Importance	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect AG-3: Conflict with Existing Zoning for Agricultural Use	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect AG-4: Conflict with Williamson Act Contract	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect AG-5: Loss of Agricultural Production	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect LU-1: Conflict with Applicable Land Use Plan, Policy, or Regulation	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect SOC-1: Temporary Increase in Study Area Employment during Construction	SB-8 and SB-7	Beneficial	None required	Beneficial
Effect SOC-2: Conflict with Applicable Socioeconomic Plan or Policy	SB-8 and SB-7	Less than significant	None required	Less than significant
Population, Housing, and Environmental Justice (Findings for Preferred Alternative in FRWLP Final EIS Applicable to Study Alternatives)				
Effect POP-1: Displacement of Existing Housing Units	SB-8 and SB-7	Significant	POP-MM-1: Property Acquisition Compensation and Resident Relocation Plan	Less than significant
Effect EJ-1: Result in a Disproportionately High and Adverse Human Health or Environmental Effect on Minority Populations and Low-Income Populations from Construction Activities	SB-8 and SB-7	Less than significant	None required	Less than significant
Visual Resources				
Effect VIS-1: Result in Temporary Visual Effects from Construction	SB-8 and SB-7	Significant	None available	Significant and Unavoidable
Effect VIS-2: Adversely Affect a Scenic Vista	SB-8 and SB-7	Significant	None available	Significant and Unavoidable

Effect	Alternative	Significance before Mitigation	Mitigation Measure	Significance after Mitigation
Effect VIS-3: Substantially Degrade the Existing Visual Character or Quality of the Site and Its Surroundings	SB-8 and SB-7	Significant	None available	Significant and Unavoidable
Effect VIS-4: Create a New Source of Substantial Light or Glare That Would Adversely Affect Day and Nighttime Public Views	SB-8 and SB-7	Less than significant	None required	Less than significant
Recreation				
Effect REC-1: Temporary Changes in Recreation Opportunities during Construction	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect REC-2: Long-Term or Permanent Loss of Recreation Opportunities in the Levee Corridor	SB-8 and SB-7	Less than significant	None required	Less than significant
Utilities and Public Services (Findings for Preferred Alternative in FRWLP Final EIS Applicable to Study Alternatives)				
Effect UTL-1: Potential Temporary Disruption of Irrigation/Drainage Facilities and Agricultural and Domestic Water Supply	SB-8 and SB-7	Significant	UTL-MM-1: Coordinate with Water Supply Users before and during All Water Supply Infrastructure Modifications and Implement Measures to Minimize Interruptions of Supply	Less than significant
Effect UTL-2: Damage of Public Utility Infrastructure and Disruption of Service	SB-8 and SB-7	Significant	UTL-MM-2: Verify Utility Locations, Coordinate with Utility Providers, Prepare a Response Plan, and Conduct Worker Training	Less than significant
Effect UTL-3: Increase in Solid Waste Generation	SB-8 and SB-7	Less than significant	None required	Less than significant
Effect UTL-4: Increase in Emergency Response Times	SB-8 and SB-7	Less than significant	None required	Less than significant
Public Health and Environmental Hazards (Findings for Preferred Alternative in FRWLP Final EIS Applicable to Study Alternatives)				
Effect PH-1: Temporary Exposure to or Release of Hazardous Materials during Construction	SB-8 and SB-7	Significant	Environmental Commitment: Stormwater Pollution Protection Plan	Less than significant
Effect PH-2: Exposure of the Environment to Hazardous Materials during Ground-Disturbing Activities	SB-8 and SB-7	Significant	Environmental Commitment: Stormwater Pollution Protection Plan PH-MM-1: Complete Phase I and Phase II (If necessary) Environmental Site Assessment Investigations and Implement Required Measures PH-MM-2: Employment of a Toxic Release Contingency Plan	Less than significant

Effect	Alternative	Significance before Mitigation	Mitigation Measure	Significance after Mitigation
Effect PH-3: Temporary Exposure to Safety Hazards from the Construction Site and Vehicles	SB-8 and SB-7	Significant	PH-MM-3: Implementation of Construction Site Safety Measures PH-MM-4: Implementation of an Emergency Response Plan	Less than significant
Effect PH-4: Exposure of People or Structures to Increased Flood Risk	SB-8 and SB-7	Beneficial	None required	Beneficial
Cultural Resources				
CR-1: Effects on Identified Archaeological Sites Resulting from Construction of Levee Improvements and Ancillary Facilities	SB-8 and SB-7	Significant	CR-MM-1: Perform Field Studies, Evaluate Identified Resources and Determine Effects, and Develop Treatment to Resolve Significant Effects	Significant and unavoidable
CR-2: Potential to Disturb Unidentified Archaeological Sites	SB-8 and SB-7	Significant	CR-MM-2: Implement a Cultural Resources Discovery Plan, Provide Related Training to Construction Workers, and Conduct Construction Monitoring	Significant and unavoidable
CR-3: Potential to Disturb Human Remains	SB-8 and SB-7	Significant	CR-MM-3: Monitor Culturally Sensitive Areas during Construction, Follow State and Federal Law Governing Human Remains if Such Resources are Discovered during Construction	Significant and unavoidable
CR-4: Direct and Indirect Effects on Built Environment Resources Resulting from Construction Activities	SB-8 and SB-7	Significant	CR-MM-4: Conduct Inventory of Built Environment Resources, Evaluate Identified Properties, Assess Effects, and Prepare Treatment to Resolve and Mitigate Significant Effects	Significant and unavoidable

Chapter 1
Study Information

1.1 Purpose of the Study and Need for the Project and Report

A high risk of flooding from levee failure threatens the public safety of approximately 95,000 people, as well as property and critical infrastructure throughout the Sutter Basin study area. Past flooding events have caused loss of life and extensive economic damages. Recent geotechnical analysis and evaluation of past levee performance indicate the existing project levees, which are part of the authorized Sacramento River Flood Control Project, do not meet current U.S. Army Corps of Engineers (USACE) levee design criteria, and are at risk of breach failure at stages less than overtopping of the levees.

The purpose of the Sutter Basin Pilot Feasibility Study (SBPFS) is to investigate and determine the extent of Federal interest in plans that reduce flood risk to the Sutter Basin in Sutter and Butte Counties. This report: (1) assesses the risk of flooding; (2) describes a range of alternatives formulated to reduce flood risk; and (3) identifies a Recommended Plan (RP) for implementation. This report constitutes both a Feasibility Report that describes a USACE "pilot" planning process followed to identify the RP, and an Environmental Impact Report/Supplemental Environmental Impact Statement (EIR/SEIS) required to comply with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). Following public and governmental agency review, this report will be finalized and submitted to Headquarters, USACE, for review and approval, then transmitted to Congress for recommended project authorization. Project construction is dependent upon Congressional appropriation of funding for the Federal share of the project.

1.1.1 NEPA and CEQA Purpose and Need Statement

NEPA and CEQA specifically require a discussion of the purpose, need, and objectives of the proposed project to facilitate an analysis of reasonable alternatives. NEPA implementing regulations provide that an EIS must include a statement that briefly specifies NEPA guidance states that the purpose and need "shall briefly specify the underlying purpose and need to which the agency is responding in proposing the alternatives, including the proposed action" (40 Code of Federal Regulations [CFR] Section 1502.13). CEQA and the State CEQA Guidelines require a clearly written statement of objectives to guide the lead agency in developing a reasonable range of alternatives and aid decision-makers in preparing findings or a statement of overriding considerations.

The primary purpose of the Sutter Basin Project is to reduce overall flood risk to the Sutter Basin study area. A high risk of flooding from levee failure threatens the public safety of approximately 95,000 people, as well as property and critical infrastructure throughout the Sutter Basin study area. Past flooding events have caused loss of life and extensive economic damages. Approximately 26,783 structures throughout the study area are at risk of flooding in a 100-year event (1% annual chance of flooding). Recent geotechnical analysis and evaluation of past levee performance indicate the existing project levees, which are part of the authorized Sacramento River Flood Control Project, do not meet current USACE levee design criteria, and are at risk of breach failure at stages less than overtopping of the levees. Recent geotechnical analysis and evaluation of historical performance during past floods indicate the existing project levees within the study area do not meet USACE levee design criteria and are at risk of breach failure. Approximately 26,783 structures throughout

the study area are at risk of flooding in a 1% Annual Chance Exceedance flood event (100-year event).

1.2 Study Authority

The authority for USACE to study flood risk management (FRM) and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962, Public Law No. 87-874, Section 209, 76 Stat. 1180, 1196 (1962). A portion of the authorization reads as follows:

> The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes...to be made under the direction of the Chief of Engineers, in drainage areas of the United States..., which include the following named localities: Sacramento River Basin and streams in northern California, draining into the Pacific Ocean for the purpose of developing, where feasible, multi-purpose water resource projects, particularly those which would be eligible under the provision of title III of Public Law 85-500.

1.3 Study Area

The 326-square-mile Sutter Basin is the study area. It is located in Northern California in Sutter and Butte Counties. A substantial portion of the study area lies within the geographically named Sutter Basin, which is a historic flood basin located between the Sacramento and Feather Rivers. The study area is within the 14,000-square-mile Sacramento River watershed, as shown on Plate 1-1. The study area, which is approximately 50 miles north of Sacramento, is bounded by the Feather River on the east, the high ground of the Sutter Buttes on the west, the Sutter Bypass on the southwest, and Cherokee Canal and the Butte Basin on the northwest and is shown on Plate 1-2. Existing levees along the Feather River, Sutter Bypass, Cherokee Canal, and Wadsworth Canal, as well as the Butte Basin, are features of the Sacramento River Flood Control Project (SRFCP). Authorized by the Flood Control Act of 1917, the SRFCP incorporates features such as levees, weirs, and pumping facilities into a system of leveed river channels and flood bypass channels to provide FRM benefits to the Sacramento Valley.

The climate and geography of the Sacramento Valley combine to produce an area where regular flooding is a natural occurrence. The Sacramento Valley is a semi-arid region with an annual rainfall of approximately 18 inches. There are two distinct annual seasons, a hot dry summer and a cool wet winter. Approximately 80% of the annual rainfall occurs from October to March. Just to the east of the region lies the Sierra Nevada mountain range. Some areas in these mountains receive 100 inches of precipitation annually. The snowpack in some regions can reach 300 inches, with resulting runoff causing flooding problems in the Central Valley. Floodwaters potentially threatening the Sutter Basin originate in the Feather River watershed or the upper Sacramento River watershed, above Colusa Weir. These waterways have drainage areas of 5,920 and 12,090 square miles, respectively. The study area is primarily rural, with extensive agricultural areas and low population density. The total population within the study area is approximately 95,000. Yuba City, located on the west bank of the Feather River, is the largest community in the study area with a population of approximately 67,000. The northern basin Cities of Biggs, Gridley, and Live Oak are situated roughly along the north-south railroad and State Route 99 corridors.

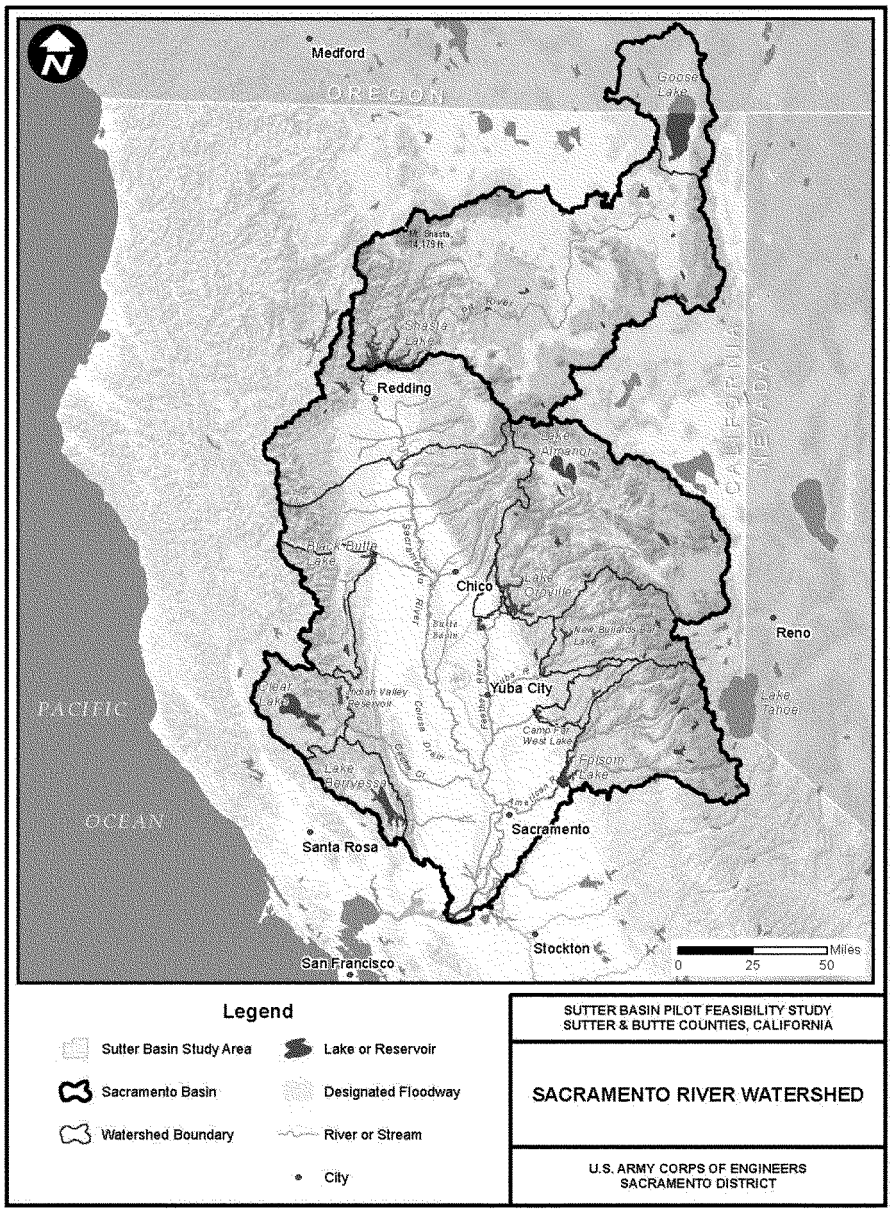


Plate 1-1. Sacramento River Watershed

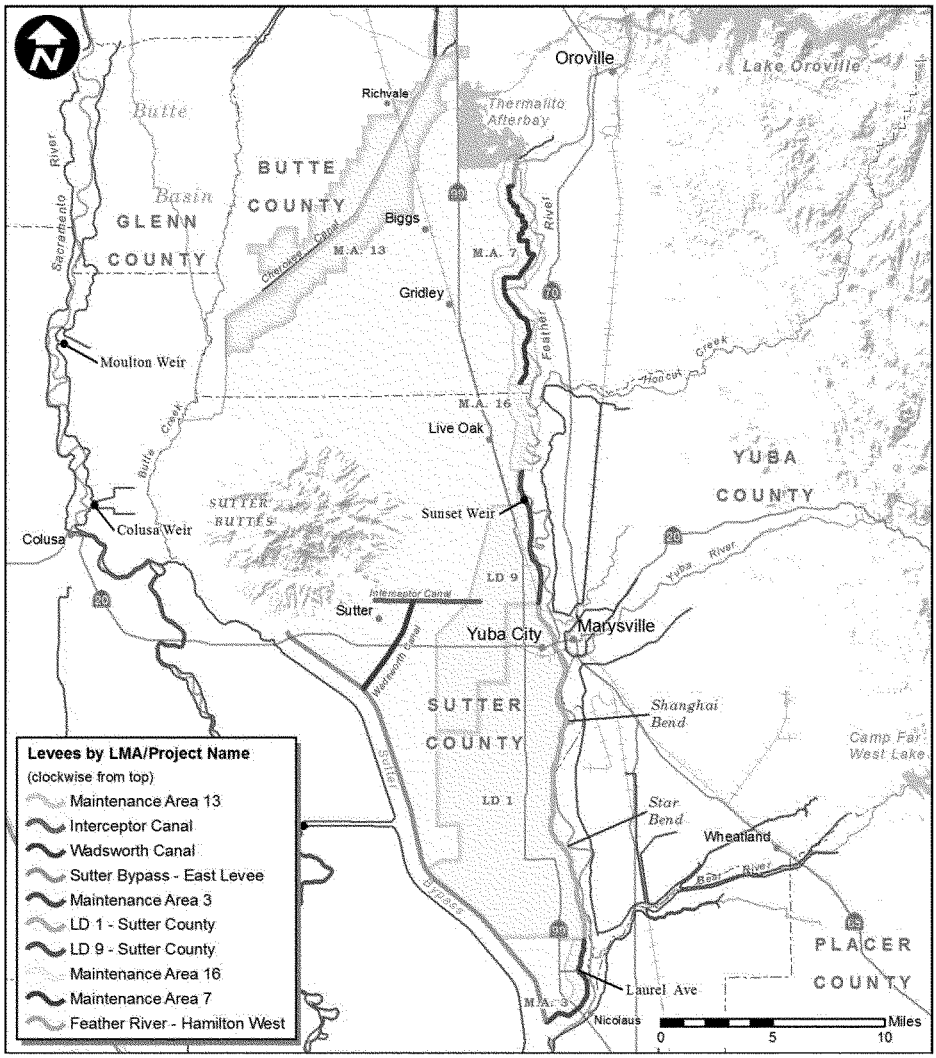


Plate 1-2. Study Area

The existing levees along the Feather River are set back some distance from the river channel, allowing for a wide band of riparian vegetation of up to 1 mile wide. Within this area, south of Yuba City, are the California Department of Fish and Wildlife's Feather River Wildlife Management Area, consisting of about 2,000 acres, and the Audubon Society's 300-acre Bobelaine Sanctuary. The Sutter National Wildlife Refuge operated by the U.S. Fish and Wildlife Service is located within and along the Sutter Bypass and consists of about 3,000 acres along about 20 miles of riparian channels on both sides of the interior of the bypass. The 11,869-acre Oroville Wildlife Area is primarily riparian woodland habitat along the Feather River and grasslands around the Thermalito Afterbay. The California Department of Fish and Wildlife operates Oroville Wildlife Area.

1.4 Study Sponsor and Participants

The non-federal project sponsors are the State of California Central Valley Flood Protection Board (CVFPB), formerly the State Reclamation Board, and the Sutter Butte Flood Control Agency (SBFCA). SBFCA is a joint powers agency formed in September 2007 by Sutter and Butte Counties, the Cities of Biggs, Yuba City, Gridley, and Live Oak, and Levee Districts 1 and 9 of Sutter County to finance and construct regional levee improvement projects. USACE originally executed a Feasibility Cost Sharing Agreement on March 20, 2000, with the Reclamation Board. The agreement was amended on July 10, 2010, to include both the CVFPB and SBFCA as non-federal sponsors.

1.5 History of Sutter Basin Investigations

The floods of 1986 and 1997 resulted in numerous levee failures within the Central Valley, including those of the SRFCP, and raised concerns about the adequacy of the existing levee system. In response, the State of California enacted the Central Valley Flood Protection Act in 2008 which, in part, provided for the evaluation of existing levees and the development of a strategic plan, known as the Central Valley Flood Protection Plan (CVFPP), to achieve new state standards for flood risk reduction throughout the Central Valley. Recognizing the urgent need to improve the existing flood protection system, the Act allows local urban flood improvement projects to be funded with state bond funds in advance of the CVFPP.

The devastating floods of 1986 and 1997 also prompted Sutter County and the CVFPB to request assistance from USACE to investigate alternatives to reduce future flood risks within Sutter County. The Sutter Basin Feasibility Study was initiated in 2000 with the CVFPB as the non-federal sponsor and Sutter County as the local sponsor. Initially, the study area was delineated by the political boundary of Sutter County. A Feasibility Scoping Meeting (FSM) was held in January 2005, but following the FSM, the study essentially became inactive due to local funding limitations and local efforts to clarify the area of immediate concern.

Federal Emergency Management Agency (FEMA) flood insurance rate remapping and California Senate Bill (SB) 5, which mandated the CVFPP (described in Section 1.7.3.1), sparked renewed local interest to address flood risk–reduction measures within the Sutter Basin. SBFCA was formed in 2007 as a joint powers agency by the Counties of Butte and Sutter, the Cities of Biggs, Gridley, Live Oak and Yuba City, and Levee Districts 1 and 9, with the authority to finance and construct regional levee improvements. In 2010, Sutter Basin voters passed a $6.65 million per year assessment to study and implement a project to reduce flood risks to the basin; the assessment rates are among the highest in the state. This action was a strong public endorsement of the need for immediate action to address the flood threat, particularly because the Sutter Basin is an economically disadvantaged community under California guidelines and has higher than average unemployment.

The initial Feasibility Cost Sharing Agreement for the Sutter Basin Feasibility Study was amended in July 2010 to add SBFCA as a non-federal sponsor and the study area was changed from the county boundary to an area that corresponds to the SBFCA boundary. In addition, SBFCA began to aggressively pursue a program to strengthen the existing levees to provide increased flood risk reduction to the Sutter Basin. SBFCA, in coordination with the CVFPB, is preparing design documents for construction of improvements to strengthen the existing levees. SBFCA intends to seek financial support from the California Department of Water Resources' (DWR's) Early Implementation Program (EIP). SBFCA plans to initiate construction in 2013 to advance completion of the Federal project that may be recommended and authorized as a result of the Sutter Basin Feasibility Study. SBFCA is also planning to request credit for any construction they complete prior to implementation of the Federal project under the provisions of Section 221 of the Flood Control Act of 1970, Public Law No. 91-611, Section 221, 84 Stat. 1831(1970) (hereinafter Section 221), as amended.

1.6 Pilot Study

The Sutter Basin Feasibility Study was one of the first studies selected for inclusion in the National Pilot Program in February 2011. The pilot initiative provides an opportunity to test principles that were developed by a workgroup of planning and policy experts from USACE and the Office of the Assistant Secretary of the Army for Civil Works (ASA[CW]), referred to as the 17+1 Team, for the purpose of modernizing the Civil Works Planning Program to better address the many water resource challenges facing the nation. The goal of the revised study paradigm is a more predictable and efficient process that significantly lessens the time required to complete a feasibility study.

The study process relies on sound professional engineering, economics, and environmental judgment and analyses, and focuses the amount and type of data collected and analysis on the risk and consequences of the decisions being made. Costs and benefit estimates used for the initial steps of the planning process are based on an appropriate level of detail for screening of draft alternatives to a final array of alternatives. For the SBPFS, the appropriate level of detail was selected considering that comparative cost estimates are more accurate than absolute cost estimates. The range of confidence in cost and benefit estimates is presented in the comparison of alternatives; however, only mean estimates are presented in the study. More detailed total cost estimates were prepared for the evaluation of the final array of alternatives leading to the identification of the RP.

The new study paradigm recognizes that no single factor, including net national economic development benefit, should provide the basis for the USACE decision for a recommendation for Federal investment. Alternative comparison and selection recognizes that there is no single "best" plan, and there are a variety of approaches (quantitative and qualitative) to multi-criteria decision making.

1.7 Related Projects and Studies

1.7.1 Sacramento River Flood Control Project

The history of the SRFCP dates back to the mid 1800's with the initial construction of levees along the Sacramento, Feather, Yuba, and American Rivers. The early history of the system was characterized by trial and error, with initial construction followed by a levee failure, followed by improvements (strengthening and/or raising), followed by another levee failure, etc. This continued until 1910, when the California Debris Commission produced a comprehensive plan for controlling

the floodwaters of the Sacramento River and its tributaries, known as the "Jackson Report." This comprehensive project was first authorized by the California Legislature in the Flood Control Act of 1911, which also established the California Reclamation Board. The California Reclamation Board was empowered to approve plans for the construction of levees along the Sacramento River or its tributaries or within any of the overflow basins. The comprehensive plan of improvement was authorized by the U.S. Congress in the Flood Control Act of 1917, Public Law No. 64-367, Section 2, 39 Stat. 948, 949-950 (1917), which authorized Federal participation with the State of California in construction of the flood control system.

Federal participation in the SRFCP began shortly after authorization in 1917 and continued for approximately 40 years. The completed flood control system was documented in 1957 in a design memorandum, referred to as the 1957 Profile, which included design water surface profiles based upon the flow characteristics of the flood events of 1907 and 1909. To this day, these are the profiles which govern the operations and maintenance requirements of the levee system. Table 1-1 provides the estimated mean annual chance of exceedance (ACE) for the design flows specified in each reach. The design flow changes at tributary inflows.

Table 1-1. SRFCP Authorized Design Flow Estimated Annual Chance of Exceedance

Stream & Reach	Authorized Design Flow (cfs)	Annual Chance of Exceedance
Feather River		
Oroville to Honcut Creek	210,000	0.4% (1/250)
Honcut Creek to Yuba River	210,000	0.4% (1/250)
Yuba River to Bear River	300,000	0.8% (1/125)
Bear River to Sutter Bypass	320,000	2% (1/50)
Sutter Bypass		
Meridian to Wadsworth Canal	150,000	2% (1/50)
Wadsworth Canal to Tisdale Weir	155,000	2% (1/50)
Tisdale Weir to Feather River	180,000	3% (1/70)
Feather River to Sacramento River	380,000	5% (1/25)
Wadsworth Canal		
Tributary Specific Storm Centering	1,500	30% (1/3)
Cherokee Canal		
Western Canal to Afton Road	11,500	5% (1/25)

cfs = cubic feet per second.

The SRFCP is designed to keep flows from frequent flood events within the river and convey and divert larger flows floods into the Yolo and Sutter bypass system. The Sutter Bypass, part of the SRFCP borders the study area on the southwest, receives flood flows from the Sacramento River, Feather River, and Butte Basin.

CVFPB is responsible for operations and maintenance of the SRFCP levees. Under the oversight of the CVFPB, the SRFCP levees within the Sutter Basin study area are maintained by three different local maintenance agencies: DWR, Sutter maintenance yard; Levee District 1; and Levee District 9. The levees are maintained in accordance with a Standard Operations and Maintenance Manual for the SRFCP prepared by USACE.

1.7.2 Upstream Reservoirs

The Oroville Dam and Reservoir, built in 1967 and operated by the State of California, is a unit of the Feather River Project, which is a part of the State Water Project. Oroville Dam is located on Feather River, a tributary of Sacramento River, in the Feather River Canyon, about 6 miles upstream from the town of Oroville. The dam was built for multi-purpose functions: water supply, flood control, power generation, recreation, and conservation. The reservoir provides water supply to the areas adjacent to the Feather River as well as additional water for diversions from Sacramento-San Joaquin Delta to areas in the San Joaquin Valley, San Francisco Bay Area, and Southern California. The 750,000 acre-feet flood control storage space in Oroville Reservoir provides flood protection to the cities of Marysville, Yuba City, Oroville, and many smaller communities located in the floodplain.

New Bullards Bar, built in 1969 and operated by the Yuba County Water Agency, is located on the Yuba River. It provides 170,000 acre-feet of flood control space. Operations at New Bullards Bar are coordinated with operations at Oroville to control flood flows on the Feather River. For both Oroville and New Bullards Bar, the flood control space was purchased under Section 7 of the Flood Control Act of 1944 (58 Stat. 890) by the Federal government. Any encroachment into the flood control space must be released during the flood season, as defined by the water control operations manual.

Flood control operations for the Feather River (as defined in the Oroville and New Bullards Bar Water Control Manuals) require Feather River flows to not exceed 150,000 cubic feet per second (cfs) at Oroville, 180,000 cfs above Yuba River, and 300,000 cfs below Yuba River. Insofar as possible, the Feather River below Bear River must be limited to 320,000 cfs. During very large floods, releases greater than 150,000 cfs at Oroville may be required, as indicated by the emergency operations, in order to minimize uncontrolled spillway discharges.

Given the unregulated local flows in the Feather River and Yuba River drainage areas as well as the uncertainties associated with regulating for downstream controls, the State, in cooperation with Yuba County Water Agency and USACE, has invested heavily in coordinating operations, including developing models, establishing off-site data servers, and holding annual mock operations scenarios.

1.7.3 Advance Work by Local Interests in Study Area

Non-federal interests have completed construction of a local project, and are actively pursuing a second, to strengthen the existing SRFCP levees in advance of construction of a Federally authorized project. These non-federal interests are seeking credit for the local work to be applied toward the local cost share of the Federal project. The two non-federal projects are discussed below.

As required by Section 14 of the Rivers and Harbors Act of 1899, 33 United States Code (U.S.C.) Section 408 (hereinafter Section 408) temporary or permanent alteration, occupation, or use of any public works, including levees, for any purpose is allowable only with the permission of the Secretary of the Army. Under the terms of Section 408, any proposed modification to an authorized Federal levee project, such as the existing levees in the study area that are part of the SRFCP, requires a determination by the Secretary that the proposed alteration, permanent occupation, or use of a Federal project will not be injurious to the public interest and will not impair the usefulness of the levee. The authority to make this determination and approve modifications to Federal works under Section 408 has been delegated to the Chief of Engineers, USACE.

Section 104 of the Water Resources Development Act (WRDA) of 1986, Public Law No. 104-303, Section104, 110 Stat. 3658 (1996) (hereinafter Section 104) and Section 221 provide authorization for non-federal sponsors to apply the cost of local advanced work to the required local contribution for the Federal project. Section 104 authorizes credit for local work accomplished prior to authorization of the Federal project, provided that the ASA(CW) has approved the proposed work prior to initiation of construction, and that the locally constructed work is compatible with the Federal project. Section 221 authorizes in-kind credit for local work accomplished after execution of an agreement with the ASA(CW). If the non-federal sponsors propose to undertake construction prior to execution of the Project Partnership Agreement (PPA), an in-kind memorandum of understanding (MOU) must be eluted; however, any work undertaken by a non-federal sponsor pursuant to an in-kind MOU is at its own risk and responsibility. Credit will be applied only in accordance with the PPA and only for local work that is determined to be integral to the authorized Federal project.

1.7.3.1 Star Bend Setback Levee Project

Levee District 1 has completed construction of 3,400 feet of setback levee along the Feather River in the vicinity of Star Bend, approximately 7 miles south of Yuba City, under DWR's EIP. EIPs are for the construction of projects that rehabilitate, reconstruct, replace, improve, or add to the facilities of the State Plan of Flood Control (SPFC). DWR provides bond funds to cost share for early implementation of State-Federal system modifications for FRM. The Star Bend Setback Levee Project replaced a critical section of the right bank of the Feather River levee system to address critical under-seepage and flow constriction issues, and returned about 50 acres of land to the floodplain. Construction was completed in 2010 at an estimated cost of $20,776,000. Levee District 1 received Section 408 approval for the project in June 2009. Section 104 credit consideration for the local project was approved by the ASA(CW) in June 2010, prior to initiation of construction.

In addition to providing for potential credit, Section 104 also has a significant effect on the study process and on the establishment of study parameters. The legislation and USACE implementation guidance (ER 1165-2-29) provide that the benefits and costs of potentially creditable local work must be considered in the economic evaluation of the potential Federal project. Thus, the identification and evaluation of project alternatives is to proceed without the consideration of the work performed by local interests; that is, the local work approved by the ASA(CW) for potential credit would be considered as a potential measure/alternative and would not be considered as part of the without-project condition.

1.7.3.2 Feather River West Levee Project

SBFCA is constructing levee improvements along the Feather River West Levee under DWR's EIP and has requested in-kind credit to be applied toward the non-Federal cost share of the Sutter Basin construction project in accordance with the provisions of Section 221 of WRDA 1998. The local Feather River West Levee Project (FRWLP) involves the construction of slurry walls, stability berms, and seepage berms to remediate the identified geotechnical problems, including under-seepage and embankment instability, for about 41 miles of the existing Feather River project levees from Thermalito Afterbay south to a point approximately 4 miles north of the Feather River-Sutter Bypass confluence. The FRWLP is a distinct project formulated independently and separate from the Federal Sutter Basin pilot project. The FRWLP is intended to advance the implementation of local flood risk–reduction measures in conjunction with implementation of a Federal project. Section 408

approval was granted for the first construction contract on July 19, 2013. In accordance with the requirements of ER 1165-2-208, an In-Kind MOU was executed on June 14, 2013, after identification of the RP (release of Draft Feasibility Report for public review) and prior to initiation of the local construction effort. The FRWLP has not been assumed as part of the without-project condition, but rather will be evaluated for potential in-kind credit.

1.7.4 Systemwide Studies

1.7.4.1 Central Valley Flood Protection Plan

California SB 5, the Central Valley Flood Protection Act (Act), required that DWR and the California Flood Protection Board (Flood Board) address flooding problems in the Central Valley and report to the Legislature in 2012 with updates every 5 years. This landmark legislation obligated the State and local governments to approach flood management in a much more holistic way. Importantly, the Act required that urban communities (communities with a population with 10,000 people or communities expected to have 10,000 people within 10 years) achieve a 200-year level of protection by 2016 or no new discretionary development entitlements may be granted. In the event that this performance objective cannot be achieved by 2016, the communities must certify they have made (and annually are making) adequate progress in implementation and will achieve the State's 200-year standard by 2025. The Act also required that DWR prepare maps showing areas subject to inundation in a 200-year event, and provide annual notices to all homes protected by levees to ensure homeowners understand their flood risk. Significantly, the Act also required that DWR prepare, and the CVFPB adopt, a CVFPP by July of 2012. This plan was to provide the framework for modification of and future investment decisions in the Central Valley's flood protection system. On June 29, 2012, the CVFPB did adopt the CVFPP which included a strategy for reducing the flood risk of the citizens of the Central Valley. The plan focuses on (i) urban areas obtaining at least 200-year protection through structural improvements, (ii) significant upgrades to system-wide facilities (such as bypasses) to add additional robustness and redundancies to the system, (iii) investment in small community systems (structural improvements or nonstructural improvements, such as home elevation) to achieve at least 100-year protection, (iv) spot repairs and operation and maintenance improvements for the rural areas of the Valley, and (v) investment to update emergency response and recovery plans.

One outgrowth of the CVFPP was the creation of six regional flood management planning areas in the Central Valley. The formal creation of these regions by DWR built upon existing regional collaboration and cooperation among local agencies to consider the many issues that connect the various protected basins, such as reservoir operations, bypass expansion, system modifications, habitat banks, and habitat conservation plans. The six regional planning areas (mid and upper Sacramento, lower Sacramento / Delta North, Feather River, lower San Joaquin / Delta South, mid San Joaquin, and upper San Joaquin) have received State grants in excess of $8 million to promote bottom-up regional flood management planning. While these plans will identify and prioritize potential structural and nonstructural improvements in the region, they also will make recommendations for operation and maintenance practices, operation and maintenance budgets, improved emergency response capabilities, and potential flood management organization consolidation to promote efficiencies. Importantly, these regional plans will reach beyond just the flood management agencies in each region, also including cities, counties, fire departments, police, environmental non-governmental organizations (NGOs), and other important stakeholders. Each of these planning efforts is to be completed in 2014, and the information from these efforts is to feed

into basin-wide feasibility studies and the 2017 update of the CVFPP, both of which are being prepared by DWR.

The CVFPP also includes a conservation framework. This framework is intended to integrate ecosystem mitigation, restoration, and enhancement, into multi-objective projects that will be constructed as part of the CVFPP. The strategy sets forth a series of measurable goals, and in order to help achieve those goals, DWR has begun offering grants to implement conservation projects. The first set of grants, totaling nearly $25 million, will allow for the creation of mitigation credits to be used for future flood damage reduction projects in the Valley. DWR has announced projects to be funded by these grants and the projects are spread throughout the Valley, offering opportunities to dovetail with existing and planned flood risk reduction projects.

Even before adoption of the CVFPP, DWR, the CVFPB, and local agencies understood the importance of specific structural improvements to protect high risk urban areas. As a result, DWR created the EIP Program, a State of California grant program which, when leveraged with local dollars, will result in nearly $1 billion worth of urban levee improvements in the Central Valley. Some of the more well-known projects under this program include the Natomas Levee Improvement Project, the West Sacramento Improvement Project, design of SBFCA's FRWLP and construction of urgently needed reaches, the Three Rivers Levee Improvement Program, and the Reclamation District (RD) 2103 / City of Wheatland Bear River Levee Improvement Project. Each of these projects is intended to promote structural improvements to levees to protect existing urban areas, and most acted as advanced construction for existing urban protection studies underway by USACE. While the EIP Program has sunsetted with the adoption of the CVFPP, DWR has recently announced the Urban Flood Risk Reduction (UFRR) Program, which is designed to continue to fund levee improvements to meet the State's 200-year flood protection requirements for urban areas. In addition, the California Legislature also enacted new laws giving the CVFPB new authorities for managing and enforcing encroachment standards on Federally-authorized levees, and is currently considering legislation that would further streamline that process.

1.7.4.2 Central Valley Integrated Flood Management Study

The Central Valley Integrated Flood Management Study (CVIFMS) is a continuation of the *Sacramento-San Joaquin River Basins, California Comprehensive Study*. The CVIFMS is intended to determine Federal interest and provide the Federal support for the CVFPP vision of improved FRM in the Central Valley. The study will provide parallel technical and policy support to the CVFPP study, basin-wide feasibility studies, and pertinent regional planning efforts where applicable. As part of the Planning Modernization Initiative, the study was re-scoped to reduce the focus to the Sacramento River Basin and the system-based improvement components proposed in the state systemwide investment approach.

1.8 Scope of the NEPA/CEQA Effect Analysis

As noted in Section 1.1, this report integrates into a single document both plan formulation and NEPA/CEQA effect assessment. As described in Section 1.7.2.2, the FRWLP is separate from but related to the SBPFS. The FRWLP is a local and State led project that is proposed by SBFCA to remediate the highest flood risk deficiencies for the urban portions of the Sutter Basin in advance of a potential Congressional authorization and appropriation of a Federal project. SBFCA is striving to initiate construction of the FRWLP in 2013.

In December 2012, USACE released for public review a Draft EIS/EIR for the FRWLP, State Clearinghouse No. 2011052062. The Draft EIS/EIR addressed SBFCA's proposal to construct the FRWLP. Following release of the Draft EIS/EIR, the NEPA and CEQA processes were separated and a stand-alone EIS and a stand-alone EIR were prepared. SBFCA has certified and adopted its Final EIR and filed a Notice of Determination. The Final EIS was circulated by USACE for 30-day public comment and a Record of Decision (ROD) was signed on July 19, 2013 which covered about 2 miles of work (Reach 13 of Contract C) proposed by SBFCA for construction in 2013. A second ROD was signed by USACE on September 13, 2013 covering the remaining portion of the project.

SBFCA is requesting permission from USACE pursuant to Section 408 for alteration of Federal project levees. SBFCA is also seeking a permit under Clean Water Act Section 404 for placement of fill in jurisdictional waters of the United States; and Section 10 of the Rivers and Harbors Act for work performed in, over, or under navigable waters of the United States. The FRWLP Final EIS addressed alternatives that are similar to those evaluated in this integrated report. For purposes of identifying the project proposed for Federal authorization, and because the FRWLP Final EIS analyzed a project whose reach and environmental impacts are similar to those of the SBPFS, the actions proposed in the FRWLP Final EIS have been supplemented to include work associated with the SBPFS, including an additional reach of levee improvements and impacts on vegetation. Consequently, this document supplements the analyses and conclusions reached by USACE in the FRWLP Final EIS.

Therefore, the scope of the NEPA/CEQA effect analysis in this document focuses on the additional effects that would result from Federal construction. Accordingly, this document is intended to supplement the analysis in the FRWLP Final EIS, incorporating by reference, where appropriate, information, analyses, and conclusions contained in the FRWLP Final EIS. This integrated EIR/SEIS will refer to the FRWLP Final EIS, as appropriate, to avoid unnecessary duplication.

Incorporation by reference is encouraged by both NEPA (40 CFR Section 1502.21) and CEQA (14 California Code of Regulations Section 15150) to eliminate repetitive discussions of the same issues. Council on Environmental Quality regulation 40 CFR Section 1502.21 states:

> Agencies shall incorporate material into an environmental impact statement by reference when the effect will be to cut down on bulk without impeding agency and public review of the action. The incorporated material shall be cited in the statement and its content briefly described. No material may be incorporated by reference unless it is reasonably available for inspection by potentially interested persons within the time allowed for comment.

Both NEPA and CEQA require citation to and a brief summary of the referenced material, as well as information about the public availability of the incorporated material. CEQA also requires citation of the state identification number of the EIRs cited.

The FRWLP Final EIS, where specifically noted, is summarized throughout this integrated EIR/SEIS. The FRWLP Final EIS is available on USACE's Web site at http://www.spk.usae.army.mil and SBFCA's Website at http://www.sutterbutteflood.org.

1.9 Planning Process and Report Organization

The planning process, which this Pilot Study followed, consists of six major steps: (1) specification of water and related land resources problems and opportunities; (2) inventory, forecast, and analysis of water and related land resources conditions within the study area; (3) formulation of alternative

plans; (4) evaluation of the effects of the alternative plans; (5) comparison of the alternative plans; and (6) selection of the RP based upon the comparison of the alternative plans.

This report is an integrated Pilot Feasibility Report, and EIR/SEIS. As such, it documents the six-step water resources planning process and meets the requirements of NEPA and CEQA to analyze and disclose potential environmental impacts and mitigation and to inform planning and decision-making. Table 1-2 documents how the USACE's planning process and the NEPA/CEQA process are coordinated. Those chapters or sections required by NEPA and CEQA are indicated by an asterisk in the Table of Contents. The chapter headings and order in this report generally follow the outline of an EIR/SEIS. The report chapters relate to the six steps of the planning process as follows:

- Chapter 2, *Need for and Objectives of Action*, covers the first step in the planning process (specification of water and related land resources problems and opportunities). It also covers the second step of the planning process (inventory and forecast) to the extent necessary to establish the future "without-project condition" prior to development of the alternatives.
- Chapter 3, *Plan Formulation*, is the heart of the report and is, therefore, placed before the more detailed discussions of resources and effects. It covers the third step in the planning process (formulation of alternative plans), the fifth step (comparison of alternative plans), and the sixth step (selection of the recommended plan based upon the comparison of the alternative plans).
- Chapter 4, *Affected Environment and Environmental Consequences*, covers the second step of the planning process (inventory, forecast and analysis of water and related land resources) in greater detail than what was provided in Chapter 2. Chapter 4 also covers the fourth step of the planning process (evaluation of the effects of the alternative plans).
- The remaining chapters discuss public involvement, review, and consultation (Chapter 5); describe compliance with applicable laws, policies, and plans (Chapter 6); present a description of the recommended plan (Chapter 7); present the study recommendation (Chapter 8); list the report preparers (Chapter 9); list the recipients of the draft feasibility report (Chapter 10); and list of references (Chapter 12). A list of acronyms and abbreviations and a glossary of terms precede Chapter 1. An index is found in Chapter 11.

Table 1-2. Comparison and Coordination of USACE Planning, Pilot Study Process, and NEPA/CEQA Processes

USACE Planning Process	Sutter Basin Pilot Study Milestones	NEPA/CEQA Process
Step 1. Identify Problems and Opportunities	Scoping Phase Decision Point 1: Federal Interest Decision	Publish Notice of Intent (NOI)/Notice of Preparation (NOP)[a]
Step 2. Inventory and Forecast		Conduct scoping process[b]
		Prepare Statement of Purpose and Need/Project Objectives Describe existing and future without-project conditions
Step 3. Formulate Alternatives	Analysis Phase Decision Point 2: Tentatively Selected Plan	Identify reasonable alternatives
Step 4. Evaluate Alternatives		
Step 5. Compare Alternatives		Evaluate impacts Develop mitigation
		Compare alternatives
Step 6. Select Alternative	Review Phase Decision Point 3: Civil Works Review Board	Draft EIR/SEIS: public notice and 45-day public review
	Confirmation Phase Decision Point 4: USACE Chief's Report ASA(CW) Transmits Chief's Report to OMB ASA(CW) Transmits Chief's Report to Congress Congressional Authorization	Final EIR/SEIS: respond to public comments
		Final EIR/SEIS: public notice and 30-day public review
		Record of Decision (ROD)/Notice of Determination (NOD)

Notes:
[a] On May 20, 2011, USACE published a NOI in the *Federal Register* (Vol. 76, No. 98) and SBFCA published a NOP with the State Clearinghouse.
[b] Public Scoping Meetings were held jointly by USACE and SBFCA for the SBFPS and FRWLP on June 27, 2011 and June 28, 2011.
ASA(CW) = Assistant Secretary of the Army (Civil Works).
OMB = Office of Management and Budget.

The USACE planning process follows the six-steps defined in *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implemental Studies*, also known as the Principles and Guidelines. The Principles and Guidelines were issued by the Water Resources Council on March 10, 1983 (ER 1105-2-100). This chapter describes the results of the first step of the planning process—the identification of problems and opportunities to be addressed by the Sutter Basin Pilot Feasibility Study (SBPFS). Planning objectives and constraints are also presented.

2.1 Problems and Opportunities

This section discusses the key problems and opportunities identified by the study team and concerned stakeholders.

2.1.1 Flooding Problems

Problem: A high risk of flooding from levee failure threatens the public health and safety of approximately 95,000 people residing within the study area.

The entire Sutter Basin study area receives flood risk management (FRM) benefits from the authorized Sacramento River Flood Control Project (SRFCP) and upstream reservoirs on the Sacramento, Feather, and Yuba Rivers. However, the study area remains at a high risk of flooding. From 1950 to 2011, 19 flood events required extensive flood fighting in the study area. The flood of 1955 resulted from a levee failure on the right bank of the Feather River just below Yuba City. Additional levee failures occurred during the floods of 1986 and 1997 on the Yuba, Feather, and Bear Rivers, which are adjacent to the Sutter Basin and have levees similar in construction to those surrounding the Sutter Basin. A discussion of historical flood events is in Section 4.2.2.4, *Historical Floods*.

The primary risk of flooding in the Sutter Basin has been determined to be geotechnical failure of the existing project levees and not hydrologic or hydraulic factors that result in levee overtopping. Recent geotechnical analysis and evaluation of historical levee performance during past flood events have resulted in a greater understanding of under-seepage and led to a revision of levee design criteria. Geomorphologic and geotechnical studies have identified subsurface features, such as former river channels, meanders, and oxbows. These features are likely to contain coarse-grained pervious soils (i.e., sands and gravels). The potential for seepage problems to occur along the existing levees in the project area is created by discontinuous layers of coarse-grained pervious soils. These soils are found in the study area at varying depths of up to 80 feet. During high-water events, water from the river can enter the pervious soil layers and then move laterally through these layers and under the levee. Excessive seepage can erode soil within the levee and lead to a rapid collapse and subsequent breach. Historically, foundation conditions were evaluated assuming homogeneous materials, but the floods of 1986 and 1997 and the resulting levee failures throughout the Central Valley resulted in a revision of the criteria for the evaluation of under-seepage. The risk of levee failure is not due to design deficiency or to lack of O&M of the existing levees, but to a better understanding of the mechanics of under-seepage in the Central Valley.

The project levees within the study area do not meet current USACE levee design criteria and are at risk of breach failure at stages considerably less than levee crest elevations. This is evidenced by historical levee boils and heavy seepage at river stages less than design flows. Table 2-1 summarizes

the estimated performance of the existing levees with and without geotechnical fragility (the risk of poor geotechnical performance of the levee at a given water surface elevation or flood frequency) to show the significance of the geotechnical condition of the levees in overall levee performance.

Table 2-1. Performance of Existing Levees

Median Flood Frequency	Assurance[a] with Fragility	Assurance[a] without Fragility
Upper Feather River (Index Point FR8.0R)		
10% (1/10)	0.82	0.99
1% (1/100)	0.58	0.99
0.5% (1/200)	0.48	0.86
Lower Feather River and Sutter Bypass (Index Point FR3.0R)		
10% (1/10)	0.94	0.99
1% (1/100)	0.84	0.99
0.5% (1/200)	0.68	0.80

[a] Assurance is the probability that a given flood event will not result in levee failure.

Various without-project levee breach scenarios were developed and evaluated to determine the inundation area for flood events of different magnitudes within the study area. Plate 2-1 is a summary, or composite, of the 10% (1/10) Annual Chance Exceedance (ACE) inundation areas for the entire study area from all evaluated breach locations that have less than a 90% reliability for a given mean annual exceedence event (in this case 10%). While this floodplain is larger than would likely be seen in a single flood/breach event, it is meant to represent the relative residual risk for the area from all remaining breach locations. Plate 2-1 shows that the Sutter Basin is subject to a high risk of flooding. Major urban centers of Yuba City, Biggs, Gridley, and Live Oak are subject to being inundated during a 10% (1/10) ACE event and are considered at high flood risk, as are most of the identified evacuation routes in the study area.

Geotechnical issues, such as under-seepage breach failures, result in large volume flood flows at high velocities that are sudden and unpredictable. These failures allow for minimal warning time and minimal time for effective implementation of evacuation and emergency plans. Study area flood events generally occur during the winter months when cold air and water temperatures significantly increase the risk of death by exposure. The risk probability of unexpected levee failure coupled with the consequence of basin-wide flooding presents a continued threat to public safety, property, and critical infrastructure in the Sutter Basin.

Problem: Urban and rural areas within the Sutter Basin are subject to damages from flooding.

As shown in Figure 2-1, the topographic surface elevations (excluding the high ground of Sutter Buttes) range from 110 feet North American Vertical Datum of 1988 (NAVD88) in the northeast to 30 feet NAVD88 in the southwest, creating deep floodplain pooling in the southern basin.

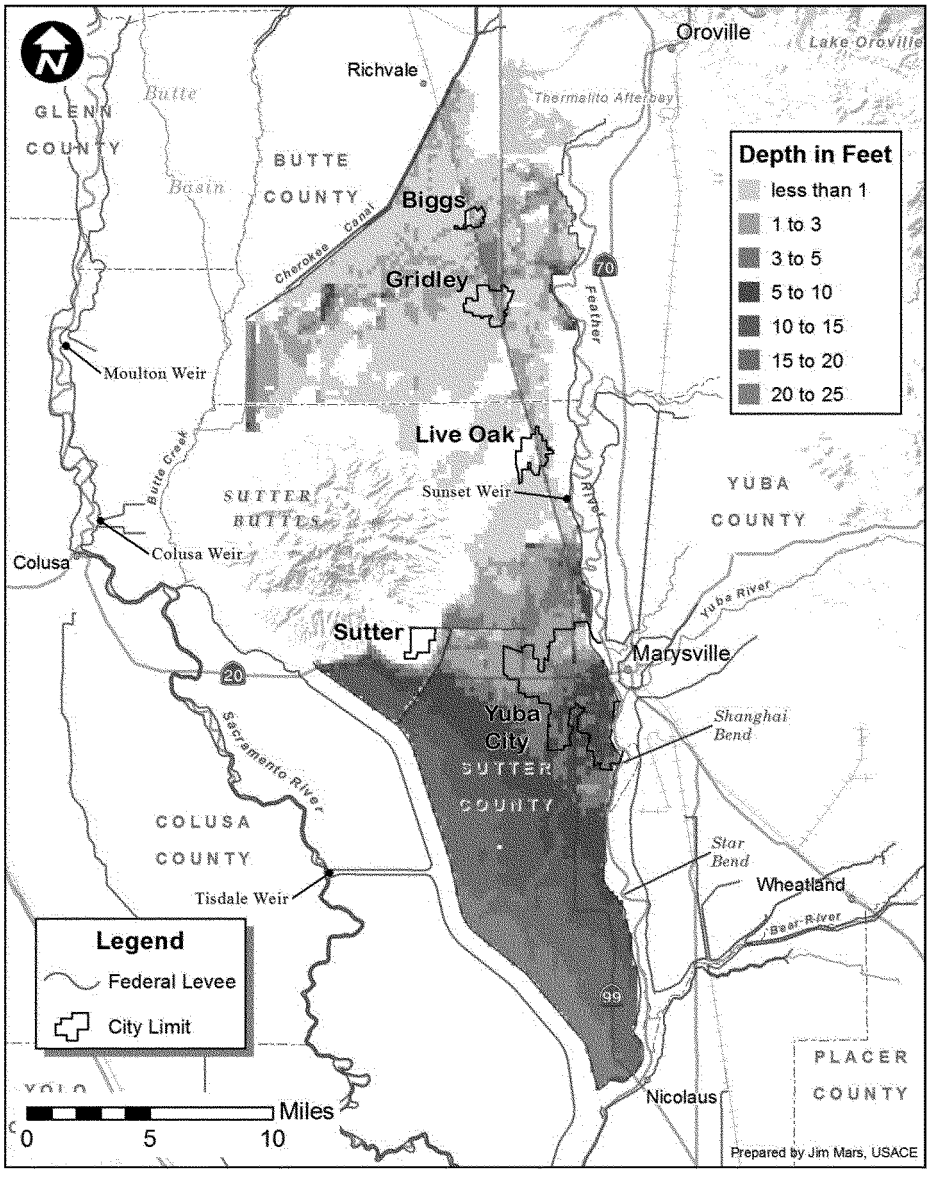
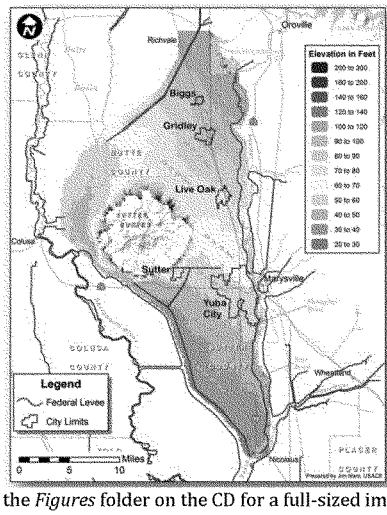


Plate 2-1. 10% (1/10) ACE Composite Floodplain



(See the *Figures* folder on the CD for a full-sized image.)

Figure 2-1. Sutter Basin Topography

As discussed previously, multiple levee breach scenarios were modeled along the Feather River and Sutter Bypass to assist in the analysis of the study problems. Floodplains resulting from levee breaches differ significantly in nature depending on the location of the breach (Figure 2-2). Simulated breaches along the northern portion of the Feather River flood the northern basin in a shallow northeast to southwest flooding flow. Breaches from the Sutter Bypass and southern most portion of the Feather River only flood the deeper southern basin and do not affect the northern half of the basin. Figure 2-3 shows the composite 1% ACE floodplain for the Sutter Basin.

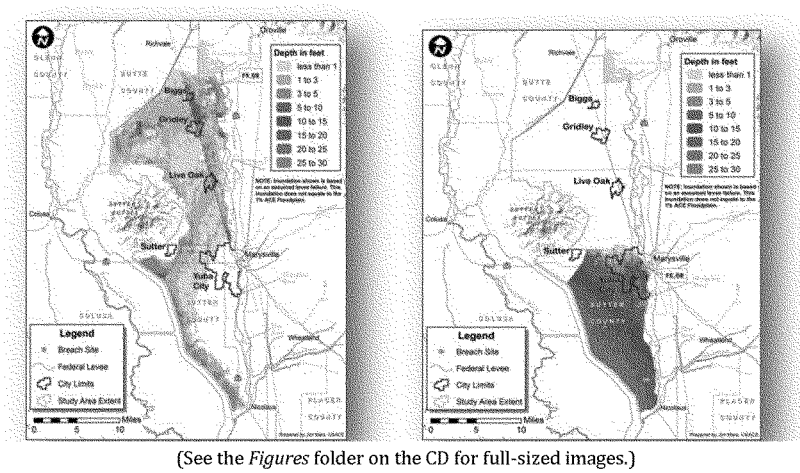


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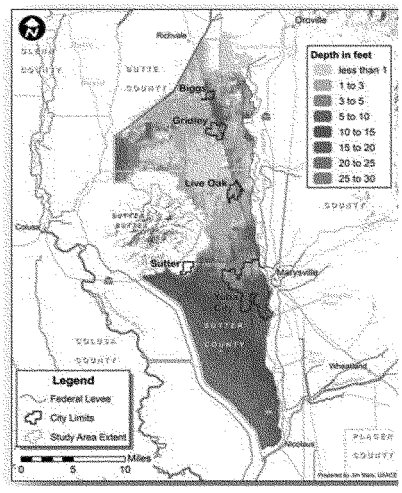
Figure 2-2. Simulated Levee Breach Scenarios, 1% ACE event



(See the *Figures* folder on the CD for a full-sized image.)

Figure 2-3. 1% ACE Without-Project Floodplain

Based on the 2010 Census, the population of the Sutter Basin is estimated to be 95,360 and distributed as shown in Table 2-2.

Table 2-2. Population within Study Area

Economic Impact Area	Population
Town of Sutter	250
Yuba City Urban	67,370
Biggs Urban	1,760
Gridley Urban	6,380
Live Oak Urban	8,360
Sutter County Rural	6,340
Butte County Rural	4,900
TOTAL	**95,360**

An economic inventory was assembled following standard USACE methods. For the study area, a base geographic information system (GIS) inventory with parcel attribute data was provided by the local sponsor for both Sutter and Butte Counties. Field visits were conducted to collect and validate the base inventory data. Parcels with structures were categorized by land use and grouped into residential, commercial, industrial or public categories. The value of damageable structures was estimated based on depreciated replacement values. The total value of the existing damageable property (structures and contents) within the Sutter Basin study area is estimated at $7.0 billion (October 2013 prices) as shown in Table 2-3. Table 2-4 displays the structural inventory by land use category. Total study area without-project expected annual damages are approximately $137 million.

Table 2-3. Value of Damageable Property (Values in $1,000's)

Economic Impact Area	Structures and Contents within 0.2% (1/500) ACE Floodplain				
	Commercial	Industrial	Public	Residential	TOTAL
Biggs	6,700	2,400	0	75,700	84,800
Gridley	73,200	52,6000	3,600	290,900	420,300
Live Oak	26,000	3,800	42,600	324,500	396,900
Yuba City	1,070,000	423,800	339,200	3,645,300	5,478,300
Rural Butte County	4,000	46,400	0	203,200	253,600
Rural Sutter County	9,100	40,200	18,800	279,000	347,100
TOTAL	**1,189,000**	**569,200**	**404,200**	**4,818,600**	**6,981,000**

Table 2-4. Structural Inventory–Existing Conditions

Economic Impact Area	Number of Structures within 0.2% (1/500) ACE Floodplain				
	Commercial	Industrial	Public	Residential	TOTAL
Biggs	18	1	0	586	605
Gridley	81	7	4	1,931	2,023
Live Oak	51	5	23	2,088	2,167
Yuba City	872	210	122	18,760	19,964
Town of Sutter	0	0	0	0	0
Rural Butte County	10	16	0	1,242	1,268
Rural Sutter County	10	29	8	1,162	1,209
TOTAL	**1,042**	**268**	**157**	**25,769**	**27,236**

The December 1955 flood was the most damaging flood recorded to date in the basin, based on loss of lives and damages. Simultaneous peaks occurred on the Feather and Yuba Rivers, with the peak flow on the Feather River at Oroville gage estimated at 230,180,000 cubic feet per second (cfs), and a peak flow of about 155,000 cfs measured at the Marysville gage on the Yuba River. There was no upstream dedicated flood storage at Oroville Dam and Reservoir on the Feather River or at New Bullards Bar Dam and Reservoir on the Yuba River at the time of the event because those facilities had not been constructed yet. At midnight December 24, the right bank Feather River levee at Yuba City had a geotechnical failure about 2 miles downstream of the mouth of the Yuba River at Shanghai Bend (Figure 2-4). This event is illustrative of the limited warning time preceding geotechnical levee failures. The levee failure was preceded by the Governor of the State of California issuing a "State of Emergency" on December 22 due to the abnormal and heavy rainfall. However, the general evacuation order was given approximately 1 hour after the levee break. The left bank levee of the Feather River also broke near Nicolaus. Marysville's levees were threatened. The resulting flooding inundated about 100,000 acres of land, including 95% of Yuba City. Thirty-eight people were killed in the Yuba City area, and two were killed in the Nicolaus area. About 3,300 homes were flooded; 6,000 cattle were killed; and more than 30,000 people were evacuated and rescued. Flood damage was estimated at $50.5 million (1955 dollars). The flooded communities and lives of thousands of residents were disrupted for several months as the basin recovered from the flood.

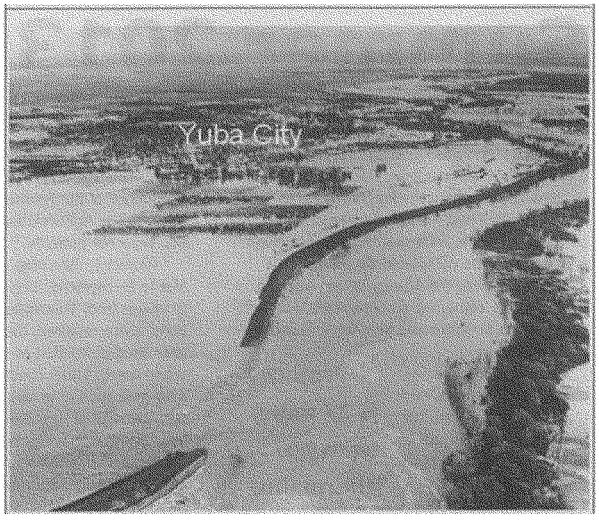


Figure 2-4. 1955 Levee Failure at Shanghai Bend

The 1986 event consisted of a closely spaced series of large storms. On February 20, while the Feather and Yuba Rivers were receding, a section of levee near the community of Linda had a geotechnical failure. About 24,000 people were evacuated. One person died; 32 people were injured; 855 homes and 150 businesses were destroyed; and 3,000 homes and 150 businesses were damaged. Flood damages were estimated at $95 million in 1986 dollars.

The January 1997 flood was the largest in northern California since measured records began in 1906. The flood was notable in the sustained intensity of rainfall, volume of floodwater, and areal extent—from the Oregon border to the southern end of the Sierra Nevada. Over the 3-day period around New Year's Day, warm moist winds from the southwest blowing over the Sierra Nevada poured more than 30 inches of rain onto watersheds that were already saturated by one of the wettest Decembers on record. Levees throughout the SRFCP sustained moderate to heavy damage. A geotechnical-related break in the left bank Feather River levee near the community of Arboga occurred on January 2, 1997, prompting the evacuation of about 15,000 people from Linda and Olivehurst. Nearly 50,000 inhabitants of Yuba City, Marysville, and surrounding areas were evacuated because of fears over possible additional levee failures. Two additional breaks did occur on the right bank of the Bear River near the State Route 70 bridge outside the study area.

2.1.2 Opportunities

Opportunity: Reduce the risk of flooding and flood damages through the least environmentally damaging structural or non-structural method.

There is an opportunity to reduce the risk to public safety and damages caused by flooding from the Feather River and the Sutter Bypass.

Opportunity: Reduce the residual risk to public health and safety by structural or non-structural methods.

There is an opportunity to reduce the risk to public health and safety through the protection of critical health and safety infrastructure.

Opportunity: Sustain and improve aquatic, riparian, and adjacent terrestrial habitats in conjunction with FRM features.

There is an opportunity to sustain and improve floodplain habitats along existing water courses in conjunction with FRM features.

Opportunity: Provide public access and use, and improved outdoor recreational experiences in conjunction with FRM features.

There is an opportunity to provide increased public access to additional habitat areas established in conjunction with FRM features.

2.2 Objectives and Constraints

2.2.1 Federal Objectives

The policy of the United States, as set forth in Section 2031 of the Water Resources Development Act (WRDA) of 2007, Public Law No. 110-114, §2031, 121 Stat. 1041 (2007), is that all Federal water resources investments shall reflect national priorities, encourage economic development, and protect the environment by:

1. seeking to maximize sustainable economic development;
2. seeking to avoid the unwise use of floodplains and flood-prone areas and minimizing adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used; and
3. protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems.

In consideration of the many competing demands for limited Federal resources, it is intended that Federal investments in water resources as a whole should strive to maximize public benefits, with appropriate consideration of costs. Public benefits encompass environmental, economic, and social goals, include monetary and nonmonetary effects, and allow for the consideration of both quantified and unquantified measures.

The Federal objective is not specific enough for the development of a water resource project. The formulation of alternative plans requires the identification of study-specific planning objectives.

2.2.2 Non-Federal Objectives

The State of California, recognizing the continuing risk of flooding within the Central Valley, has enacted the Central Valley Flood Protection Act (CVFPA) and related legislation that establishes in California law the objective of providing 200-year (1/200 or 0.5% annual exceedance probability) protection to urban and urbanizing areas. Additionally, the CVFPA requires an immediate analysis of

the condition of the system levees, an action plan for achieving the desired level of protection, and associated actions to reduce residual risks to development within the protected area.

In addition to complying with the state requirement, the non-federal sponsors seek to reduce residual risk to the rural south portion of the Sutter Basin for sustainable high-value agricultural operations.

2.2.3 Planning Objectives

Planning objectives for the SBPFS are more specific than the Federal and non-federal objectives and reflect the problems and opportunities in the study area; an objective is developed to address each of the identified problems and opportunities. Planning objectives represent desired positive changes to the future without-project conditions. All of the objectives focus on activity within the study area and within the 50-year period of analysis.

The planning objectives are:

- Reduce the risk to life, health, public safety and critical infrastructure due to flooding.
- Reduce the risk of property damage due to flooding.
- In conjunction with FRM, improve ecosystem functions and values including restoration of conductivity of historic floodplains.
- In conjunction with FRM, and associated with improving ecosystem functions and associated habitat, improve the public's access to and use of outdoor recreational opportunities.

2.2.4 Planning Constraints

A planning constraint is a restriction that limits the extent of the planning process. It is a statement of things the alternative plans must avoid. Constraints are designed to avoid undesirable changes between future without- and with-project conditions.

The planning constraints are:

- Minimize adverse hydraulic effects where they could result in economic damage to other areas.
- Minimize significant adverse effects on the human environment.
- Comply with all applicable Federal laws, regulations, and policies, including Executive Oder 11988.
- Section 308 of WRDA of 1990 prohibits the inclusion of damages to structures built in the Federal Emergency Management Agency (FEMA) regulated floodplain after 01 July 1991 in the economic analysis.

2.3 Critical Assumptions Affecting Development of Future Without-Project Conditions

The future without-project condition (NEPA/CEQA No Action) is the most likely condition expected to exist in the future in the absence of a proposed water resource project. The future without-project condition defines the benchmark against which the alternative plans are evaluated. These forecasts of future conditions are from the base year (year when a project is expected to be operational) to the end of the period of analysis (50 years). Future without-project conditions for this study are

projected assuming a base year of 2023 and a 50-year period of analysis out to 2073. If no action is taken, the geotechnical condition of the levees within the study area will slowly deteriorate in the future. Every major flood event causes internal erosion of foundation soils, which weakens the levee foundation if it is not remediated after the flood. Drainage and utility lines crossing the levee will corrode, eventually resulting in failure if the lines are not replaced or rehabilitated. This slow deterioration is not quantifiable under existing guidance for the production of geotechnical levee fragility curves, so the existing geotechnical levee conditions, as given by the existing condition levee fragility curves, is assumed to continue into the future. While most of the documentation of the inventory and forecast of affected resources is in Chapter 4, *Affected Environment and Environmental Consequences*, some critical assumptions that affect the plan formulation are discussed below.

- If no action is taken, the existing performance characteristics of the project levees were assumed to remain the same over the period of analysis.
- Ongoing levee maintenance will result in no change to geotechnical conditions and levee performance curves.
- Oroville and New Bullards Bar Reservoirs on the Feather and Yuba River systems, respectively, will continue to be operated using the existing rule curves.
- Vegetation and topographic conditions within the channel are expected to remain the same as existing conditions.
- Fish and wildlife areas in the study area are not anticipated to substantially change in acreage or natural floodplain values over the period of analysis.
- Economic analysis assumes the future without-project condition is equal to existing conditions (NEPA/CEQA baseline) because any future development would take place above the 1% ACE floodplain boundary.
- The 2012 Central Valley Flood Protection Plan (CVFPP) includes only general recommendations for systemwide improvements, not specific project recommendations. Therefore, the 2012 CVFPP recommendations have not been included in the future without-project condition.

The plan formulation process, encompassing the six-step planning process, develops and evaluates alternative plans to address specific planning objectives. These planning objectives and the determining of the Federal interest, which are consistent with the Federal Water Resources Council's Principles and Guidelines and the Planning Guidance Notebook (ER-1105-2-100), guide the planning process to a recommendation of a tentatively selected plan (TSP). The plan formulation process for the Sutter Basin Pilot Feasibility Study (SBPFS) followed a multi-criteria method based on risk-informed decision making, existing data and available information, and coordinated professional judgment.

3.1 Flood Risk–Management Measures

3.1.1 Management Measures Strategy and Development

After the identification of the problems and objectives, a broad array of management measures consisting of flood risk management (FRM), associated ecosystem restoration, and associated recreation opportunities was developed. These measures were based on existing reports and studies, local sponsor information, public input, risk assessment, and professional judgment. The Sutter Basin is protected by project levees that are part of the Sacramento River Flood Control Project (SRFCP). The SBPFS limits its focus to those project levees that provide FRM to the study area, acknowledging that statewide FRM programs such as the Central Valley Flood Protection Plan (CVFPP) are studying system approaches. Initial measures considered a wide range of both nonstructural improvements (e.g., ring-levees around structures, elevations of buildings, relocation) and structural actions (e.g., levee improvements, bypass improvements, reservoir operations) for FRM solutions. The following list provides a summary and general categorization of management measures that were considered.

- Structural FRM Measures
  - Biggs Ring Levee
  - Gridley Ring Levee
  - Live Oak Ring Levee
  - Yuba City Ring Levee
  - Fix-in-Place Feather River West Levee from Thermalito to Shanghai Bend
  - Southern Portion of J-levee
  - Fix-in-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee
  - Butte Bypass
  - Nelson Slough Sediment Removal at Sutter Bypass and Feather River Confluence
  - Southern Relief Structure
  - Modify Fremont Weir

- Reoperation of Oroville Dam and Reservoir (Feather River)
- Increased Flood Storage in Shasta and Black Butte Reservoirs Upstream of Sutter Bypass
- Authorized Marysville Reservoir (South Yuba River)
- Feather River Dredging
- Modify Pumps along Sutter Bypass
- Cherokee Canal Sediment Removal
- Sunset Weir Modification
- Gilsizer Cross Levee with Flap Gates
- Wadsworth Canal Tributary Drainage
- Managed Overtopping (Levee Superiority) on Feather River and Sutter Bypass
- Sutter Bypass Sediment Removal

- Structural FRM Measure with Associated Ecosystem Restoration
  - Sutter Bypass Setback Levee
  - Northern Feather River Setback Levee
  - Sutter Bypass and Feather River Confluence Setback Levee
  - Star Bend Setback Levee
  - Oroville Wildlife Area – Degrade Land Surface and Restore Wetlands
  - Improve Upstream Fish Passage in Sutter Bypass (Remove Fish Passage Barriers)
  - Vegetation Management in Lower Feather River
  - Vegetation Management in Upper Feather River
  - Vegetation Management in Sutter Bypass
- Nonstructural Measures (some overlap with other measures)
  - Relocate Structures and Critical Infrastructure in Floodplain
  - Floodproof Isolated Locations
  - Elevate Structures and Transportation Infrastructure
  - Establish Flood-Resistant Housing
  - Secure Large Floatable Objects
  - Flood Warning System
  - Evacuation Plan
  - Construct Ring Levees at Isolated Locations
  - Flood Fight Pre-Staging Equipment and Supply Area
- Recreational Measures (associated with ecosystem restoration and FRM measures)
  - Multi-Use Trails

- Bicycle Trails
- Equestrian Trails
- Day Use Area
- River Access
- Scenic Overlook
- Recreational Parkway

3.1.2 Management Measures Screening

These management measures were initially screened as part of a critical thinking Charette (workshop). The Charette Team consisted of the Project Delivery Team (PDT), non-federal sponsors, the Vertical Team (composed of representatives of the USACE local, district, division, and headquarters levels of review and approval authority), and the National Pilot Program 17+1 Team (the original pilot study program development team). The Charette Team reviewed each measure, identified additional measures, and then evaluated the measures based on study objectives, study constraints, and Water Resources Council Principles and Guidelines criteria. The Charette Team screened whether each measure should be retained or dropped from further consideration. Of the initial 46 measures that were evaluated, 32 were retained to assist in the development of conceptual alternatives (Table 3-1).

Initial geotechnical and hydraulic analysis, along with analysis of historical records of flood events, indicated that geotechnical failure of existing levees is the most significant FRM issue in the Sutter Basin. Under-seepage can cause existing levees to breach. Because several levee breach scenarios demonstrated the extent of impacts on associated residual floodplains, management measures were mostly screened to focus on fixing existing levees or constructing new levees, especially along the Feather River West Levee sections.

The formulation strategy for screening and analysis of measures developed four management themes (strategies) aligned to the study objectives to focus the plan formulation and the development of conceptual alternatives.

- Theme 1: Consequence management focused on public safety
- Theme 2: Urban FRM focus
- Theme 3: Maximize existing system with FRM focus
- Theme 4: Ecosystem emphasis

These themes were used to assist in formulating an array of conceptual alternatives by grouping measures according to their primary focus of theme. Table 3-2 shows how the measures were grouped and screened into themes and conceptual alternatives.

The majority of these screened conceptual alternatives were composed of new levees or strengthening (fix-in-place) existing levees. To further refine and screen these conceptual alternatives, parametric quantities, costs, and economic benefits were developed.

Table 3-1. Summary of Management Measures and Screening

Measure	Measure Description	Retained	Dropped	Primary Reason(s) for Dropping Measure
Biggs Ring Levee	Construct ring levee around highly developed area of Biggs.	X		
Gridley Ring Levee	Construct ring levee around highly developed area of Gridley.	X		
Live Oak Ring Levee	Construct ring levee around highly developed area of Live Oak.	X		
Yuba City Ring Levee	Construct ring levee around highly developed area of Yuba City.	X		
Fix-in-Place Feather River West Levee from Thermalito to Shanghai Bend	Fix-in-place Feather River West Levee from Thermalito to Shanghai Bend.	X		
Southern Portion of J-Levee	Construct southern portion of J-Levee. This measure would prevent potential levee failures on Sutter Bypass or Feather River downstream of Shanghai Bend from backing up into Yuba City. However, if a failure occurred upstream of Shanghai Bend, the measure would increase flood depths in Yuba City by ponding floodwater behind the J-levee.	X		
Fix-in-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee	Fix-in-place existing Feather River West Levee from Shanghai Bend to Sutter Bypass, Sutter Bypass East Levee, and Wadsworth Canal Levee.	X		
Butte Bypass	Construct a 1,400-foot-wide bypass from Feather River to Butte Basin.		X	This measure would need to be combined with an increase in capacity of the Sutter Bypass and additional easements, which is a system approach being studied under the CVFPP. This measure would also require a fix-in-place levee. Additional engineering improvements along Feather River and Sutter Bypass and/or a ring levee would be needed before this measure would be effective.

Measure	Measure Description	Retained	Dropped	Primary Reason(s) for Dropping Measure
Sutter Bypass Setback Levee	Construct a 500-foot long setback levee along Sutter Bypass.	X		
Northern Feather River Setback Levee	Construct a 5.3-mile-long setback levee.	X		
Sutter Bypass and Feather River Confluence Setback Levee	Construct a 2.1-mile-long setback levee near the Feather River and Sutter Bypass confluence.	X		
Star Bend Setback Levee	Construct a 0.8-mile-long setback levee at Star Bend.	X		
Oroville Wildlife Area – Degrade Land Surface and Restore Wetlands	Degrade the land surface and restore wetlands.	X		
Nelson Slough Sediment Removal at Sutter Bypass and Feather River Confluence	Remove sediment upstream from Nelson Slough rock weir.		X	This measure would provide only a minor hydraulic benefit. The benefit would be temporary because this area would continue to have sediment deposition. This measure would result in high operations and maintenance costs, along with potential increased costs related to hazardous, toxic and radioactive waste concerns.
Southern Relief Structure	Construct a relief structure in the levee at the south end of Sutter Basin. If a levee were to fail upstream this downstream gate or fuse plug type feature would be used to convey floodwaters back into the Feather River and Sutter Bypass channel. In a levee breach scenario this may reduce peak flood stages in the southern basin, resulting in fewer structures being flooded in the Yuba City area.	X		
Modify Fremont Weir	Modify Fremont Weir to reduce flood stages in the study area.		X	This measure would not reduce the water surface elevations enough to reduce the under-seepage problem occurring with the existing levee.
Reoperation of Oroville Dam and Reservoir (Feather River)	Offset approximately 100,000 acre-feet of water supply for flood control storage space in Oroville Reservoir.		X	This measure was dropped because fixes to the existing levee would still be required. This measure provides limited benefits downstream. Other listed measures would provide more efficient means to achieve comparable performance.

Measure	Measure Description	Retained	Dropped	Primary Reason(s) for Dropping Measure
Increased Flood Storage in Shasta and Black Butte Reservoirs Upstream of Sutter Bypass	Offset approximately 1,460,000 acre-feet of water supply in Shasta Reservoir and 674,000 acre-feet in Black Butte Reservoir for flood control storage space.		X	Based on the Sacramento-San Joaquin Comprehensive Study results, this measure was found to have almost no impact on flood stages in the study area.
Authorized Marysville Reservoir (South Yuba River)	Marysville Reservoir is a USACE authorized project that has not been constructed. Marysville Reservoir would be located on the Yuba River just upstream of the city of Marysville and downstream from New Bullards Bar and Englebright dams.		X	This measure is considered cost-infeasible in terms of costs exceeding any benefits. Further this measure has major environmental impacts due to deep foundation problems and construction challenges.
Feather River Dredging	This measure consists of dredging the Feather River from Oroville to the mouth of Sacramento River.		X	This measure was dropped from further consideration because it does not fix the under-seepage problem occurring within the existing levee. This measure also results in high costs due to ongoing operation and maintenance and land acquisition. In addition, there are environmental concerns with mercury and heavy metals.
Modify Pumps along Sutter Bypass	Reduce or eliminate flooding due to ponding of excess floodwaters in the southwestern portion of the study area.		X	This measure does not fit within the study objectives. The study objectives do not focus on interior drainage.
Cherokee Canal Sediment Removal	Remove sediment that may have accumulated in the Cherokee Canal.		X	Canal maintenance is the responsibility of the California Department of Water Resources. There are other ongoing efforts to address sediment removal in the Cherokee Canal.
Sunset Weir Modification	Modify a hydraulic structure in the Feather River that is used to divert water into an irrigation canal.	X		
Gilsizer Cross Levee with Flap Gates	Construct a new levee across the Sutter Basin from Star Bend on the Feather River to Pumping Plant No. 2 on the Sutter Bypass. The areas to the north and south of the new levee would have different residual flood probability.	X		
Wadsworth Canal Tributary Drainage	Increase the capacity of Wadsworth Canal to accommodate additional runoff.	X		

Measure	Measure Description	Retained	Dropped	Primary Reason(s) for Dropping Measure
Managed Overtopping (Levee Superiority) on Feather River and Sutter Bypass	Increase the resilience of the existing levee system by providing designated overtopping locations similar to spillways.	X		
Improve Upstream Fish Passage in Sutter Bypass (Remove Fish Passage Barriers)	Identify and remove fish passage barriers in the Sutter Bypass.	X		
Sutter Bypass Sediment Removal	Remove sediment that may have accumulated in the Sutter Bypass.		X	This measure is considered maintenance. Maintenance is outside of this study's scope and is the responsibility of the California Department of Water Resources.
Vegetation Management in Sutter Bypass	Manage vegetation that affects flood stages within the Sutter Bypass.		X	This measure is considered maintenance. Maintenance is outside of this study's scope and is the responsibility of the California Department of Water Resources.
Vegetation Management in Lower Feather River	Manage vegetation that affects flood stages within the Lower Feather River.		X	This measure is considered maintenance. Maintenance is outside of this study's scope and is the responsibility of the California Department of Water Resources.
Vegetation Management in Upper Feather River	Manage vegetation that affects flood stages within the Upper Feather River.		X	This measure is considered maintenance. Maintenance is outside of this study's scope and is the responsibility of the California Department of Water Resources.
Relocate Structures and Critical Infrastructure in Floodplain	Move structures and critical infrastructure away from floodplains.	X		
Floodproof Isolated Locations	Residential structures and other buildings would be evaluated for potential damages from floodwater entering the structure. Floodproofing techniques would be selected on a case-by-case basis.	X		
Elevate Structures and Transportation Infrastructure	Elevate structures, railroads, and highways.	X		

Measure	Measure Description	Retained	Dropped	Primary Reason(s) for Dropping Measure
Establish Flood-Resistant Housing	Construct flood-resistant housing.	X		
Secure Large Floatable Objects	Objects that might be mobilized and strike people during a flood event would be removed, relocated, or secured.	X		
Flood Warning System	Develop, establish and implement a system for warning the public about potential flood events.	X		
Evacuation Plan	Coordinate with local entities to establish and implement a plan for evacuation during a flood event.	X		
Construct Ring Levees at Isolated Locations	Construct ring levees around structures that are subject to damage from floodwaters.	X		
Flood Fight Pre-Staging Equipment and Supply Area	Establish designated sites within the study area for pre-staging flood fighting equipment and supplies.	X		
Multi-Use Trails	Establish an interconnected multiuse trail system.	X		
Bicycle Trails	Connect bike trails to a larger trail system, with a focus on Class 1 trails.	X		
Equestrian Trails	Equestrian trails are designed for horses and their riders. They are typically separated from bike and pedestrian trails.	X		
Day Use Area	Day use areas are staging or access points to recreation spaces that have their own specific uses.	X		
River Access	River access facilities allow the public to directly engage the water safely at controlled locations.	X		
Scenic Overlook	Construct wildlife viewing platforms and/or boardwalks on levees or flood risk–management lands for bird watchers and wildlife enthusiasts separate from main trails.	X		
Recreational Parkway	This measure compliments the multi-use trail measure by preserving natural areas and wildlife habitat along the trail system.	X		

Table 3-2. Summary of Themes and Conceptual Alternatives

Management Measure	Theme or Alternative												
	Theme 1: Consequence Management Focused on Public Safety	Conceptual Alternative 1.1: Nonstructural	Theme 2: Urban FRM Focus	Conceptual Alternative 2.1: Ring Levees	Conceptual Alternative 2.2: Big J	Conceptual Alternative 2.3: Little J	Conceptual Alternative 2.4: Minimal Fix-in-Place	Conceptual Alternative 2.5: Fix-in-Place Thermalito to Star Bend	Theme 3: Maximize Existing System with FRM Emphasis	Conceptual Alternative 3.1: Fix-in-Place without Raising	Conceptual Alternative 3.2: Fix-in-Place without Raising, including Modest Setbacks	Theme 4: Ecosystem Emphasis	Conceptual Alternative 4.1: Setbacks with Ecosystem Restoration
Biggs Ring Levee			*	X									
Gridley Ring Levee			*	X									
Live Oak Ring Levee			*	X									
Yuba City Ring Levee			*	X									
Fix-in-Place Feather River West Levee from Thermalito to Shanghai Bend			*		X	X	X SBFCA segments 4 and 5 only (Sunset Weir to Shanghai Bend)	X	*	X May include subreaches	X	*	X
Southern Portion of J-Levee			*			X							

Management Measure	Theme or Alternative												
	Theme 1: Consequence Management Focused on Public Safety	Conceptual Alternative 1.1: Nonstructural	Theme 2: Urban FRM Focus	Conceptual Alternative 2.1: Ring Levees	Conceptual Alternative 2.2: Big J	Conceptual Alternative 2.3: Little J	Conceptual Alternative 2.4: Minimal Fix-in-Place	Conceptual Alternative 2.5: Fix-in-Place Thermalito to Star Bend	Theme 3: Maximize Existing System with FRM Emphasis	Conceptual Alternative 3.1: Fix-in-Place without Raising	Conceptual Alternative 3.2: Fix-in-Place without Raising, including Modest Setbacks	Theme 4: Ecosystem Emphasis	Conceptual Alternative 4.1: Setbacks with Ecosystem Restoration
Fix-in-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee			* South to Star Bend only		X Feather River north of Star bend and Shanghai Bend north of Gilsizer Slough		X Shanghai Bend to Star Bend	X Shanghai Bend to Star Bend	*	X May include subreaches	X	* Without Sutter Bypass fix-in-place	X Without Sutter Bypass fix-in-place
Sutter Bypass Setback Levee									*		O	*	X
Northern Feather River Setback Levee			*						*		O	*	X
Sutter Bypass and Feather River Confluence Setback Levee									*		X	*	X
Star Bend Setback Levee			*		X			X	*	X	X	*	X
Oroville Wildlife Area – Degrade Land Surface and Restore Wetlands					O	O				O	O	*	X
Southern Relief Structure	*	O	*						*	O	O	*	X
Sunset Weir Modification			*		O	O	O		*	O	O	*	X
Gilsizer Cross Levee with Flap Gates	*		*		X								

Management Measure	Theme or Alternative												
	Theme 1: Consequence Management Focused on Public Safety	Conceptual Alternative 1.1: Nonstructural	Theme 2: Urban FRM Focus	Conceptual Alternative 2.1: Ring Levees	Conceptual Alternative 2.2: Big J	Conceptual Alternative 2.3: Little J	Conceptual Alternative 2.4: Minimal Fix-in-Place	Conceptual Alternative 2.5: Fix-in-Place Thermalito to Star Bend	Theme 3: Maximize Existing System with FRM Emphasis	Conceptual Alternative 3.1: Fix-in-Place without Raising	Conceptual Alternative 3.2: Fix-in-Place without Raising, including Modest Setbacks	Theme 4: Ecosystem Emphasis	Conceptual Alternative 4.1: Setbacks with Ecosystem Restoration
Wadsworth Canal Tributary Drainage			*		O	O			*	O	O		
Managed Overtopping (Levee Superiority) on Feather River and Sutter Bypass			*		O	O	O		*	O	O		
Improve Upstream Fish Passage in Sutter Bypass (Remove Fish Passage Barriers)												*	X
Relocate Structures and Critical Infrastructure in Floodplain	*	O	*	O	O	O	O	O	*	O	O	*	O
Floodproof Isolated Locations	*	O	*	O	O	O	O	O	*	O	O	*	O
Elevate Structures and Transportation Infrastructure	*	O	*	O	O	O	O	O	*	O	O	*	O
Establish Flood-Resistant Housing	*	O	*	O	O	O	O	O	*	O	O	*	O
Secure Large Floatable Objects	*	O	*	O	O	O	O	O	*	O	O	*	O
Flood Warning System	*	X	*	X	X	X	X	X	*	X	X	*	X
Evacuation Plan	*	X	*	X	X	X	X	X	*	X	X	*	X
Construct Ring Levees at Isolated Locations	*	O	*	O	O	O	O	O	*	O	O	*	O

Management Measure	Theme or Alternative												
	Theme 1: Consequence Management Focused on Public Safety	Conceptual Alternative 1.1: Nonstructural	Theme 2: Urban FRM Focus	Conceptual Alternative 2.1: Ring Levees	Conceptual Alternative 2.2: Big J	Conceptual Alternative 2.3: Little J	Conceptual Alternative 2.4: Minimal Fix-in-Place	Conceptual Alternative 2.5: Fix-in-Place Thermalito to Star Bend	Theme 3: Maximize Existing System with FRM Emphasis	Conceptual Alternative 3.1: Fix-in-Place without Raising	Conceptual Alternative 3.2: Fix-in-Place without Raising, including Modest Setbacks	Theme 4: Ecosystem Emphasis	Conceptual Alternative 4.1: Setbacks with Ecosystem Restoration
Flood Fight Pre-Staging Equipment and Supply Area	*	X	*	X	X	X	X	X	*	X	X	*	X
Multi-Use Trails	*	O	*	O	O	O	O	O	*	O	O	*	O
Bicycle Trails	*	O	*	O	O	O	O	O	*	O	O	*	O
Equestrian Trails	*	O	*	O	O	O	O	O	*	O	O	*	O
Day Use Area	*	O	*	O	O	O	O	O	*	O	O	*	O
River Access	*	O	*	O	O	O	O	O	*	O	O	*	O
Scenic Overlook	*	O	*	O	O	O	O	O	*	O	O	*	O
Recreational Parkway	*	O	*	O	O	O	O	O	*	O	O	*	O

* = Included in theme.
X = Included in alternative.
O = Optional to alternative.

3.2 Measures and Alternatives Development

As part of the plan formulation process, the level of detail of design analysis was defined and maintained for the development of measures and alternatives by using available information, professional judgment, and risk-informed assumptions. The following are descriptions for each of the primary disciplines of the level of detail and assumptions used for the screening and development of conceptual alternatives on the way to determining a draft array of alternatives.

3.2.1 Level of Detail and Design Assumptions

The study planning process utilized two increasing levels of detail analysis to describe and determine the level of detail and potential uncertainty in the engineering, design, costs, and assumptions for the development of measures, conceptual alternatives, draft alternatives, and ultimately the final alternatives. The level of detail for the conceptual and draft array of alternatives was performed at a reconnaissance level or Class 4 Analysis with the final array of alternatives completed at the more detailed feasibility level or Class 3 Analysis.

The classes of analysis used are from EM 1110-2-1302, *Civil Works Cost Engineering*, and are based on ASTM E 2516-06, *Standard Classification for Cost Estimate Classification System*. The purpose of this classification system is to improve communication among all the stakeholders involved with preparing, evaluating, and using cost estimates (ASTM 2011). The five class definitions are described below.

- Class 5 is least accurate and is the minimum required for assessing rough order of magnitude. The level of project definition is 0% to 2% of a complete definition. A Class 5 cost estimate may vary from the best (Class 1) estimate by a magnitude of 4 to 20. Class 5 analysis was not used.
- Class 4 is the minimum required for Reconnaissance/905b Reports and alternative analysis in feasibility studies. The level of project definition is 1% to 15% of a complete definition. The expected cost accuracy (+/-) may vary from the accuracy of the best (Class 1) estimate by a magnitude of 3 to 12. Class 4 analysis was used for management measures and alternative development for the draft array of alternatives.
- Class 3 is the minimum required for analyzing the feasibility of the National Economic Development (NED) Plan and the Sponsor Preferred Plan. The level of project definition is 10% to 40% of a complete definition. The expected cost accuracy (+/-) may vary from the accuracy of the best (Class 1) estimate by a magnitude of 2 to 6. Class 3 analysis was used for validating the final array of alternatives.
- Class 2 is the minimum required for Preconstruction, Engineering, and Design up to 90% Plans and Specifications. The level of project definition is 30% to 70% of a complete definition. The expected cost accuracy (+/-) may vary from the accuracy of the best (Class 1) estimate by up to a magnitude of 3. Class 2 analysis was not used.
- Class 1 is the minimum required for Preconstruction, Engineering, and Design 100% Plans and Specifications and the Independent Government Estimate. The level of project definition is 50% to 100% of a complete definition. This is considered the most accurate estimate. It does not imply that all unknowns and risk are eliminated. Class 1 analysis was not used.

The management measures and draft array of alternative development were formulated at the Class 4 (reconnaissance) level of detail and design using construction quantities, costs, real estate

requirements, and economic benefits based on a parametric design approach and assumptions that were derived from professional judgment, standard design templates, and existing comparable cost information. Costs of the final array of alternatives were developed from a feasibility level of 35% design and detail or Class 3 Analysis to determine a TSP. See Section 3.9, *Final Array Economic Analysis*, for additional details.

3.2.1.1 Civil Design

3.2.1.1.1 Levee Heights

The following describes the approach to setting the design levee height for fix-in-place levee measures, ring levee measures, new levee measures, and setback levee measures.

Fix-in-Place Measures

Fix-in-place levee reaches would be reconstructed to the existing top of levee elevation or the 1957 design top of levee elevation, whichever is higher. The 1957 design profile and operations and maintenance manuals for the SRFCP define the currently authorized design flow, design water surface elevation, and minimum design top of levees. In no cases would the reconstructed levee height exceed the existing or 1957 design profiles.

The 1957 design profile top of levee is based on the 1957 design water surface profiles and the minimum freeboard specified in the 1951 operations and maintenance manuals. The SRFCP adopted multiple existing levees of varying height. The operations and maintenance manuals indicate the adopted levee segments met or exceeded the design freeboard. The 1957 design profile and freeboard are described in detail in the *Memorandum for File: Design of Existing Corps Project Features, December 2012*.

An increase or decrease to the currently authorized levee design height was considered but is not proposed because of project economics and possible adverse hydraulic effects that would transfer flood risk to other reaches of the system. One of the primary factors in USACE plan selection is maximizing net flood risk benefits (benefits minus costs). The increased costs of raising a levee relative to the minimal increase in flood damage benefits (no new structures with reduced risk) would have resulted in a decrease in the economic net benefits. Therefore, levee height increases were not pursued because they were judged to decrease net benefits.

Increases or decreases in the levee height would likely result in a transfer of flood risk within the system. For example, increasing the height of the Feather River West Levee without an increase in the East Levee would increase the probability of an overtopping failure of the East Levee. Likewise, a decrease in levee height of the West Levee without decreasing the East Levee would increase the probability of an overtopping failure of the West Levee. The floodwaters from an overtopping breach would not be confined to the area directly adjacent to the lowered levee and result in a transfer of risk.

New Levee Measures

The heights of new levee reaches were determined by reviewing the flood elevations from the hypothetical levee breaches near the levee area. Wind wave run-up analysis was also conducted, and the levee height was increased as necessary to provide similar levee assurance as the Feather River portion of the levee.

Levee Setback Measures

The design heights for all setback levee measures were based on the same height as the fix-in-place measures.

3.2.1.1.2 Levee Design

All existing and new levees under each alternative were assumed to have a design that meets current State of California and USACE standards for slopes (1V:3H waterside, 1V:2H or 1V:3H landside for existing or new slopes, crest width (20 feet), operation and maintenance, repair, replacement, and rehabilitation (OMRR&R), maintenance access (15 feet minimum for existing levees), and seepage and stability. The levees were assumed to perform to the 1957 levee design profile. To achieve this performance, seepage control measures were included in every alternative based on a parametric approach explained below.

- The parametric levee design approach utilized nine levee cross sections that represent typical design configurations applicable to the study area levees. For parametric simplicity, low-impact soil-bentonite cutoff walls were assumed at this level of design, though a seepage berm, relief wells, or some other measure may be required.
- A set of applicable templates was assigned to each reach based on a review of the levee and soil conditions. Each template was then specified as a percentage of overall reach length. For example, a reach might include 20% soil-bentonite slurry wall template and 90% levee crest widening template (note that the totals can be more than 100%, even for seepage control measures). The basic parameters that define each template were then specified based on an assessment of the existing performance of the levee within each reach.
- Parametric templates were specified to meet current USACE geotechnical design requirements. Cutoff walls, instead of seepage berms, were typically specified for levee strengthening. In general, seepage berms and cutoff walls have roughly the same overall cost (considering real estate acquisition, and local contractor capability and expertise) but seepage berms usually have a greater environmental impact.
- Proposed fix-in-place seepage control measures, including type (e.g., berm, cutoff wall), sizing (depth, width), and length (or percentage of length) were based on the existing conditions report, and augmented by professional judgment, specific local knowledge, and geological and soil maps.

New levee alignments were based on a review of aerial photography and topographic features. Geographic placement was based on minimizing impacts on existing structures, environmentally sensitive areas, and features expected to require costly mitigation or relocation. The design objective was to maximize FRM benefits to existing structures while minimizing the length (cost) of a new levee.

3.2.1.2 Geotechnical Design

Geotechnical design template parameters for fix-in-place seepage control measures were based on "expected" or median values. Judgment was used to estimate the minimum and maximum possible values, followed by an assumption of a median value. For instance, a ring levee far from the river was assumed to require a cutoff wall for some portion of the ring, and the lowest possible value that was expected based on engineering judgment was selected (for instance 25%). Next, the highest

possible value was estimated (for instance 75%). The same approach was used for the depth of cutoff walls. Based on engineering experience, the expected value was estimated to lie between these extreme values. The median value was not necessarily a conservative value, nor was it the mean value.

Additional features necessary to meet current USACE standards were tabulated for each levee reach. Examples of additional features include utility penetrations, drainage culverts, and pipelines. Estimates of additional features were based on levee logs recently completed by the California Department of Water Resources (DWR).

3.2.1.3 With-Project Floodplains

With-project residual floodplains were estimated for each alternative. The floodplains for the with-project conditions were estimated using the modeled breaches under existing conditions. For the fix-in-place alternatives, only breaches in the unimproved levee reaches were included. For the ring and J-levee conceptual alternatives, the existing condition breach maps were modified to remove areas on the landside of the ring or J-levee.

3.2.1.4 Cost Estimates

Cost estimates were completed for each conceptual alternative. Construction quantities for levee improvements were developed from the levee design templates and levee logs. Construction quantities for relocations, additional non-levee features, and real estate were developed primarily from assessment of aerial imagery.

A levee improvement and new levees spreadsheet estimated the costs based on a parametric approach. The spreadsheet calculated the cost based on the design cross section templates and typical parameters within the reach (levee top width, height, etc.). The spreadsheet utilized a database of unit price data from public bid results, similar state projects, and other public agencies. Unit prices in the spreadsheet were reviewed and updated to reflect present costs. For each levee reach and selected design template, the design parameters and quantities provided by USACE civil and geotechnical engineers were utilized to generate the cost estimate.

Other major cost items including roads, railroads, and canals crossing new levees, utility relocations, interior drainage, traffic control, erosion control, cultural resources protection and mitigation, and fish and wildlife mitigation, along with corresponding project costs for Preconstruction, Engineering, and Design (PED), and Construction Management, were considered separately. The costs for work relative to obstructions and structures crossing levees (special items) and interior drainage (pump stations) were based on preliminary quantity take-offs, hydrological analysis, existing cost data for similar projects, and historic cost estimates for projects with similar work. A percentage of the construction costs were used to compute costs for the other major cost items.

3.2.1.5 Real Estate Costs

Real estate land costs were estimated using the same cost estimate parametric spreadsheet. The spreadsheet multiplies the estimated footprint area by the percentage of land in four typical categories found within the study area, specifically, agricultural, residential, commercial, and orchard. The percentage of land within each category was based on a review of the linear distribution in recent aerial photography. The approximate land costs of each category were based

on a range of values (high and low) provided by the appraisal section. The costs included in the parametric spreadsheet were based on the average of the high and low values within each category.

Real estate and structure relocation cost estimates were developed for each alternative based on estimated rights-of-way. Acreage was calculated using the levee template parameters within each design reach.

Real estate acquisition costs were assumed to be less for existing levees because they are likely to be within an existing right-of-way. The costs were estimated based on historical USACE projects. Actual values would vary significantly because each parcel is unique.

The total estimated real estate cost for alternatives is the summation of the costs from the parametric spreadsheet output, the costs developed for special items and interior drainage, and the costs of the other major cost items (as a percentage of construction cost).

3.2.1.6 Economics

Economic benefit ranges were estimated for each conceptual alternative. The maximum economic benefit of fixing all levees to their design height was estimated. For each alternative, the benefit was estimated by applying a ratio based on the without- and with-project floodplains. The results were used to screen out those conceptual alternatives that did not appear economically justified even in the most favorable benefit/cost ratio ranges.

3.2.2 Conceptual Alternative Screening and Evaluation

A combined Value Engineering (VE) Study and Planning Charette (workshop) screened and evaluated the conceptual alternatives developed during the initial management measurement efforts. VE methodology was incorporated into the planning process to compare, refine, and optimize alternatives based on multiple criteria to ensure a robust array of alternatives. The VE Study/Charette process also provided an opportunity to validate the array of conceptual alternatives and to ensure that significant alternatives had not been overlooked.

Initial alternative evaluation criteria were reviewed and expanded using VE Study criteria and Charette Team input. Final criteria were used to assess each alternative in conjunction with the conceptual level cost estimates and economics for each alternative. The VE Study/Charette used the following criteria to rate and evaluate the conceptual alternatives and respective measures.

- Life safety – focused on potential loss of life, health impacts, and associated life safety services.
- Flood damage benefits – focused on reduction of flood damages to property.
- Critical infrastructure impacts – focused on impacts on critical public services infrastructure, utilities, transportation, and communication.
- Design capacity exceedance – focused on flood risks after the project is constructed that are above and beyond those risks being addressed by the project.
- Wise use of floodplain (minimize growth inducement in the floodplain) – focused on characteristics that could encourage or facilitate growth in the floodplain in an unwise manner.
- Sustainability – emphasizing the extent to which future funds and effort will be required to sustain the project measures once built.

- Ecosystem functionality – focus was on the project's ability to maintain or enhance the natural environment to support a functioning ecosystem.
- Environmental impacts – focused on the project's temporary and permanent impacts on the environment.

As part of this evaluation and VE analysis, the construction of setback levees to reduce flood risk was determined to be not as cost effective or as efficient, in terms of higher construction, environmental, and real estate costs, for addressing the existing levee geotechnical issues as compared to the fix-in-place measures. The study objectives state that ecosystem restoration and recreation opportunities and measures needed to be in conjunction to FRM measures (setback or fix-in-place measures). Setback levees address FRM issues and also provide opportunities at the newly created waterside areas for ecosystem restoration and recreation. Fix-in-place measures do not have associated or conjunctive ecosystem or recreation opportunities. Any ecosystem restoration and recreation will need to be independent of the FRM fix-in-place measures.

The Feather River levees differ from other California levees such as the Sacramento River in that in the majority of reaches the levees are already setback hundreds of feet from the river channel with this connected floodplain area consisting of remnant riparian, fallow, and agriculture areas. During the analysis, it was determined that these existing remnant riparian and fallow areas provide better and less costly opportunities for ecosystem restoration and recreation that can be pursued independently from the study.

With setback levees screened out, and better independent opportunities identified for both ecosystem restoration and recreation in the existing waterside areas, the ecosystem restoration and recreation objectives were not further considered.

An independent nonstructural alternative was determined not cost efficient compared to use of structural measures, and not practical for the established communities of the study area. Certain nonstructural measures were carried forward for each of the draft alternatives such as developing a flood warning system and implementing emergency evacuation planning.

Based on these screening criteria discussions and decisions during the VE Study/Charette, conceptual alternatives with very similar functions were combined and consolidated to a preliminary draft array as shown in Table 3-3.

The VE Study/Charette evaluation and further formulation resulted in a final refinement of this preliminary array of alternatives and their associated common measures. Two additional alternatives (SB-7 and SB-8) were identified during this formulation step to provide additional flood risk reduction by including an additional fix-in-place levee section from Star Bend to Laurel Avenue. The resulting alternatives and their respective measures defined and completed a draft array of eight alternatives (Table 3-4).

Table 3-3. Preliminary Array of Alternatives

Management Measure	Preliminary Alternative				
	Primarily Nonstructural Measures with Minimal Levee Improvement Reaches	Yuba City Ring Levee	Little J-Levee	Fix-in-Place Feather River Levees Thermalito to Star Bend	Fix-in-Place Feather River[a], Sutter Bypass[b], and Wadsworth Canal[c] Levees
Yuba City Ring Levee		X			
Fix-in-Place Feather River West Levee from Thermalito to Shanghai Bend	X SBFCA segments 4 and 5 only (Sunset Weir to Shanghai Bend)		X	X	X
Southern Portion of J-Levee			X		
Fix-in-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee				X Shanghai Bend to Star Bend	X
Sutter Bypass Setback Levee					O
Northern Feather River Setback Levee			O	O	O
Sutter Bypass and Feather River Confluence Setback Levee					O
Star Bend Setback Levee	O	O	O	O	O
Oroville Wildlife Area – Degrade Land Surface and Restore Wetlands	O	O	O	O	O
Southern Relief Structure	O	O	O	O	O
Sunset Weir Modification	O		O		O
Managed Overtopping (Levee Superiority) on Feather River and Sutter Bypass	O		O	O	O
Improve Upstream Fish Passage in Sutter Bypass (Remove Fish Passage Barriers)					O
Sutter Bypass Sediment Removal			O	O	O
Relocate Structures and Critical Infrastructure in Floodplain	O	O	O	O	O
Floodproof Isolated Locations	O	O	O	O	O

Management Measure	Preliminary Alternative				
	Primarily Nonstructural Measures with Minimal Levee Improvement Reaches	Yuba City Ring Levee	Little J-Levee	Fix-in-Place Feather River Levees Thermalito to Star Bend	Fix-in-Place Feather River[a], Sutter Bypass[b], and Wadsworth Canal[c] Levees
Elevate Structures and Transportation Infrastructure	O	O	O	O	O
Establish Flood-Resistant Housing	O	O	O	O	O
Secure Large Floatable Objects	O	O	O	O	O
Flood Warning System	X	X	X	X	X
Evacuation Plan	X	X	X	X	X
Construct Ring Levees at Isolated Locations	O	O	O	O	O
Flood Fight Pre-Staging Equipment and Supply Area	X	X	X	X	X
Multi-Use Trails	O	O	O	O	O
Bicycle Trails	O	O	O	O	O
Equestrian Trails	O	O	O	O	O
Day Use Area	O	O	O	O	O
River Access	O	O	O	O	O
Scenic Overlook	O	O	O	O	O
Recreational Parkway	O	O	O	O	O

X = Included in alternative.
O = Optional / Not Further Pursued in an alternative.
[a] Feather River West Levee from Thermalito to Sutter Bypass.
[b] Sutter Bypass East Levee, Wadsworth Canal to Feather River.
[c] Wadsworth Canal East Levee, East Interceptor to Sutter Bypass.

Table 3-4. Draft Array of Alternatives and Associated Management Measures

	Alternative							
Management Measure	**Alternative SB-1: No Action**	**Alternative SB-2: Minimal Fix-in-Place Feather River Levees: Sunset Weir to Star Bend**	**Alternative SB-3: Yuba City Ring Levee**	**Alternative SB-4: Little J-Levee**	**Alternative SB-5: Fix-in-Place Feather River Levees: Thermalito Afterbay to Star Bend**	**Alternative SB-6: Fix-in-Place Feather River, Sutter Bypass, and Wadsworth Canal Levees**	**Alternative SB-7: Fix-in-Place Feather River Levees: Sunset Weir to Laurel Avenue**	**Alternative SB-8: Fix-in-Place Feather River Levees: Thermalito Afterbay to Laurel Avenue**
Yuba City Ring Levee			X					
Southern Portion of J-Levee				X				
Fix-in-Place Feather River Levee: Thermalito to Sunset Weir				X	X	X		X
Fix-in-Place Feather River Levee: Sunset Weir to Shanghai Bend		X		X	X	X	X	X
Fix-in-Place Feather River Levee: Shanghai Bend to Star Bend		X			X	X	X	X
Fix-in-Place Feather River Levee: Star Bend to Laurel Avenue						X	X	X
Fix-in-Place Feather River Levee: Laurel Avenue to Sutter Bypass						X		
Fix-in-Place Wadsworth Canal East Levee Plus Sutter Bypass to East Levee						X		
Flood Warning System	X	X	X	X	X	X	X	X
Evacuation Plan	X	X	X	X	X	X	X	X
Flood Fight Pre-Staging Equipment and Supply Area	X	X	X	X	X	X	X	X

3.3 Draft Array of Alternatives

The draft array of alternatives represents eight alternatives ranging from fixing-in-place existing Feather River levees to constructing new ring or J-shaped levees in combination with fixing-in-place other levee sections. The draft array was then further evaluated and screened to identify and determine a final array of alternatives with appropriate level of detail, risk-informed decisions, use of existing data and information, and use of professional judgment. Some general determinations and measures common to all draft alternatives being carried forward, except for Alternative SB-1: No Action, are listed below.

- All alternatives include the nonstructural measures of a flood warning system, emergency evacuation plan, and flood fight pre-staging equipment and supply areas.
- A southern relief structure (a levee section removal) measure for addressing post-basin flood drainage relief is being deferred and recommended as a separate local initiative.
- Fix-in-place levee improvements refer to the seepage control measure of slurry cutoff wall in addition to some other measures at levee infrastructure penetrations (see Table 3-5).
- The Star Bend levee section is assumed to be a fix-in-place measure for all alternatives.
- The structural measures for all the alternatives were focused on fix-in-place features of the existing Feather River levees or construction of new levees.

3.3.1 Engineering Features for Draft Alternatives

A range of engineering features was further developed and confirmed at the Class 4 Analysis level of detail and design (reconnaissance level) for each draft alternative. These engineering features consisted primarily of under-seepage design solutions, specifically, fix-in-place existing levees with design measures of berms or cutoff walls, or constructing new levees. All features were inclusive of real estate needs for easements, relocations, utilities, and encroachments. Table 3-5 presents the general engineering features developed for the draft array of alternatives consisting of fix-in-place or new levees.

Table 3-5. Engineering Features of the Draft Array of Alternatives

	Alternative							
Engineering Feature	**SB-1**	**SB-2**	**SB-3**	**SB-4**	**SB-5**	**SB-6**	**SB-7**	**SB-8**
Gravel Stability Berm (Fix-in-Place)		X	X	X	X	X	X	X
Centerline Soil-Bentonite Slurry Cutoff Wall (Fix-in-Place)		X	X	X	X	X	X	X
New Levee			X	X				
New Levee with Centerline Soil-Bentonite Slurry Cutoff Wall (Fix-in-Place)			X	X				
Levee Crest Widening (Fix-in-Place)		X	X	X	X	X	X	X

3.3.2 Alternative SB-1: No Action

Under the No Action Alternative, or the future without-project condition, the Federal government would take no action toward implementing a specific flood risk–management plan. The economic evaluation necessary to determine if the locals will received Section 104 credit requires the USACE to assume for planning purposes that the local agencies will take no action in improving levees within the study area. Current maintenance practices and OMRR&R manuals would continue to be followed on the existing levees. The entire study area would continue to be at high risk of flooding and would rely on emergency responses and flood fighting to ensure the public and life safety of local communities. Significant damage to property and potential loss of life could occur if existing project levees fail. Subsequent improvements to the existing project levees would be done under

emergency or post-failure conditions. Emergency costs associated with evacuation, flood fighting, fire and police services, and government disruptions would result. Transportation and evacuation routes throughout the area could be severely restricted by a flood event, and critical infrastructure could be rendered nonfunctional for an extended period of time after the flood event. See Figure 3-1.

3.3.3 Alternative SB-2: Minimal Fix-in-Place Feather River Levees: Sunset Weir to Star Bend

This alternative includes the fix-in-place levee structural measures and nonstructural measures. Alternative SB-2 focuses on strengthening the existing Feather River levee in the immediate vicinity of Yuba City and would reduce risk to the Yuba City urban core. See Figure 3-1.

3.3.4 Alternative SB-3: Yuba City Ring Levee

This alternative includes the construction of new levee sections surrounding Yuba City. The eastern section of the ring levee would utilize the existing levee and would be fixed-in-place. Two new pump stations were assumed to be required to address interior drainage caused by the new levees for areas inside the ring levee. This alternative would reduce flood risk and isolate the primary urban boundary of Yuba City. See Figure 3-1.

3.3.5 Alternative SB-4: Little J-Levee

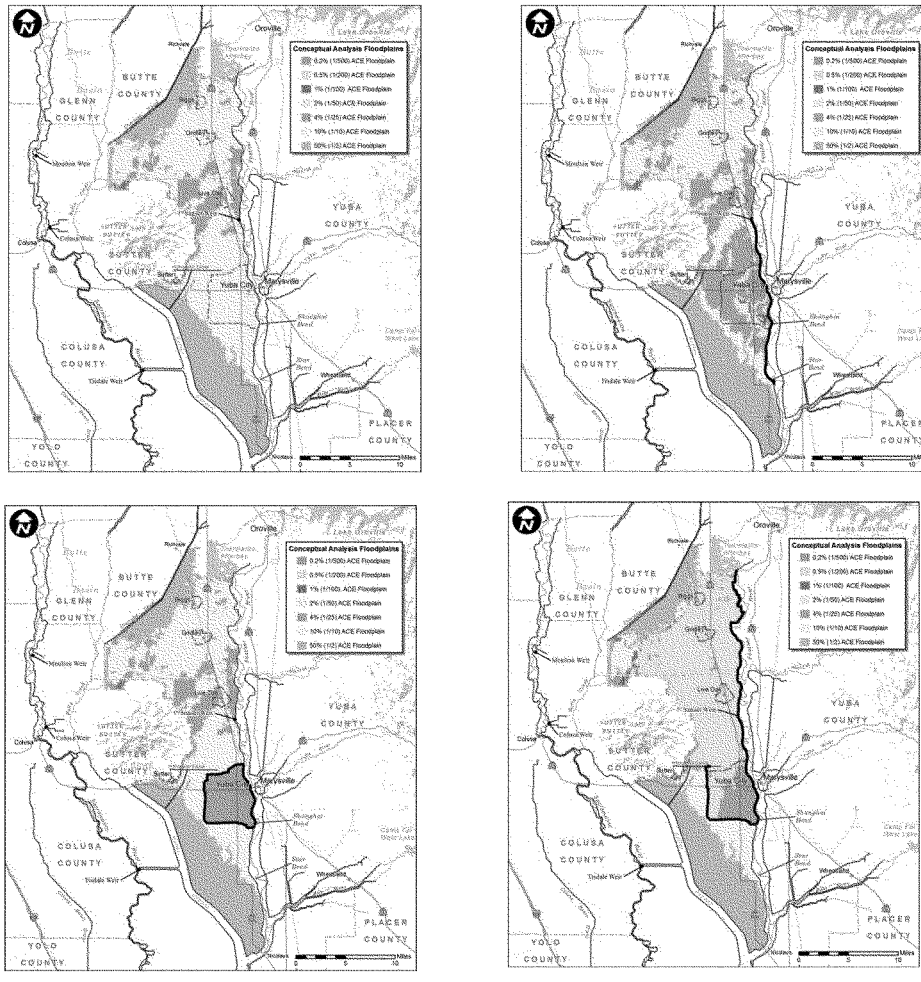
This alternative is a nonstructural/structural hybrid that includes fixing-in-place the Feather River levees north of Yuba City from Shanghai Bend to Thermalito, and the construction of a new levee to the south and west of Yuba City (little J). Fix-in-place levee and new levee structural measures and nonstructural measures are included in this alternative. This alternative assumes two new pump stations to address interior drainage. Reduction of flood risk would be centered in Yuba City and the northeastern part of the Sutter Basin. See Figure 3-1.

3.3.6 Alternative SB-5: Fix-in-Place Feather River Levees: Thermalito Afterbay to Star Bend

This alternative includes Alternative SB-2 but further extends levee fix-in-place improvements north to Thermalito Afterbay. Alternative SB-5 includes fix-in-place levee structural measures and nonstructural measures. Reduction of flood risk would extend from around the Yuba City area into the Sutter Basin's northern area and communities. See Figure 3-2.

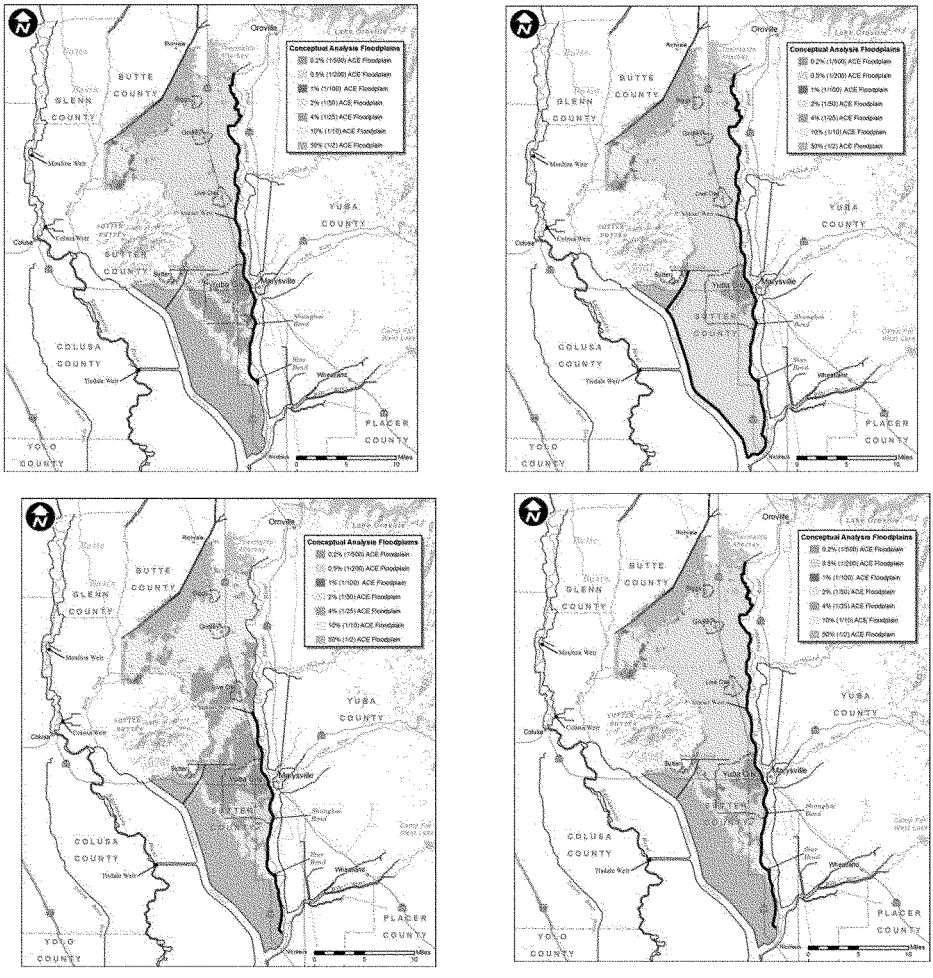
3.3.7 Alternative SB-6: Fix-in-Place Feather River, Sutter Bypass, and Wadsworth Canal Levees

This alternative consists of fix-in-place improvements to the Sutter Bypass and Wadsworth Canal levees and the Feather River levees from Thermalito Afterbay to Laurel Avenue. Alternative SB-6 includes fix-in-place levee structural measures and nonstructural measures. Flood risk would be reduced most extensively throughout the entire basin except near the Cherokee Canal area. See Figure 3-2.



(See the *Figures* folder on the CD for full-sized images.)

Figure 3-1. Alternatives SB-1, SB-2, SB-3, and SB-4



(See the *Figures* folder on the CD for full-sized images.)

Figure 3-2. Alternatives SB-5, SB-6, SB-7, and SB-8

3.3.8 Alternative SB-7: Fix-in-Place Feather River Levees: Sunset Weir to Laurel Avenue

This alternative includes Alternative SB-2 but extends Feather River fix-in-place levee improvements south of Yuba City to a point 2,250 linear feet downstream of Laurel Avenue. Alternative SB-7 includes fix-in-place levee structural measures and nonstructural measures. The additional increment of levee improvements includes the flood risk–reduction benefits of Alternative SB-2 and provides additional flood risk–reduction benefits in the most southern areas of Yuba City. See Figure 3-2.

3.3.9 Alternative SB-8: Fix-in-Place Feather River Levees: Thermalito Afterbay to Laurel Avenue

This alternative includes Alternative SB-7 but extends Feather River levee improvements north to Thermalito Afterbay. Alternative SB-8 includes fix-in-place levee structural measures and nonstructural measures. Alternative SB-8 includes all the flood risk benefits of all of Alternative SB-7. However, Alternative SB-8 would also provide extensive flood risk reduction in the northern areas, including the communities of Live Oak, Gridley, and Biggs. See Figure 3-2.

3.4 Evaluation Strategy of Draft Alternatives

The plan formulation evaluation strategy for the draft alternatives was based upon existing policy and guidance (ER 1105-2-100) to determine a final array of alternatives and a Recommended Plan (RP).

3.4.1 Federal Planning Criteria

Federal planning criteria were used as the screening structure for the first level screening of the draft array of alternatives.

3.4.1.1 Acceptability

The local sponsors (Sutter Butte Flood Control Agency [SBFCA] and Central Valley Flood Protection Board [CVFPB]) and the public are highly aware of the Basin's flood risk. The sponsors and community continue their support and acceptance of the FRM efforts. All alternatives for the Sutter Basin with a strategy to reduce flood risk and life safety risk have sponsor support and acceptance. Further, all alternatives are acceptable because they are compatible with existing laws, regulations, and public policies. No further evaluation and screening were necessary for this criterion.

3.4.1.2 Effectiveness

Within identified constraints of the study, each alternative in the draft array addresses all of the planning objectives regarding FRM and life safety to varying degrees. No further evaluation and screening was necessary for this criterion.

3.4.1.3 Efficiency

This criterion is defined in terms of cost efficiency of economic residual annual damages and FRM analysis for annual net benefits. As part of the analysis for cost efficiency, the NED Plan is identified as the alternative that reasonably maximizes annual net benefits. The draft array of alternatives will be screened for cost efficiency using economic criteria.

3.4.1.4 Completeness

The definition of "completeness" from the Planning Guidance Notebook is, "the extent to which the alternative plans provide and account for all necessary investments or other actions to ensure the realization of the planning objectives, including actions by other Federal and non-federal entities." The study further defines a complete and effective alternative as one that best meets the study objectives of reducing flood risk and damages and minimizes the resulting residual flood risk to public and life safety. Completeness is evaluated using metrics for public and life safety developed during the study.

3.4.2 Evaluation Metrics for Completeness

The evaluation metrics, as part of the multi-objective planning process to support the study objectives, were developed as a screening analysis tool to assist in organizing and evaluating alternatives across the system of planning accounts. These planning accounts are USACE tools used to categorize benefits of a project. The four accounts used are listed below.

- National Economic Development (NED).
- Environmental Quality (EQ).
- Regional Economic Development (RED).
- Other Social Effects (OSE) – public and life safety.

The evaluation metrics were partly aligned with the VE Study evaluation criteria. The metrics were developed to permit evaluation of the project beyond the traditional single account of NED. The metrics permitted the evaluation of the project by the other accounts of EQ, RED, and OSE with an emphasis on the study objective of public and life safety.

The pilot formulation process anticipated that evaluation and comparison of the alternatives in the draft array would be based on multiple criteria, including the following: monetary and nonmonetary effects; qualitative and quantitative data; and economic, public safety, environmental, and regional criteria. The evaluation metric criteria identified in Table 3-6 were based upon both existing USACE policy, including the Water Resources Council Principles and Guidelines criteria, and the Planning Guidance Notebook.

Table 3-6. Evaluation Metric Criteria and Study Objectives

Study Objectives	Evaluation Metric
(a) Reduce the risk to life, health, and public safety due to flooding	Population at Risk Critical Infrastructure-Life Safety Evacuation Routes
(b) Reduce the risk of property damage due to flooding	NED Costs NED Benefits
(c) Reduce the risk of damage to critical infrastructure due to flooding	Critical Infrastructure-Life Safety
(d) Encourage the wise use of the floodplain	Potentially Developable Floodplain (Acres)

For the EQ account, the study objectives state that ecosystem restoration and recreation opportunities and measures needed to be in conjunction to FRM measures. Viable measures to meet this objective were limited in this study to new setback levees that potentially reduced flood risk and created additional waterside areas for potential restoration and recreation.

The Feather River levees in the majority of the reaches of the study area are setback hundreds of feet from the main channel and river bank. These existing setback areas contain agricultural and remnant riparian areas still connected to the natural floodplain that provide better and more cost efficient independent opportunities for restoration and recreation in the study area. During plan formulation, setback measures were determined not an effective or cost efficient FRM measure compared to fix-in-place levee measures. Dropping setback measures from further consideration during the plan formulation process also eliminated ecosystem restoration and recreational opportunities from this study. Definitions of the study-specific evaluation metrics, aligned with VE/Charette evaluation criteria and strategy, are shown in Table 3-7.

Table 3-7. Description of Evaluation Metrics

Evaluation Metric	Description
Population at Risk (People)	Number of people within the 1% ACE floodplain[a] based on the 2010 census blocks.
Critical Life Safety Infrastructure (Facilities)	Number of fire stations, police stations, hospitals, senior living facilities, jails, etc. that are of life safety significance.
Evacuation Routes (Number of Routes)	The vulnerability of populations with regard to the number of escape routes available during flood events.
Potentially Developable Floodplain (Acres)	Potentially developable land within the 1% ACE floodplain with flood depths less than 3 feet. General determination of potential acres (supply).

[a] 1% ACE floodplains and residual 1% ACE floodplains are used to provide a standard comparison graphic. The 1% ACE is not a safety metric or study objective. A range and composite of flood events with ACE of 50%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% were used in the study analysis and evaluation. Larger events beyond the 1% ACE are possible and continued floodplain management actions will be needed to reduce residual flood risk.

3.4.2.1 Evaluation of Residual Risk of Draft Array of Alternatives

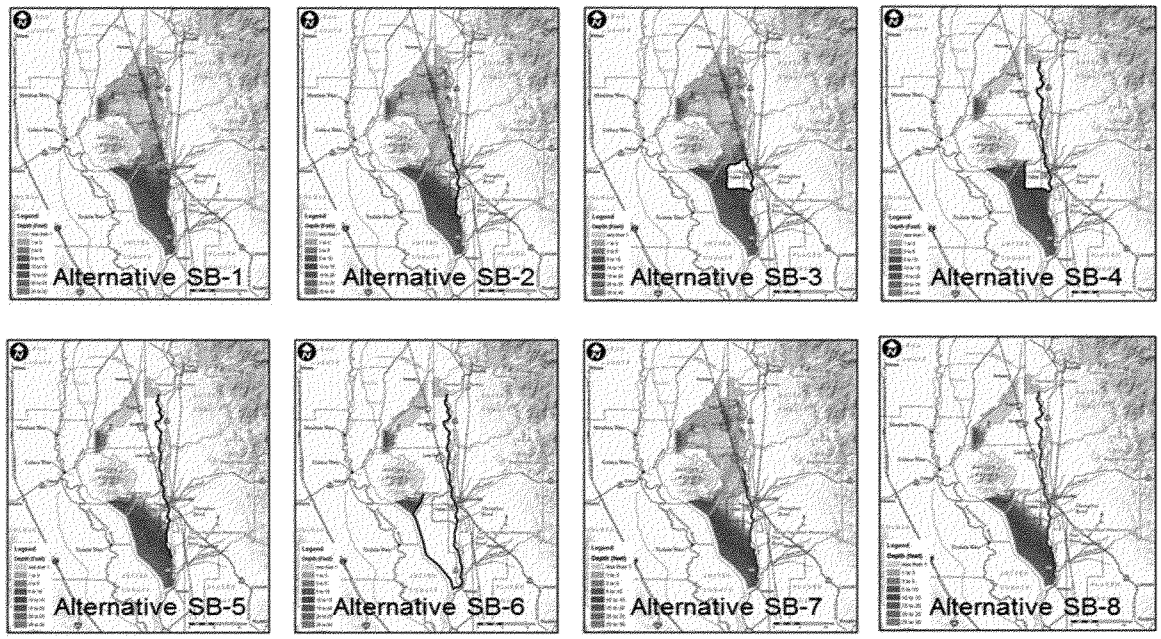
In order to conduct completeness criteria screening, a general qualitative ranking of the alternatives in the draft array was performed for residual risk focused on OSE planning to account for public and life safety. Evaluation metrics for public and life safety and the residual 1% ACE floodplain maps under the alternatives were used to evaluate alternatives at the appropriate level of detail and to provide an initial ranking and grouping of the draft alternatives. Public and life safety evaluation metrics factored in residual floodplains and the existing communities and population centers of Yuba City, Live Oak, Gridley, and Biggs (See Table 3-8 and Figure 3-3). Alternatives that removed communities and population from the residual floodplain were determined generally to have a lower residual risk ranking. The potentially developable floodplain metric was ranked according to the alternative's minimization of developable floodplain, which would reduce public safety risk in the future.

Table 3-8. Draft Array of Alternatives: Comparison of Residual 1% ACE Floodplain Risk

	Alternative							
Evaluation Metric	**SB-1**	**SB-2**	**SB-3**	**SB-4**	**SB-5**	**SB-6**	**SB-7**	**SB-8**
Population at Risk	5	3	3	2	2	1	3	2
Critical Infrastructure	5	4	4	2	2	1	4	2
Evacuation Routes Choices	5	4	4	2	2	1	4	2
Loss of Life	5	3	3	2	2	1	3	2
Minimizing Potentially Developable Floodplain	1	2	2	3	3	5[a]	2	3

Note: Qualitative rankings range from 5 (High Residual Risk) to 1 (Low Residual Risk).

[a] Only alternative with entire lower Basin in potentially developable floodplain.



(See the *Figures* folder on the CD for full-sized images.)

Figure 3-3. Residual Risk of Draft Array of Alternatives Using Residual 1% ACE Floodplains

Residual risk rankings were developed for each evaluation metric. The rankings provide a relative ranking of alternatives. Residual risk was defined for three areas: Yuba City area, northern communities area, and southern area, and ranked as follows:

- A 5 ranking is for maximum residual risk to public and life safety for urban areas and rural areas in the Basin.
- A 4 ranking is for reducing some residual risk to public and life safety in most of Yuba City and no reduction in risk in the northern community and rural areas.
- A 3 ranking is for reducing residual risk to public and life safety for most of Yuba City, and minimal northern urban areas and rural areas.
- A 2 ranking is for minimizing residual risk to public and life safety for the majority of urban areas (Yuba City, Live Oaks, Biggs, and Gridley), and for most of the northern rural areas.
- A 1 ranking is for minimizing residual risk to public and life safety for the entire Basin's urban and rural areas.

The residual risk comparison distributed the alternatives into two main groupings of high residual risk (Alternatives SB-1, SB-2, SB-3, and SB-7) and lower residual risk (Alternatives SB-4, SB-5, SB-6, and SB-8).The residual risk comparison presented a grouping of alternatives (SB-4, SB-5, SB-6, and SB-8) that had a generally low residual risk ranking compared with all draft alternatives. Alternative SB-6 had the lowest residual risk ranking, but with significant risk concerns related to potentially developable floodplain in the southern deeper floodplain end of the Basin.

3.4.3 Cost Efficiency

Cost efficiency was determined through economic analysis for the draft array of alternatives, and results were presented as residual annual damages and annual net benefits using the conceptual parametric costs at the Class 3 Analysis level of detail. The cost effectiveness determination also identified the NED Plan from the draft array.

3.4.3.1 Annual Net Benefits

Economic analysis provided annual net benefits and benefit-to-cost ratios (BCR) ranges that were evaluated for the draft array of alternatives in Table 3-9. Note that price levels and interest rates from this 2011 draft array screening analysis were not updated to current price levels and discount rates as it would not impact screening level decisions.

- The low annual benefit column represents the 75% confidence level that benefits will exceed the indicated value, the mid annual benefit represents the 50% confidence level, and the high annual benefit represents the 25% confidence level.
- The low annual cost represents the 20% confidence level that costs will be less than the indicated value, the mid annual cost represents the 50% confidence level, and the high annual cost represents the 80% confidence level that costs will be less than indicated.
- Net benefit and BCR mean values and ranges were calculated using Monte Carlo methodology Monte Carlo methods (or Monte Carlo experiments) are a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results; i.e., by running simulations many times over in order to calculate those same probabilities heuristically just like

actually playing and recording your results in a real casino situation: hence the name. Monte Carlo methods are mainly used in three distinct problems: optimization, numerical integration and generation of samples from a probability distribution. The mean net benefit and BCR represent the mean result from this Monte Carlo method. The low to high range represent the 90% confidence range, with the mean value providing the best estimate. In an asymmetrical distribution, confidence is highest that net benefits and BCR will exceed the low values, and confidence of numbers reduces toward the high values. The mean values of this total range provide the best estimate.

3.4.3.2 Identifying the NED Plan

USACE criteria require the identification of a NED Plan. The economic analysis indicates that the NED alternative is Alternative SB-7 because it most reasonably maximizes annual net benefits compared with the other alternatives. Alternative SB-7 consists of fixing-in-place the existing Feather River West Levee from Sunset Weir down river to 2,250 linear feet beyond Laurel Avenue. The total first cost, which is the sum of all initial expenditures to construct a project, is estimated at $423 million with annual net benefits of $37 million. Figure 3-5 shows the Alternative SB-7 NED Plan and the resulting residual 1% ACE floodplain.

To validate and confirm the NED Plan, an evaluation is required to demonstrate that net benefits are maximized. Alternative SB-2, which has the next highest annual net benefits, was further evaluated in comparison with Alternative SB-7 in terms of other metrics such as life safety of population at risk, critical infrastructure, evacuation routes, and wise use of floodplains. Alternative SB-2 by definition is a minimal fix-in-place of Feather River levee sections consisting of fixing-in-place the Feather River levees from Sunset Weir up to and including Star Bend. The total first cost estimate is $319 million with annual net benefits of $29 million. Benefits are concentrated in the Yuba City center of the study area.

Alternative SB-7 consists of the Alternative SB-2 levee fixes (Sunset Weir to Star Bend) plus an additional 13.4 miles of levee fixes. This addition would reduce flood risk and associated life safety risk to additional areas of south western Yuba City. The additional investment of $104 million results in an increase in annual net benefits of $8 million. The incremental BCR is 2.6:1. Benefits for this additional reach are centered in Yuba City, but the alternative also addresses significant flood risk to the southern urban edge of Yuba City. Fixing this reach provides flood risk reduction to an additional approximately 18,500 people. See Figure 3-4.

When compared with Alternative SB-2, Alternative SB-7 reasonably maximizes economic benefits (Table 3-10). The comparison and evaluation confirmed Alternative SB-7 as the NED Plan with continued Federal interest and cost effectiveness. See Figure 3-5.

Table 3-9. Net Benefits/Benefit to Cost Ratio Ranges for the Draft Array of Alternatives, Using October 2011 Prices ($ Millions) and 4.0% Discount Rate

	Total First Cost[a]			IDC[b]	Annualized Cost + O&M[c]			Annual Benefits			Annual Net Benefits[d]			Benefits to Cost Ratio[e]		
Alternative	Low (20%)	Mid (50%)	High (80%)	Mid	Low (20%)	Mid (50%)	High (80%)	Low (20%)	Mid (50%)	High (80%)	Low	Mean	High	Low	Mean	High
SB-1: No Action	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SB-2: Minimal Fix-in-Place Feather River Levees: Sunset Weir to Star Bend	290	319	361	24	14	16	18	24	38	73	14	29	48	1.9:1	2.9:1	4.1:1
SB-3: Yuba City Ring Levee	411	451	507	53	21	23	26	25	41	71	8	23	40	1.3:1	2.0:1	2.7:1
SB-4: Little J-Levee	729	798	899	94	37	40	45	31	46	87	-3	14	36	0.9:1	1.4:1	1.9:1
SB-5: Fix-in-Place Feather River Levees: Thermalito Afterbay to Star Bend	549	608	694	72	28	31	35	29	45	81	4	21	41	1.1:1	1.7:1	2.3:1
SB-6: Fix-in-Place Feather River, Sutter Bypass, and Wadsworth Canal Levees	1,018	1,131	1,297	183	53	59	67	46	73	134	-3	25	58	0.9:1	1.4:1	2.0:1
SB-7: Fix-in-Place Feather River Levees: Sunset Weir to Laurel Avenue	386	423	479	41	19	21	24	32	51	92	18	37	60	1.8:1	2.7:1	3.8:1
SB-8: Fix-in-Place Feather River Levees: Thermalito Afterbay to Laurel Avenue	645	713	812	100	33	36	42	36	58	101	7	28	52	1.2:1	1.8:1	2.4:1

Note:

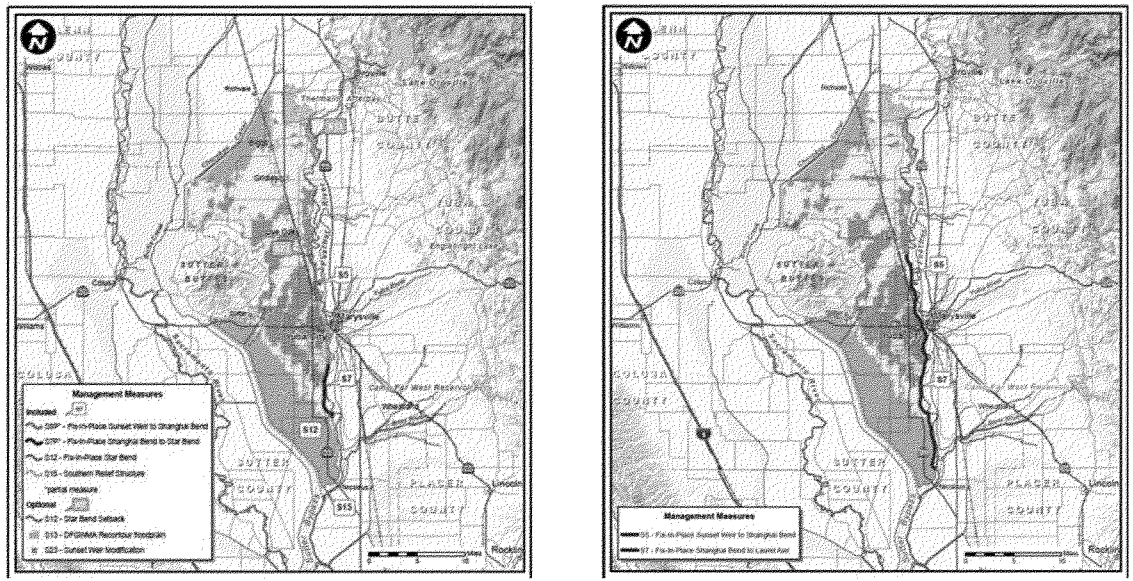
[a] Cost Range: Min = 20% Mid = 50% Max = 80% (confidence costs are less than given value).

[b] IDC = Interest during construction, which is estimated interest accumulated until the project begins to accrue intended benefits. Here, IDC is based on equal annual spending over the following construction schedules: SB-2 = 3 years, SB-3 = 5 years, SB-4 = 5 years, SB-5 = 5 years, SB-6 = 7 years, SB-7 = 4 years, SB-8 = 6 years.

[c] First Cost plus IDC amortized over 50 years at 4% plus annual O&M. Annual O&M costs: SB-2 = $195k, SB-3 = $270k, SB-4 = $477k, SB-5 = $360k, SB-6 = $661k, SB-7 = $350k, SB-8 = $500k.

[d] Benefit Range: Min = 75% Mid = 50% Max = 25% (confidence benefits are greater than given value).

[e] Benefit to Cost values are a result of Monte Carlo simulations using triangular distributions of annual benefit and annual cost confidence intervals as inputs. Mean=Mean result from simulation.

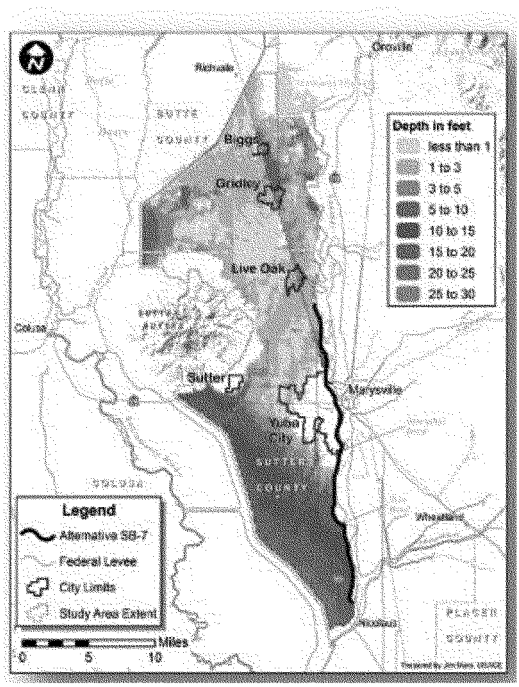


(See the *Figures* folder on the CD for full-sized images.)

Figure 3-4. Floodplains of Alternative SB-2 and SB-7

Table 3-10. Alternatives SB-1, SB-2, and SB-7 Comparison, Using October 2011 Prices ($Millions) and 4.0% Discount Rate

Item (from mean economic range number)	Alternative SB-1: No Action	Alternative SB-2	Alternative SB-7 (NED)
Investment Cost			
First Cost	-	319	423
Interest during Construction	-	24	41
Subtotal	-	343	464
Annual Cost	-		
Interest and Amortization	-	15.8	20.7
Operation, Maintenance, Repair, Replacement and Rehabilitation	-	0.2	0.4
Subtotal	-	16	21
Annual Flood Risk Management Benefits	-	38	51



(See the *Figures* folder on the CD for a full-sized image.)

Figure 3-5. Residual 1% ACE Floodplain of the NED Plan: Alternative SB-7

3.4.3.3 Efficiency Evaluation of Screened Residual Risk Alternatives

Upon the completion of the cost efficiency evaluation and analysis for the NED Plan, the alternatives previously identified and screened for completeness for their low residual life safety risk, Alternatives SB-4, SB-5, SB-6, and SB-8, were also evaluated and screened using cost effectiveness economic information. See Table 3-11. Using the cost efficiency screening criteria of maximized annual net benefits, Alternative SB-8 was identified, after the NED Plan, as the next most cost efficient alternative that also has low residual life safety risk, (i.e., Alternative SB-8 is more complete by study definition).

Table 3-11. Summation of Screened Alternatives for Completeness (Residual Risk) and Efficiency (Cost), Based on October 2011 Prices and 4.0% Discount Rate

Economic Metric ($ millions)	Residual Risk Screened Alternatives				
	SB-4	SB-5	SB-6	SB-8	SB-7 NED
Total First Cost	798	608	1131	713	423
Annual Benefits	46	45	73	58	51
Annual Net Benefits	14	21	25	28	37
Benefit to Cost Ratio	1.4:1	1.7:1	1.4:1	1.8:1	2.7:1

In summary, the completeness criteria screening identified Alternatives SB-4 and SB-8 as having low residual risk. The other two alternatives identified with low residual risk, Alternative SB-5 and SB-6, were both screened out as being less cost efficient. Alternative SB-6 was also screened out as having an unacceptable increase in potentially developable floodplain risk in the deep southern portion of the Basin relative to the other alternatives. Alternative SB-4 was put on hold from further consideration until later in the iterative formulation process due to its high cost ($798 million), low annual net benefits ($14 million), reduced life safety benefits in the southern Yuba City area, complexity, and high environmental impacts associated with new levee construction. The remaining Alternatives SB-7 and SB-8 were further evaluated for the final array.

3.4.4 Alternative Evaluation: NED Plan Residual Risk

The completeness criteria and the cost efficiency criteria screenings identified two alternatives for the final array: Alternative SB-7 as the NED Plan, and Alternative SB-8. Alternative SB-8 is the next most cost efficient alternative with low residual risk and can be considered as a potential Locally Preferred Plan (LPP). A LPP is defined as a plan that deviates from the identified NED Plan and is supported by the local sponsors. Identification of a LPP as the TSP requires ASA(CW) approval. As part of the iterative planning process, the NED Plan and Alternative SB-8 required a more a detailed residual risk screening, comparison, and evaluation using the evaluation metrics for public and life safety to further establish and verify a final array of alternatives.

3.4.4.1 Evaluation of the NED Plan Residual Risk and Mitigation Strategies

A next step in the screening for a final array of alternatives involved validating as part of the planning reiteration process the completeness of the NED Plan. This process required more detailed analysis of the NED Plan's residual risk and mitigation strategies using the evaluation metrics.

Residual risk of the NED Plan was assessed by the life safety metrics, described in Table 3-12. The NED Plan benefits are derived from reduction in adverse flooding effects, but benefits are primarily centered on the Yuba City area. The analysis of the NED Plan's residual 1% ACE floodplain (Figure 3-5) reveals that substantial residual risk to the communities of Biggs, Gridley, Live Oak, and southern areas of Yuba City would remain (Table 3-12) from under-seepage failures of the northern Feather River levees.

Table 3-12. Evaluation Metric Residual Risk Comparison

		Alternative	
Evaluation Metric	**Measurement**	**SB-1: No Action**	**NED Plan**
Population at Risk	People within 1% floodplain	94,600	38,200
Critical Infrastructure	Facilities within 1% floodplain	28	11
Evacuation Routes	Number of routes outside 1% floodplain	0	1
Potentially Developable Floodplain	Acres within 1% floodplain with depths less than 3 feet.	71,800	88,200

3.4.4.1.1 Population at Risk

Even with the implementation of the NED Plan, a population of 38,200 people would remain at risk from a 1% ACE flood event. Of special concern are people at least 65 years old who live within the study area, because those individuals experience a higher risk of life loss in flood events. Both Butte County (15.6%) and Sutter County (13.0%) are above the state average (11.7%) for percentage of persons 65 years of age and older. Flood events most likely would occur during the winter months' cold water and air temperatures.

Risk-Reduction Measures

There are no practical mitigation measures for addressing population at risk, such as relocating entire town populations, structures, and infrastructures. These measures were deemed infeasible to address residual risk in the established population centers of Live Oak, Gridley, and Biggs. Additional nonstructural measures were evaluated in Section 3.4.6.1.6, *Cost Effectiveness of Structural vs. Nonstructural Mitigation Measures*. These measures were considered cost prohibitive due to the numbers of structures involved and multiple urban locations covered, and would be socially and economically unacceptable and disruptive.

3.4.4.1.2 Critical Infrastructure

A significant amount of critical infrastructure is located within the study area floodplain, especially in the more populated northern area outside of Yuba City. Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy from a national perspective. Most commonly associated with the term are facilities for fire stations, police stations, hospitals, senior living facilities, and prisons. The benefits of the NED Plan (Alternative SB-7) would be primarily centered on Yuba City, leaving 11 elements of critical infrastructure in the communities of Live Oak, Gridley, and Biggs at risk from a 1% ACE event.

Critical Infrastructure Risk-Reduction Measures

Risk-reduction measures that could reduce loss of life and improve the function of critical infrastructure facilities that remain at risk from a 1% ACE event after implementation of the NED Plan were evaluated and screened.

- Ring levees to floodproof structures were considered to be ineffective for facilities like hospitals, correctional facilities, and assisted living centers, because the functionality of the facilities would be compromised by isolating facilities from the community during an average flood event, which is estimated to last 2–3 weeks (using historical Sutter Basin flood event data).
- Physically elevating smaller facilities such as police stations and fire stations might be economically justified, but their functionality during flood events would be compromised by isolating facilities from the community during a flood event.
- Relocation of critical infrastructure facilities was determined not effective in terms of expense and requirements of relocation structures too far from areas they are servicing due to floodplain footprint.
- Alternatives SB-4 and SB-8 provide structural fix-in-place or new levee measures that would effectively reduce loss of life and improve the function of critical infrastructure facilities left by the NED Plan.

Evacuation Routes

The primary urban centers in the study area are Yuba City, Biggs, Gridley, and Live Oak. These communities are all located on or near State Route 99, which runs north-south through the region. The Sutter County Evacuation and Mass Shelter/Care Plan identifies State Routes 20, 99, and 113 as the primary evacuation routes in the region. Evacuation routes are subject to change because they are event-specific and official evacuation routes are established by the county sheriff's office during an emergency. The Butte County Office of Emergency Management does not have published evacuation routes at this time, but anticipates State Routes 99 and 162 and the Colusa Highway could be used as conditions allow. Interior evacuation routes to the town of Sutter and Sutter Buttes could isolate evacuees within the Sutter Basin with limited support. The best emergency evacuation practices call for evacuating people out of the flooded areas to more secure and accessible locations whenever practical.

During the 1997 event, seven different evacuation zones needed to be established over seven days because of constantly changing conditions and levee breaks.

The main evacuation routes used for the 1997 flood event were State Route 99 north and State Route 113 south. State Route 20 west and State Route 99 south were used intermittently because not all portions of these roads were accessible at all times during the flood.

Evacuation preparation can be made days in advance for predictable flood events within the major river system in the study area. As river water levels rise and are predicted to reach flood stages, warnings would be reiterated and evacuation efforts increased. This would allow time for evacuation of immobile residents and other people with special evacuation needs (hospital patients, rest home residents, jail inmates, elderly individuals, school students) via the established routes. However, none of the historical flooding evacuations in the region has been due to foreseen events. Historical flood evacuations in the region have resulted from levee failures due to under-seepage, which is characterized by its unpredictability and resulting sudden levee failure. The result has been

evacuations after levees have failed and widespread flooding is in progress. The 1955 flood was due to a levee break in late December where no prior evacuation notice was given. In the 1997 flood, Yuba City was evacuated, but a levee on the east side of the Feather River near Olivehurst—which was not evacuated—unexpectedly failed.

The residual 1% ACE (1/100 year event) floodplain resulting from the NED Plan would affect every major urban center and nearly every primary evacuation route in the region. Although flood depths can be considered shallow (1 to 3 feet) in the northern area, the California Department of Transportation guidelines do not consider depths of flooding as a primary consideration for closure; it is the length or distance of roadways being flooded that determine road closures as directed by the California Highway Patrol.

The most critical levee breach scenario used to define the composite floodplain associated with the NED Plan would be a potential levee failure upstream of Sunset Weir resulting in flooding of the northern basin and communities. This breach location would cause flooding first in the northern area and communities, and continue to migrate south through Yuba City and into the deep southern basin area. All routes out of Biggs, Gridley, and Live Oak would be affected by the flood residual inundation. The only evacuation route from Yuba City would be provided by State Route 20 east into Marysville, which is a community surrounded by a ring levee with significant flood risk. Additionally, heading eastbound to Marysville entails driving over a four-lane bridge that may create a traffic bottleneck limiting the evacuation.

Evacuation Residual Risk Mitigation Measures

Specific measures to improve evacuation during a flood event were assessed and screened. Measures considered included modifying the elevations of roads used for evacuation.

- Flooding in the northern portion of the basin would involve extensive sheet flow (northeast to southwest) flood water movement. Elevating roadway embankments can result in even greater flood depths or redirecting the water to another roadway overtopping location. Any embankment modifications to roads and the railroad would need to be raised. Culverts would not be able to convey the flood flow. Therefore, most roadways would require extensive causeway type bridges or series of culverts.
- Raising roadways was considered to be cost and environmentally prohibitive relative to other measures due to the extensive construction, borrow, infrastructure, and real estate requirements.
- Raising the railroad that travels roughly north to south is considered to be more costly and complex than raising a vehicular road due to the larger footprint, more complex construction, extensive drainage infrastructure, and special requirements required by the railroad.
- Other internal evacuation routes from populated areas to the higher ground of Sutter Buttes or the town of Sutter were considered not viable due to the number of connector roads that would need to be raised. Evacuating to essentially an "island" at Sutter Buttes would be high risk and difficult to logistically support in emergencies. Evacuation out of the flooding area is always a best practice where practicable.
- Alternatives SB-4 and SB-8 provide structural fix-in-place or new levee measures that would effectively reduce residual risk by removing critical life safety infrastructure out of the

floodplain, creating critical additional evacuation routes and options for population centers in the northern area.

3.4.4.1.3 Potentially Developable Floodplains (Wise Use of Floodplains)

The NED Plan increases potentially developable floodplains as defined for this study to approximately 88,200 acres in Sutter Basin. The floodplain metric used in this analysis is a simple index based on basic physical parameters. The metric does not forecast future population growth, economic conditions, or government decisions that will constrain future floodplain development. Current measures in place to restrict or mitigate development in the Sutter Basin are listed below.

- Sutter and Butte County General Plans contain restrictive development policies for floodplains.
- Local policies, combined with recent state legislation and Federal regulations, are expected to limit land development.
- Conservation easements and Williamson Act contracts are in place, and the potential exists to expand use of these conservation tools.
- The State of California provides annual flood risk notifications to landowners.

3.4.5 Identification of the Final Array of Alternatives

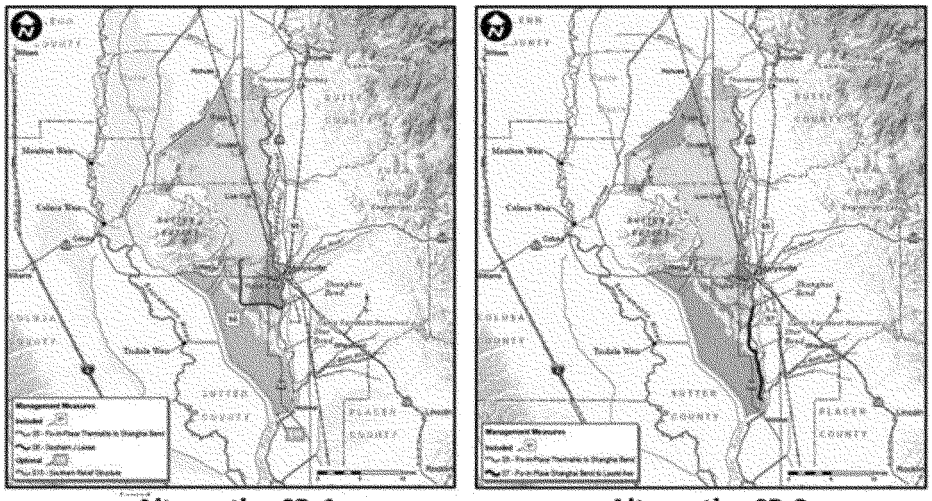
The NED Plan would reduce adverse flooding effects but significant residual risks would remain. Other alternatives and measures were evaluated and screened that would best mitigate the residual risk to life safety of the NED Plan. In summary, the completeness criteria screening identified Alternatives SB-4 and SB-8 as having low residual risk (see Figure 3-6). The other two alternatives identified with low residual risk, Alternatives SB-5 and SB-6, were both screened out as being less cost efficient. Alternative SB-6 was also screened out as having an unacceptable increase in potentially developable floodplain risk in the deep southern portion of the basin relative to the other alternatives.

Alternative SB-4 was dropped from further consideration due to its high cost ($798 million), low annual net benefits ($14 million), reduced life safety benefits in the southern Yuba City area, complexity, and high environmental impacts associated with new levee construction. This left Alternative SB-8 as a potential LPP alternative for the final array of alternatives.

3.4.6 Comparison of the Final Array of Alternatives

The screening process left the potential LPP, Alternative SB-8, as the alternative to be further evaluated and compared with the NED Plan. The levee fix-in-place extents of both the NED Plan (Alternative SB-7) and the potential LPP are shown in Figure 3-7. These two alternatives were evaluated in more detail using MCACES cost estimates, refined economic analysis and current price levels and interest rates.

Alternative SB-8 includes the NED Plan (Alternative SB-7), but contains additional fixes to existing project levees from Sunset Weir north to Thermalito Afterbay. These levee fix additions address the NED Plan's primary residual life safety risk in the northern area population centers of Live Oak, Gridley, and Biggs as shown on Figure 3-8. The geotechnical levee issues prevalent throughout all the levee sections and the hydraulic flow characteristics of the Feather River north of Yuba City necessitates addressing all the levee sections from Sunset Weir to Thermalito Afterbay.



Alternative SB-4 **Alternative SB-8**

(See the *Figures* folder on the CD for full-sized images.)

Figure 3-6. Floodplain Comparison of Alternatives SB-4 and SB-8

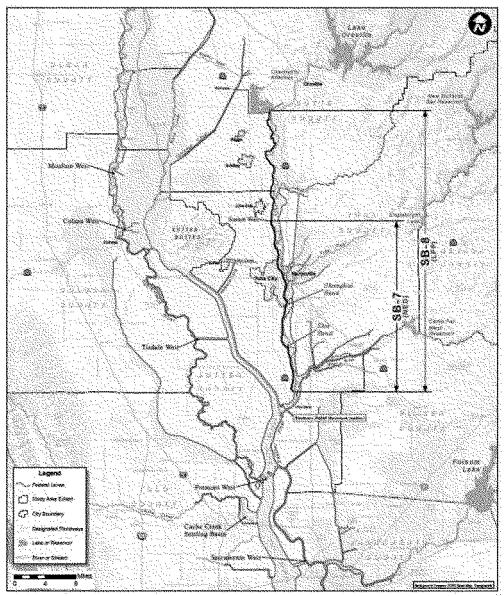


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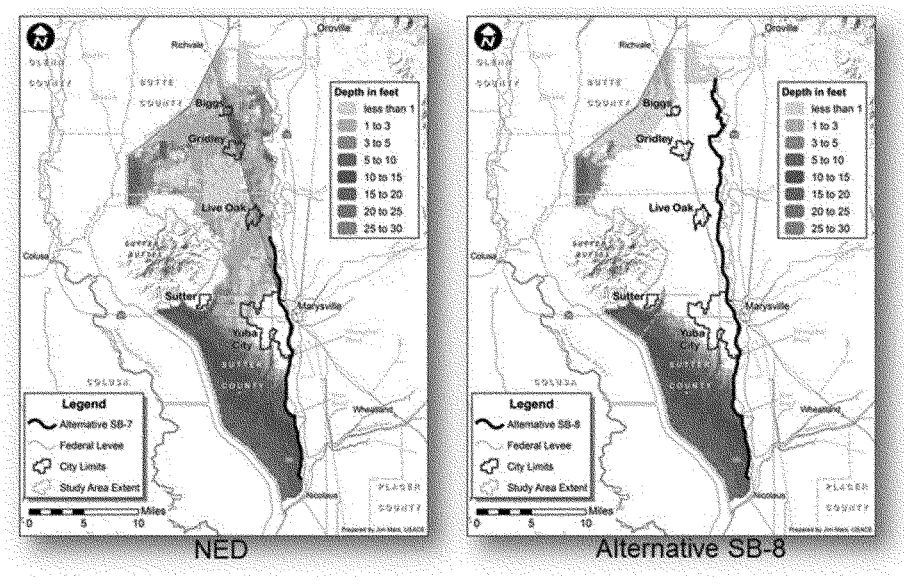
Figure 3-7. Alternative SB-7 (NED Plan) and SB-8 (LPP) Levee Extents



(See the *Figures* folder on the CD for a full-sized image.)

Figure 3-8. Residual 1% ACE Floodplains of the NED Plan and Alternative SB-8

3.4.6.1 Economic Comparison with the NED Plan

Alternative SB-8 has a roughly $297 million additional first cost (using the 80% confidence costs) and provides $7 million less in annual net benefits compared with the NED Plan. Alternative SB-8 is not incrementally economically justified, with a benefit to incremental cost ratio of approximately 0.5:1. However, Alternative SB-8 does provide additional annual benefits of $8 million and has a total benefit to cost ratio of 2.6 to 1 (see Table 3-13).

3.4.6.1.1 Population at Risk

The NED Plan would remove 60% of the basin population out of the 1% ACE floodplain while the LPP (Alternative SB-8) would remove 93% of the basin population out of the 1% ACE floodplain (see Table 3-14).

Life Safety Evaluation

To evaluate and estimate the potential loss of life and injury in a flood event that follows the planning modernization paradigm of employing sound qualitative analysis guided by professional judgment the Levee Screening Tool (LST) was used.

Table 3-13. Final Array of Alternatives – Incremental Probability Distributions Economic Comparisons (in millions)

Alternative	Total First Cost			IDC	Annualized Cost + O&M			Annual Benefits			Annual Net Benefits			Benefits to Cost Ratio		
	Low (25%)	Mid (50%)	High (75%)	Mid	Low (25%)	Mid (50%)	High (75%)	Low (75%)	Mid (50%)	High (25%)	Low	Mean	High	Low	Mean	High
SB-1: No Action	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SB-7: Fix-in-Place Feather River Levees: Sunset Weir to Laurel Avenue	355	370	386	36	17	17	18	43	64	109	33	54	79	2.9:1	4.1:1	5.5:1
SB-8: Fix-in-Place Feather River Levees: Thermalito Afterbay to Laurel Avenue	632	659	688	92	31	32	33	46	72	120	22	45	73	1.7:1	2.4:1	3.3:1
SB-8 incremental cost and benefits compared with SB-7	277	289	302	56	14	15	15	3	8	11	-11	-7	-5	0.2:1	0.5:1	0.7:1

Note: See Section 3.4.3.1, *Annual Net Benefits*, for explanation of economic ranges and calculations.
IDC = interest during construction.

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The LST provided a preliminary assessment of the general condition and associated risks of levee segments and systems in support of the USACE Levee Safety Program established in 2006 via the National Flood Risk Management Program. The LST provided an initial relative risk index to assist local, state, and Federal stakeholders in identification and prioritization of funding needs for levees of concern. Routine inspection data was combined with a preliminary engineering assessment to indicate the ability of a levee system to perform as intended and the consequences of potential failure (life loss and economic loss).

Table 3-14. Remaining Population at Risk within the 1% (1/100) ACE Floodplain

Community	NED Population Remaining at Risk	SB-8 Population Remaining at Risk	Reduction of Population at Risk
Yuba City	11,400	3,500	7,900
Biggs	1,500	20	1,480
Gridley	6,400	0	6,400
Live Oak	8,400	0	8,400
Rural Sutter County	5,800	3,100	2,700
Rural Butte County	4,800	20	4,780
Total	**38,200**	**6,600**	**31,600**

The computed fatalities under a breach scenario for the without-project condition (SB-1: No Action) are estimated to be 388 and 489 for day and night times, respectively. Table 3-15 indicates the results of the application of the LST to the estimated population under each alternative scenario. For the approximately 38,300 people at risk under Alternative SB-7, the potential loss of life estimate is 157 (day) and 197 (night). For the approximately 6,640 people at risk under Alternative SB-8, the potential loss of life estimate is 27 (day) and 34 (night).

Table 3-15. Loss of Life Estimate

	Alternative					
	SB-1		SB-7		SB-8	
Community	Day	Night	Day	Night	Day	Night
Biggs	6	8	6	8	0	0
Gridley	26	33	26	33	0	0
Live Oak	34	43	34	43	0	0
Yuba City	276	348	47	59	14	18
Rural Butte County	20	25	20	25	0	0
Rural Sutter County	26	32	24	30	13	16
Total	**388**	**489**	**157**	**197**	**27**	**34**

Note: The numbers generated by the Levee Screening Tool have very high uncertainties, and outputs are in the higher ranges.

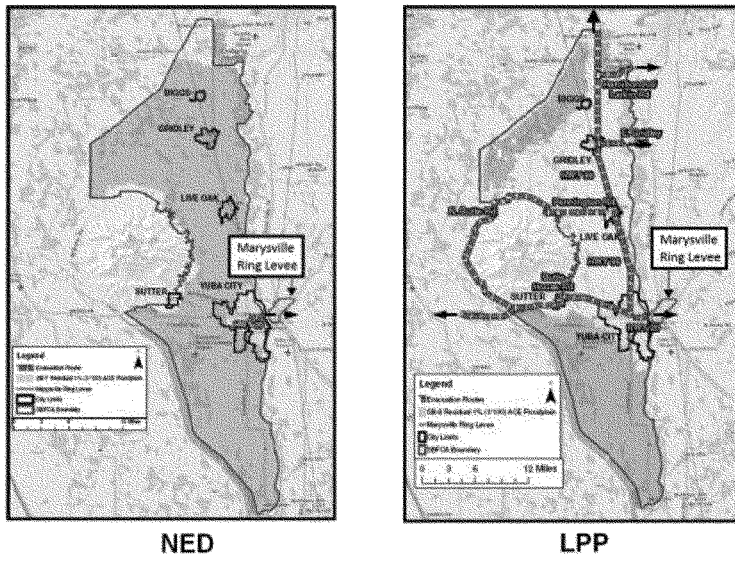
3.4.6.1.2 Evacuation Routes

The availability and access of evacuation route options during sudden, unpredictable flood events is a critical factor for effective and safe evacuations. With the population centers spread throughout the middle and northern sections of the Sutter Basin study area, evacuation route options are critical to evacuation planning and real time evacuation. Adjoining basins to the southwest, west, south, and east either have lower levels of flood protection or are surrounded by water during flood events, making them dangerous locations for evacuees.

The Sutter County Evacuation and Mass Shelter/Care Plan identifies State Routes 20, 99, and 113 as the primary evacuation routes in the region. These routes are subject to change because these routes are event-specific. Official routes are established by the county sheriff's office during an emergency. The Butte County Office of Emergency Management does not have published evacuation routes at this time but anticipates that State Routes 99 and 162 and Colusa Highway could be used as conditions allow. During the 1997 event, seven different evacuation zones were established over seven days in response to constantly changing conditions and levee breaks. The main evacuation routes used for this flood event were State Route 99 north and State Route 113 south. State Route 20 west and State Route 99 south were used intermittently because not all portions of these roads were accessible at all times during the flood.

Evacuation preparation can be made days in advance for predictable rain events. For example, a 0.2% ACE (1/500 year event) rain storm would be identified by meteorologists and residents could be given notice days in advance. As a significant rain event nears, warnings and evacuation efforts would be increased and reiterated. This would allow time for evacuation of immobile residents and other people with special evacuation needs (residents of hospitals, rest homes, and jails, elderly individuals, school students) via the established routes. However, none of the historical flooding evacuations in the region have been due to foreseen weather events. Historical flood evacuations in the region have resulted from levee failures due to under-seepage, which is characterized by its unpredictability and sudden occurrence. The result is evacuations occur after levees have failed and widespread flooding is in progress. The 1955 flood resulted from a levee break in late December when no prior evacuation notice was given. In the 1997 flood, Yuba City was evacuated; however, during the evacuation, a levee on the east side of the Feather River near Olivehurst (which was not evacuated) failed.

Every major population center and nearly every primary evacuation route in the region would remain in the residual 1% ACE floodplain resulting from implementation of the NED Plan (Alternative SB-7). The most critical levee breach scenario used to define the composite floodplain associated with the NED Plan would be a levee failure upstream of Sunset Weir floodplain. All routes out of Biggs, Gridley, and Live Oak would be affected by the residual flood inundation. The only egress from Yuba City would be State Route 20 east into Marysville, a community surrounded by a ring levee. Additionally, heading eastbound entails driving over a four-lane bridge that is not expected to adequately handle the additional traffic flow and is built to only a 1% ACE event (Figure 3-9).



NED LPP

(See the *Figures* folder on the CD for full-sized images.)

Figure 3-9. Comparison of NED Plan and LPP Evacuation Routes (Residual 1% ACE Floodplains)

3.4.6.1.3 Critical Infrastructure

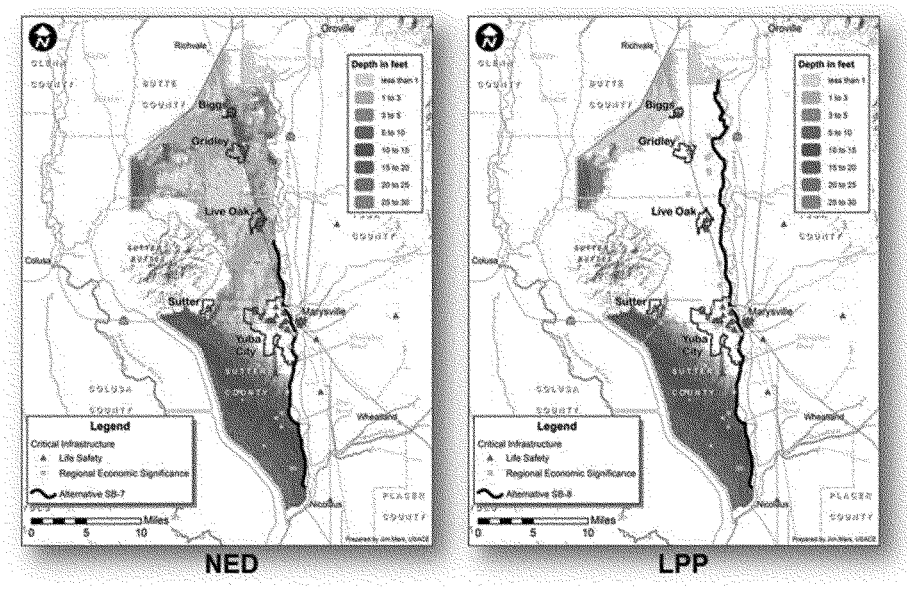
The NED Plan would leave numerous critical infrastructure facilities at risk in the residual 1% ACE floodplain in the cities of Biggs, Gridley, and Live Oak, and southern areas of Yuba City (Figure 3-10). A partial list of facilities at risk is provided here.

- 1 hospital (45 beds)
- 2 police stations
- 5 fire stations
- 1 assisted living center (99 beds)
- 3 city hall buildings
- 1 correctional facility (305 inmate capacity)
- 3 water and sewer treatment facilities
- Multiple telecommunication facilities

Additional comparisons of residential, commercial, and industrial structures were performed as part of the economic analysis to provide perspectives beyond the critical infrastructure of the communities and economic impact areas (see Table 3-16).

Table 3-16. Structures within the Residual 1% (1/100) ACE Floodplain

	Number of Structures within the 1% (1/100) ACE Residual Floodplain														
	Commercial			Industrial			Public			Residential			Total		
Economic Impact Analysis	SB-1 Without Project	SB-7 NED Plan	SB-8 LPP	SB-1 Without Project	SB-7 NED Plan	SB-8 LPP	SB-1 Without Project	SB-7 NED Plan	SB-8 LPP	SB-1 Without Project	SB-7 NED Plan	SB-8 LPP	SB-1 Without Project	SB-7 NED Plan	SB-8 LPP
Biggs	17	17	0	1	1	1	0	0	0	478	478	6	496	496	7
Gridley	80	80	0	7	7	0	4	4	0	1,931	1,931	0	2,022	2,022	0
Live Oak	51	51	0	5	5	0	23	23	0	2,088	2,088	0	2,167	2,167	0
Yuba City	871	5	5	210	2	2	122	2	2	18,709	985	985	19,912	994	994
Rural Butte County	10	10	0	16	16	1	0	0	0	1,203	1,203	7	1,229	1,229	8
Rural Sutter County	9	9	9	23	20	20	7	7	7	918	625	625	957	661	661
TOTAL	**1,038**	**172**	**14**	**262**	**51**	**24**	**156**	**36**	**9**	**25,327**	**7,310**	**1,623**	**26,783**	**7,569**	**1,670**



(See the *Figures* folder on the CD for full-sized images.)

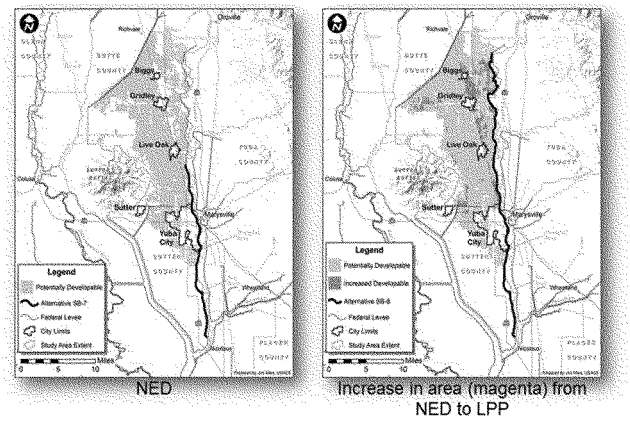
Figure 3-10. Critical Infrastructure and Life Safety Comparison

3.4.6.1.4 Potentially Developable Floodplain

Potentially developable land in the residual 1% ACE floodplain was calculated as an evaluation metric. This assumes that land is developable if the 1% ACE floodplain depths are 3 feet or less (Figure 3-11). The calculation estimates the potential of roughly 12,000 additional acres made available for development under the LPP than under the NED Plan.

Sutter Basin is an agriculturally focused region. The local and state partners have several existing land use commitments and constraints to floodplain development.

- Williamson Act contracts: These rolling 10-year agreements between local government and farmers preserve agricultural lands and open space in rural California by offering landowners tax breaks on the assessed land value.
- Conservation easements: These agreements between landowners and agencies such as the U.S. Fish and Wildlife Service (USFWS) permanently preclude future development.
- Flood risk notifications: State of California sends annual flood risk notifications to all affected property owners.



(See the *Figures* folder on the CD for full-sized images.)

Figure 3-11. Potentially Developable Floodplain Comparison

Other measures for addressing additional potential developable floodplain acres beyond the measures already in place include purchasing additional flood or land use restriction easements.

3.4.6.1.5 Incremental Cost Effectiveness Comparison of Risk-Reduction Measures

With the NED Plan identified, and Alternative SB-8 confirmed as an LPP that best addresses the residual risk of the NED Plan, mitigation measures were considered and evaluated for effectiveness and cost efficiency as part of the iterative planning process to reduce the residual risk left after implementation of the NED Plan. A cost effectiveness comparison analysis was performed and a table of the identified risk-reduction measures was developed (see Tables 3-17 and 3-18).

The metrics used for comparison of risk-reduction measures were estimated costs, annual benefits, population-at-risk, estimated loss of life, critical infrastructure, evacuation routes, flooding characteristics, and potentially developable floodplain. Table 3-17 summarizes the residual risk of the NED Plan (Alternative SB-7) and the LPP (Alternative SB-8). Table 3-18 compares each nonstructural risk-reduction measure with Alternative SB-7 and with Alternative SB-8 for effectiveness by evaluation metric.

This analysis serves to capture the potential range of cost-effective risk-reduction measures to reduce the loss of life and protect critical infrastructure in the Sutter Basin study area. This qualitative analysis was guided by professional judgment, rather than heavily based on the quantitative processes used during alternative selection. The analysis reveals that the only possible measure competitive with Alternative SB-8 (in terms of outputs for the northern basin) is relocations, a measure that has greater costs.

The results of the cost-effectiveness comparison indicate that the most cost-effective measure to address the residual risk of the NED Plan alternative is a more extensive fix-in-place levee alternative (Alternative SB-8).

Table 3-17. Summary of Residual Risk – North Basin Only (Biggs, Gridley, Live Oak, and Rural Butte County)

Alternative	Incremental First Cost [Total Cost] (Millions)	Residual Annual Damages (Millions)	Annual Benefits (Millions)	PAR during 1% ACE Event (Persons)	Estimated Loss of Life during 1% ACE Event (Persons)	Critical Inf. in floodplain (Structures)	Evacuation Routes	1% Event Flooding Characteristics within Reduced Risk Area			Potentially Developable Floodplain (Acres)
								AEP	Depth	Extent	
Final Array of Alternatives – Entire Basin											
SB-1: No Action	0	137	0	94,600	112	28	0	8%	1–15 ft	High	71,800
SB-7	391 [391]	58	79	38,200	45	10	1	0.3%	1–7 ft	Med	88,200
SB-8	297 [689]	50	87	6,600	8	1	5	0.2%	0–1 ft	Low	100,200
NED Plan Residual Risk – Northern Basin Only											
SB-7	n/a	11	0	21,100	26	9	1	8%	1–7 ft	Med	45,570
LPP Plan Residual Risk – Northern Basin Only											
SB-8	n/a	3	8	40	0	0	5	0.2%	0–1 ft	Low	58,265

PAR = population at risk
ACE = annual chance exceedance
Inf. = infrastructure
AEP = annual exceedance probability

Table 3-18. SB-7 NED Plan Residual Risk–Reduction Measures Summary – Northern Basin (Biggs, Gridley, Live Oak, Rural Butte County)

Alternative or Measures	Compare with SB-7 & SB-8	Incremental First Cost [Total Cost]	Annual Damages	Annual Benefits	PAR during 1% ACE event	Estimated Loss of Life	Critical Inf. in Floodplain	Evacuation Routes	1% ACE Event Flood Characteristics within Reduced Risk Area	Potentially Developable Floodplain
(a) Raise Homes	vs. SB-7	+ [+]	-	+	-	-	=	=	=	=
	vs. SB-8	+ [+]	+	-	=	+	+	-	+	-
(b) Flood Proof Critical Infrastructure	vs. SB-7	+ [-]	-	+	=	=	-	=	=	=
	vs. SB-8	- [-]	+	-	+	+	=	-	+	-
(c) Elevated Evacuation Route	vs. SB-7	+ [+]	=	=	=	-	-	+	=	=
	vs. SB-8	+ [+]	+	-	+	+	+	-	+	-
(d) Ring Levees	vs. SB-7	+ [+]	-	+	-	-	-	-	-	+
	vs. SB-8	+ [+]	+	-	+	+	+	-	=	-
(e) Buyouts (Relocations)	vs. SB-7	+ [+]	-	+	-	-	=	=	=	=
	vs. SB-8	+ [+]	-	+	=	=	=	-	+	-
(f) SB-8	vs. SB-7	+ [+]	-	+	-	-	-	+	-	+
	vs. SB-8	= [=]	=	=	=	=	=	=	=	=

Key:

-	Metric is lower		Less effective
=	Metric is equal		Equally effective
+	Metric is higher		More effective

PAR = population at risk
ACE = annual chance exceedance
Inf. = infrastructure
AEP = annual exceedance probability

3.4.6.1.6 Cost Effectiveness of Structural vs. Nonstructural Mitigation Measures

A last general cost comparison of Alternative SB-8 with nonstructural measures was performed, at a very conceptual level of detail, to verify that the structural measures of Alternative SB-8 are the most cost effective in addressing the residual risk and consequences left by the NED Plan. Fix-in-place levees structural measures of Alternative SB-8 are estimated to cost $260 million to $330 million more than the NED Plan. Various structural and nonstructural measures addressing similar residual risk areas were conceptually estimated and found generally to have considerably higher costs and impacts compared with the costs and impacts of Alternative SB-8's structural measures, as identified below.

- Elevate houses: approximately $650 million.
- Provide evacuation route by elevating causeway and retrofitting existing bridges: approximately $650 million.
- Construct ring levees around Live Oak, Gridley, and Biggs: approximately $375 million.
- Buyout at-risk property owners: approximately $1 billion.

The results of the comparison show Alternative SB-8 as best addressing the residual risks of the NED Plan.

3.4.7 Summary of Evaluation Metrics on Public Safety

Alternative SB-8 is the multi-objective alternative that is cost effective and best reduces flooding and residual risk to public and life safety in the Sutter Basin. Alternative SB-8 is composed of Alternative SB-7, plus fixes-in-place the northern Feather River levees from Sunset Weir north to Thermalito Afterbay. The total first cost estimate is $689 million with annual net benefits of $54 million.

The additional investment of $302 million in project cost (Alternative SB-8 first cost minus the Alternative SB-7: NED Plan cost) would buy down the residual risk of the NED Plan, provide additional annual benefits ($8 million), and provide significant non-monetized benefits (See Table 3-19). The population at risk of flooding from a 1% ACE flood event would decrease from 38,200 to 6,600, critical infrastructure facilities at risk would be reduced from 11 to 1, and the number of evacuation routes would increase from 1 to 5.

Table 3-19. Summary of Public Safety Metrics

		Alternative		
Evaluation Metric	**Measurement**	**SB-1: No Action**	**SB-7: NED Plan**	**SB-8: LPP**
Population at Risk	People	94,600	38,200	6,600
Critical Infrastructure	Facilities	28	11	1
Evacuation Routes	Number of Routes	0	1	5
Potentially Developable Floodplains	Acres	71,800	88,200	100,200

Because Alternative SB-8 reduces flood risk and significantly reduces the residual risk of the NED Plan, Alternative SB-8 is supported by the local sponsors as the LPP, and can be considered multi-objectively (reducing flood risk and risk to public and life safety) a more comprehensive and complete Federal plan.

3.4.7.1 Separable Area Consideration

Separable areas or elements are defined hydrologically for the study as the subdivision of a study area's flood risk based on hydrologic and hydraulic characteristics and functions with identifiable and distinct economic benefits. While not specific to "hydrological separableness," "separable element" is defined in 33 United States Code (USC) Section 2213(f) as a portion of the project that "(1) is physically separable from other portions of the project; and (2)(a) achieves hydrologic effects, or (b) produces physical or economic benefits, which are separately identifiable from those produced by other portions of the project." The Sutter Basin study area has three separable hydrologic areas, one north of Yuba City, one centered in Yuba City, and one south of Yuba City.

An evaluation of how the Sutter Basin study area and the TSP meet the 33 USC Section 2213(f) requirements is provided below.

- **(1) is physically separable from other portions of the project**

  Within the Sutter Basin study area, the floodplain has a relatively low gradient and the hydrologically separable areas are not clearly defined by basic topographic features alone, therefore the physical separation is best understood by analyzing the hydrologic characteristics. In general, there are three separable hydrologic areas. The separation is evident in levee breach simulations conducted for the study and the functionality of the alternatives.

- **and (2) (a) achieves hydrologic effects**

  The north of Yuba City separable area can only see a reduction in residual hydrologic floodplain from levee fixes associated with the SB-8 increment. The Yuba City separable area can only see significant reduction in residual hydrologic floodplains from levee fixes associated with the SB-7 increment. The south of Yuba City separable area can only see significant reduction in residual hydrologic floodplains from levee fixes associated with the lower Feather River and the Sutter Bypass, which are not part of the TSP.

- **or (b) produces physical or economic benefits, which are separately identifiable from those produced by other portions of the project.**

  SB-7 has distinctly identifiable economic benefits within the Yuba City separable area of $60 million that cannot be produced by any other portions of the project. The SB-8 increment has distinctly identifiable economic benefits within the north of Yuba City separable area of $8 million that cannot be produced by any other portions of the project.

The breach simulations for a 1% ACE event are shown in the Engineering Appendix, Hydraulic attachment (Appendix C1b, *Hydraulic Design and Analysis*) and are described in the following three sections and Figures 3-12, 3-13, and 3-14.

With respect to evacuation considerations related to life safety, travel routes between the hydrologically separable areas and the flood risk of the final destination was also considered.

The separable area evaluation has determined that the study area has separable areas and the TSP is by itself separable, meeting the 33 USC Section 2213(f) requirement. This conclusion also supports the completeness determination for the TSP.

3.4.7.1.1 Separable Hydrologic Floodplain 1: North of Yuba City

A breach in the area along the Feather River north of Yuba City would permit floodwaters to flow southwest and inundate the towns of Biggs, Gridley, Live Oak, and the western and southern fringes of Yuba City. Due to the topography, the northern areas of the Sutter Basin are not susceptible to flooding from a breach in the southern portion of the study area including the Sutter Bypass. This reach of levee represents the additional increment of Feather River levee fix for SB-8 over and above SB-7, and the physical separability is demonstrated by distinct flooding north of Yuba City.

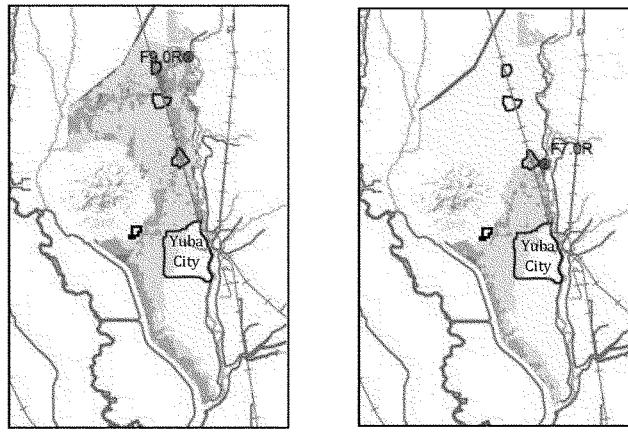


Figure 3-12. Separable Hydrologic Floodplain 1: Levee Breaches North of Yuba City

3.4.7.1.2 Separable Hydrologic Floodplain 2: Yuba City

A breach along the Feather River adjacent to Yuba City would permit floodwaters to flow directly through Yuba City and inundate the southern portion of the Basin. Due to topography, a breach at Yuba City would not inundate the northern portion of the study area. The Yuba City area is not susceptible to flooding from a Sutter Bypass or southern Feather River breach. This reach of levee represents the extent of levee fixes for SB-7, and the physical separability is demonstrated by distinct flooding within Yuba City.

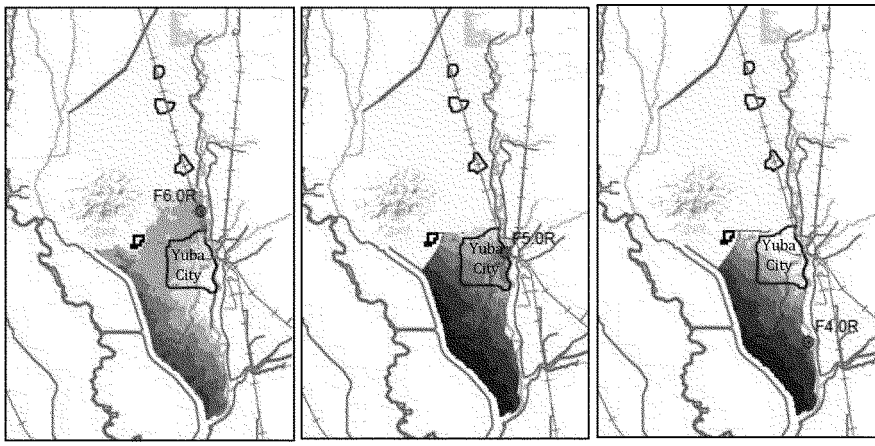


Figure 3-13. Separable Hydrologic Floodplain 2: Levee Breaches Near or In Yuba City

3.4.7.1.3 Separable Hydrologic Floodplain 3: South of Yuba City

A breach on the southern end of the Feather River or Sutter Bypass would inundate this portion of the study area (deepest part of the basin). A breach south of Yuba City would not result in inundation of Yuba City or the areas north of Yuba City. This reach of the Feather River levee represents the extent of levee not proposed for fix by either SB-7 or SB-8, and the physical separability is demonstrated by distinct flooding only in the area south of Yuba City.

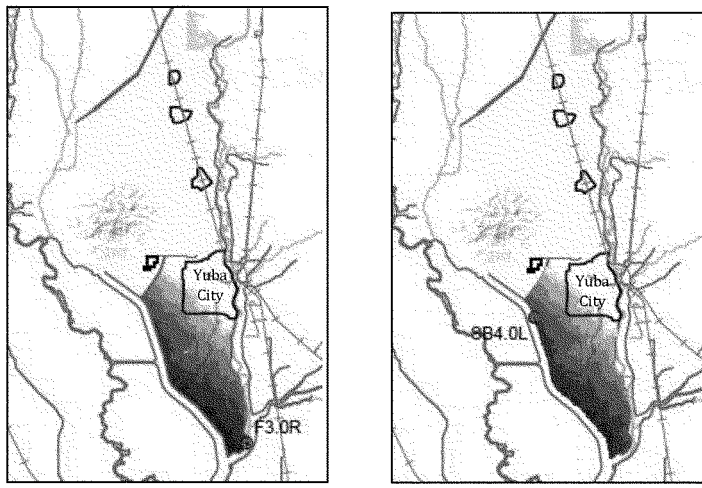


Figure 3-14. Separable Hydrologic Floodplain 3: Sutter Bypass Levee Breach or Feather River Levee Breach South of Yuba City

3.4.8 Final Array of Alternatives

With the identification of the NED Plan and the LPP, a final array of alternatives was determined.

- No Action: Alternative SB-1. This is the no action and future without-project condition alternative and is required to be in the final array.
- NED Plan: Alternative SB-7. This alternative reconfirms the Federal interest and reduces flood risk to most of the Yuba City area, but leaves considerable residual flood risk to public and life safety in the northern communities of the Sutter Basin and parts of Yuba City.
- LPP: Alternative SB-8. This alternative reconfirms the Federal interest the same as the NED Plan does, but significantly reduces residual risk of the NED Plan in the northern communities of Live Oak, Biggs, and Gridley, and in additional areas of Yuba City. Alternative SB-8 has been identified through multi-objective planning using evaluation metrics as a comprehensive Federal plan.

The Alternative SB-1 is included in the final array because NEPA and CEQA require an analysis of the no action alternative for purposes of comparison against the action alternatives. The No Action Alternative or future without-project alternative is described in Section 3.3.2, *Alternative SB-1: No Action*.

The screening process leading to the identification of the final array of alternatives was based on a Class 4 Analysis (reconnaissance level) as described in Section 3.2.1, *Level of Detail and Design Assumptions*. The final array of alternatives (SB-7 and SB-8) is now evaluated in more detail using the Class 3 Analysis (feasibility level and costs). Both of these alternatives includes the nonstructural measures of a flood warning system, emergency evacuation plan, and flood fight pre-staging equipment and supply areas.

For alternatives SB-7 and SB-8, a reach identification system was developed as shown on Plate 3-1. Alternative SB-8 contains 41 reaches (2A north to 41) along the Feather River West Levee (FRWL)) alignment, beginning approximately 1.7 miles north of the State Route 99 bridge over the Feather River (at station 180+00, approximately 2,250 feet south of Laurel Avenue) and extending north approximately 41 miles to the Thermalito Afterbay, downstream of Oroville Dam (at station 2368+00). Alternative SB-7 contains 21 reaches (2A north to 21) along the FRWL alignment, beginning at the same point south of Laurel Avenue and extending approximately 24 miles north to immediately north of Sunset Weir (station 1433+83).

3.5 Levee Design Measures

3.5.1 Selection of Design Measures

Two primary design measures of the alternative were evaluated. In general, the measures were a fully penetrating soil-bentonite cutoff wall and a partially penetrating soil-bentonite cutoff wall combined with a seepage berm or relief wells. Both measures would include a partial levee degrade to obtain the needed working platform width. A full levee degrade is proposed where the levee has a severe burrowing rodent infestation or to prevent having to use the more expensive Deep Soil Mixing method for cutoff wall construction due to depth. A reach-by-reach cost comparison between the two measures showed a fully penetrating soil-bentonite cutoff wall was the lowest cost measure for most reaches. However, site conditions dictated selection of a different measure for some reaches or portions of reaches.

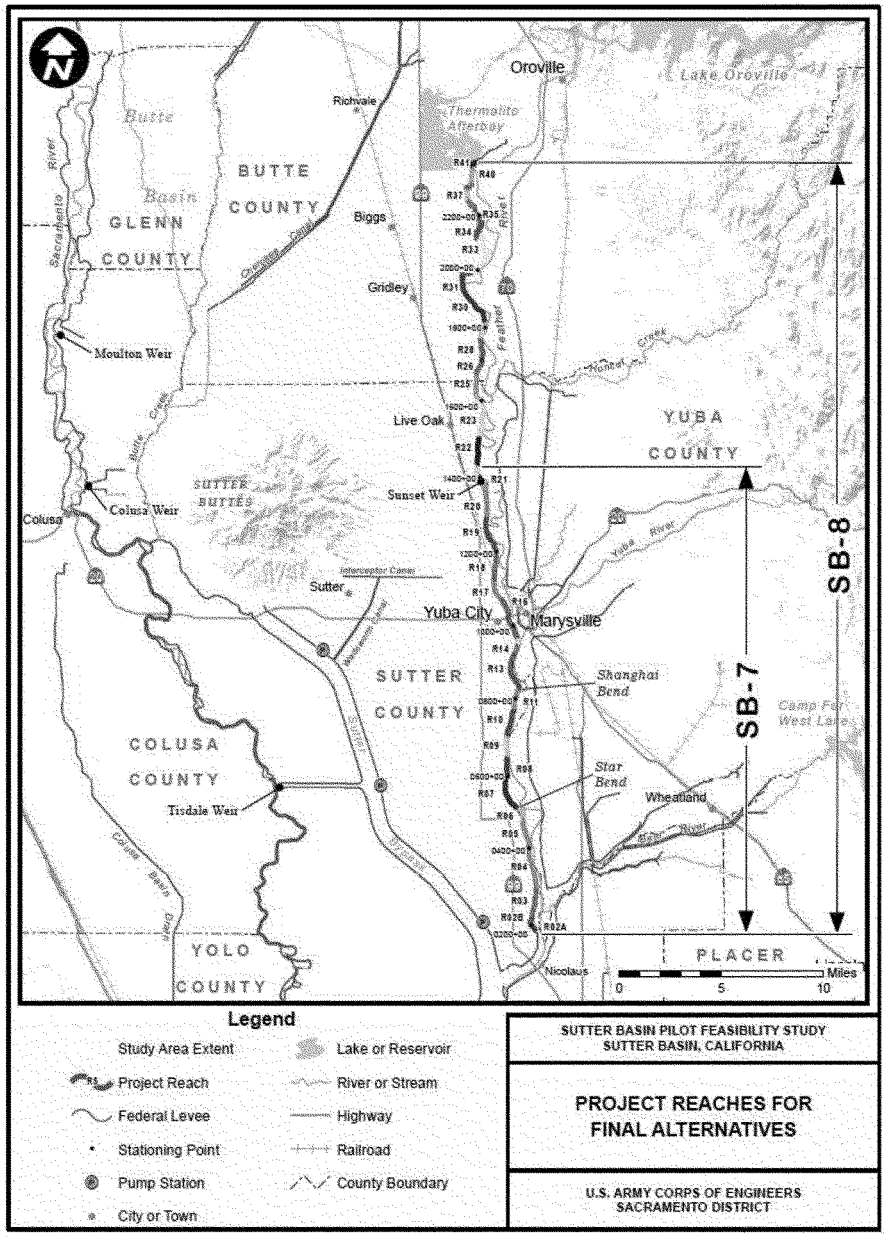


Plate 3-1. Project Reaches for Final Alternatives

Jet grouting cutoff walls are proposed at locations where it is not practical to construct a conventional soil-bentonite cutoff wall (i.e., at bridges, railroad crossings, and the Yuba City water treatment plant). Seepage berms by themselves are proposed for the northernmost end of the FRWL because a conventional soil-bentonite cutoff wall is not constructible through the cobble levee. Partially penetrating cutoff walls combined with seepage berms or relief wells are proposed for the southern end of the FRWL because fully penetrating cutoff walls would need to be too deep to be cost effective. A cutoff wall with levee relocation and a cutoff wall with Sutter Butte Canal relocation are proposed for some levee sections along the FRWL (north of Sunset Weir, where the Sutter Butte Canal is located adjacent to the landside levee toe) to obtain the required operations and maintenance (O&M) corridors.

3.5.2 Proposed Design Measures and Features

The proposed design features and measures are listed below.

- Soil-Bentonite Cutoff Walls
- Jet Grouting Cutoff Walls
- Seepage Berms
- Levee Relocations
- Canal Relocations
- Embankment Reconstruction/Landside Toe Fill
- Erosion Protections
- Closure Structure
- Utility Improvements
- Utility Relocations
- Structural Relocations

Levee Superiority – Hardening of Levee Locations

These features and measures would rehabilitate, replace, or tie in and function in conjunction with the existing system. The existing system includes the following features.

- Embankment
- Cutoff Walls
- Stability Berms
- Relief Wells
- Closure Structures
- Toe Drains

Plate 3-2 shows the location of proposed levee improvements and reaches. As shown in Plate 3-2, Alternatives SB-8 and SB-7 are similar in that the same design measures are proposed where the two alternatives overlap. Refer to the Engineering Appendix (Appendix C).

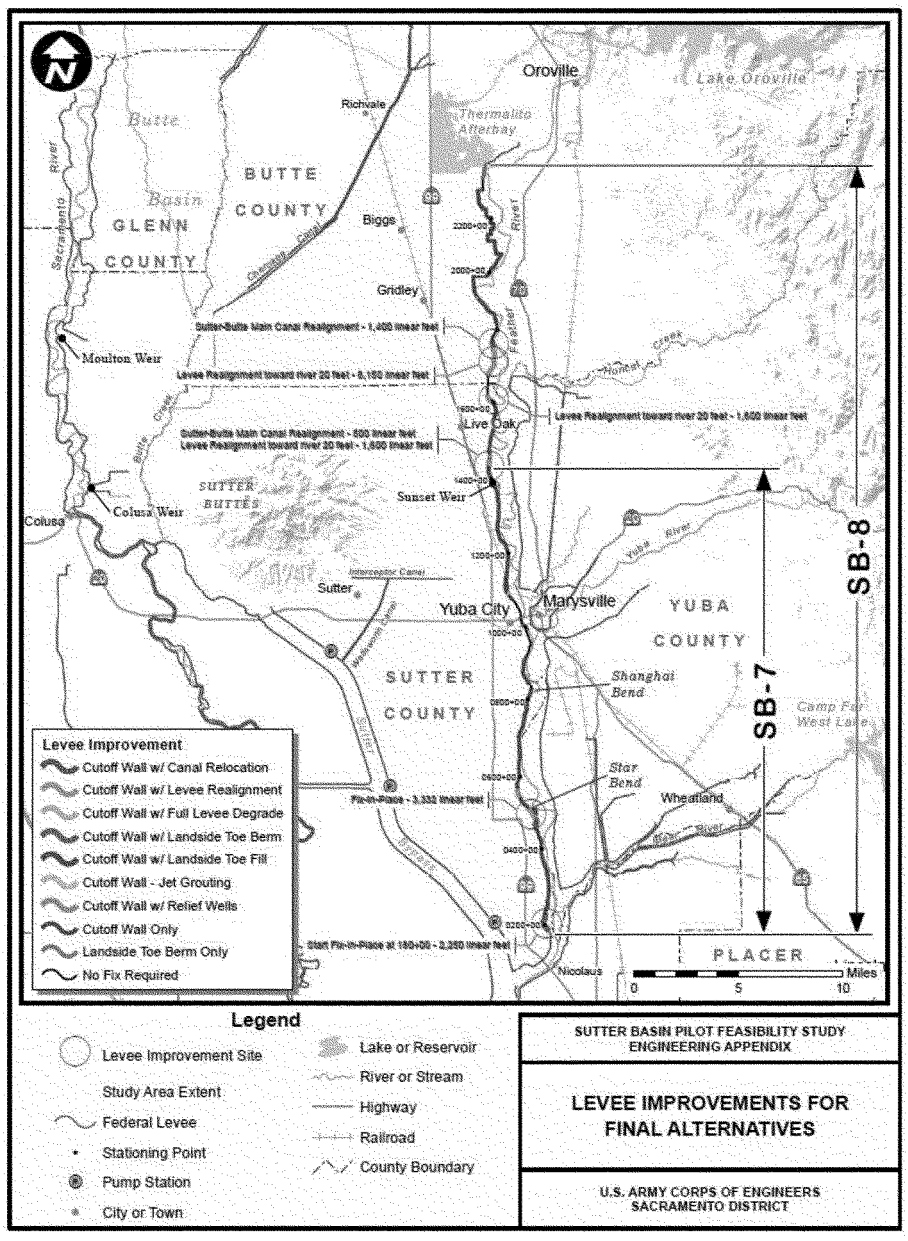


Plate 3-2. Levee Improvements for Final Alternatives

3.6 Locally Preferred Plan: Alternative SB-8

Alternative SB-8 contains 41 reaches (2A to 41) along the FRWL alignment, beginning approximately 1.7 miles north of the State Route 99 bridge over the Feather River (at station 180+00, approximately 2,250 feet south of Laurel Avenue) and extending north approximately 41 miles to the Thermalito Afterbay, downstream of Oroville Dam (at station 2368+00).

Plate 3-2 shows the location of proposed levee improvements and Table 3-20 summarizes the levee improvements by reach.

In addition, there are seven levee sections along the FRWL alignment where fix-in-place work is not required. These sections are between: (1) station 831+50 and 844+50, (2) 923+75 and 1006+24, (3) 1007+70 and 1024+00, (4) 1027+50 and 1078+00, (5) 1625+00 and 1673+00, (6) 1769+40 and 1813+30, and (7) 2303+00 and 2331+00, approximately. See Table 3-20 for more details. Existing cutoff walls (30 to 50 feet in depth) are present within the first four levee sections.

Table 3-20. Alternative SB-7 (Reach 2A North to Reach 21) and SB-8 Proposed Design Measures

Reach	Station	Length (feet)	Primary Design Measures
2A North	180+00 to 202+50	2,250	Cutoff wall with 100-foot-wide undrained seepage berm
2B	202+50 to 218+66	1,616	Cutoff wall with 100-foot-wide undrained seepage berm
3	218+66 to 300+66	8,200	Cutoff wall with 100-foot-wide undrained seepage berm (218+66 to 231+00) Cutoff wall (230+00 to 231+00)
4	300+66 to 410+67	11,001	Cutoff wall
5	410+67 to 478+68	6,801	Cutoff wall (410+67 to 478+65) Cutoff wall with 300-foot-wide undrained seepage berm (453+00 to 478+00)
6 FIP	478+68 to 512+00	3,332	Cutoff wall
6 SB	478+68 to 512+00	3,332	Remove the existing levee and construct a setback levee with 65-foot-deep (from degrade line) cutoff wall
7	512+00 to 596+00	8,563	Cutoff wall (512+00 to 596+00) Cutoff wall with relief wells (545+00 to 570+00) Erosion Protection (High-Performance Turf Reinforced Mat) (547+00 to 596+00)
8	596+00 to 654+75	5,875	Cutoff wall (596+00 to 654+75) Erosion Protection (High-Performance Turf Reinforce Mat) (596+00 to 604+60)
9	654+75 to 706+50	5,175	Cutoff wall
10	706+50 to 774+00	6750	Cutoff wall
11	774+00 to 830+00	5,600	Cutoff wall

Reach	Station	Length (feet)	Primary Design Measures
12	830+00 to 845+00	1,500	No proposed design measure with exceptions below Cutoff wall (transition only, at both ends of this reach) Cutoff wall, transition only (830+00 to 831+50) Cutoff wall, transition only (844+50 to 845+00)
13	845+00 to 927+00	8,200	Cutoff wall Cutoff wall with full levee degrade and re-construction (844+50 to 897+50)
14	927+00 to 954+40	2,740	No proposed rehabilitation measure
15	954+40 to 968+50	1,410	No proposed rehabilitation measure
16	968+50 to 1080+00	11,150	Jet grouting cutoff wall at 5th Street bridge crossing (1006+04 to 1007+90) Toe berm, 23 feet wide, at 10th Street bridge crossing (1023+90 to 1027+50) Cutoff wall and backfill landside toe depression, transition only (1077+85 to 1080+00)
17	1080+00 to 1130+86	5,086	Backfill landside toe depression (1107+00 to 1125+70) Cutoff wall (1080+00 to 1096+00) Jet grouting cutoff wall at Yuba City water treatment plant (1095+80 to 1098+30 Cutoff wall (1098+10 to 1129+50) Jet grouting cutoff wall at railroad north of Yuba City (1129+50 to 1130+67) Cutoff wall (1130+20 to 1130+86) Stop log closure structure or equivalent at 1130+00
18	1130+86 to 1213+85	8,299	Cutoff wall
19	1213+85 to 1297+83	8,398	Cutoff wall
20	1297+83 to 1374+33	7,650	Cutoff wall
21	1374+33 to 1433+83	5,950	Cutoff wall (1374+33 to 1432+50) Cutoff wall with levee relocation (20 feet riverward, transition only), (1432+50 to 1433+83) Sutter Butte Canal relocation (1429+00 to 1433+83)
22	1433+83 to 1503+83	7,000	Cutoff wall with levee relocation (20 feet riverward) (1433+83 to 1450+00) Cutoff wall with levee relocation (20 feet riverward, transition only) (1450+50 to 1451+50) Cutoff wall with full levee degrade and re-construction (1455+00 to 1461+00) Cutoff wall (1461+00 to 1503+83)
23	1503+83 to 1609+37	10,554	Cutoff wall (1503+83 to 1608+75) Cutoff wall with levee relocation (20 feet riverward, transition only)(1608+50 to 1609+37) Erosion Protection: High-Performance Turf Reinforce Mat (1582+00 to 1601+00)
24	1609+37 to 1623+86	1,449	Cutoff wall with levee relocation (20 feet riverward, transition only) (1609+37 to 1612+00) Cutoff wall with levee relocation (20 feet riverward) (1612+00 to 1623+00) Cutoff wall with levee relocation (20 feet riverward, transition only) (1623+00 to 1623+86)

Reach	Station	Length (feet)	Primary Design Measures
25	1623+86 to 1674+37	5,051	Cutoff wall with levee relocation (20 feet riverward, transition only) (1623+86 to 1624+50) Cutoff wall (transition only)(1623+86 to 1625+00) Cutoff wall (transition only)(1673+00 to 1674+37) Cutoff wall with levee relocation (20 feet riverward, transition only) (1673+00 to 1674+37)
26	1674+37 to 1707+11	3,274	Cutoff wall with levee relocation (20 feet riverward, transition only) (1674+37 to 1675+00) Cutoff wall with levee relocation (20 feet riverward) (675+00 to 1707+11)
27	1707+11 to 1721+60	1,449	Cutoff wall with levee relocation (20 feet riverward) (1707+11 to 1721+60)
28	1721+60 to 1769+31	4,771	Cutoff wall with levee relocation (20 feet riverward)(1721+60 to 1753+00) Cutoff wall with levee relocation (20 feet riverward, transition only)(1753+00 to 1754+50) Sutter Butte Canal Relocation (1752+00 to 1766+00) Cutoff wall (1754+50 to 1769+31)
29	1769+31 to 1813+33	4,402	No proposed rehabilitation measure
30	1813+33 to 1902+00	8,867	Cutoff wall (1813+33 to 1900+50) Jet grouting cutoff wall (1900+00 to 1902+00)
31	1902+00 to 1958+00	5,600	Jet grouting cutoff wall (1902+00 to 1904+00) Cutoff wall (1904+50 to 1958+00)
32	1958+00 to 1989+00	3,100	Cutoff wall
33	1989+00 to 2122+00	13,300	Cutoff wall
34	2122+00 to 2182+00	6,000	Cutoff wall
35	2182+00 to 2224+00	4,200	Cutoff wall
36	2224+00 to 2259+00	3,500	Cutoff wall
37	2259+00 to 2290+00	3,100	Cutoff wall
38	2290+00 to 2303+00	1,300	Seepage berm up to 11 feet high tapering to a distance 170 feet from the centerline of the existing levee (2290+00 to 2303+00) Seepage berm with cutoff wall (transition only, extend from reach 37 into reach 38 Cutoff wall (transition only) (2290+00 to 2292+00)
39	2303+00 to 2319+00	1,600	No proposed rehabilitation measure
40	2319+00 to 2359+00	4,000	No design measure: 2319+00 to 2331+00 Seepage berm 120 feet wide (2331+00 to 2335+00) Seepage berm 100 feet wide (2335+00 to 2359+00)
41	2359+00 to 2368+00	900	Seepage berm 100 feet wide with filter drain (2359+00 to 2368+00)

3.7 NED Plan: Alternative SB-7

Alternative SB-7 contains 21 reaches (2A to 21) along the FRWL alignment, beginning at station 180+00 (approximately 2,250 feet south of Laurel Avenue) and extending approximately 24 miles north to station 1433+83 (immediately north of Sunset Weir). The levee reaches are shown on Plate 3-1. Table 3-20 summarizes the design measures.

There are four levee sections along the FRWL alignment where fix-in-place work is not required. These sections are between: (1) 831+50 and 844+50, (2) 923+75 and 1006+24, (3) 1007+70 and 1024+00, and (4) 1027+50 and 1078+00, approximately. See Table 3-20 for more details. Existing cutoff walls (30 to 50 feet in depth) are present within these levee sections.

3.8 Common Elements and Environmental Commitments of Alternatives

The following sections describe the project elements and environmental commitments common to Alternatives SB-7 and SB-8.

3.8.1 Borrow and Disposal Requirements

3.8.1.1 Borrow Requirements

While some of the embankment material removed during levee degrading would be re-used to reconstruct the levee, it is anticipated that borrow materials would be needed to meet the levee fill material specifications. Two primary types of borrow material needed for levee and cutoff wall construction are Type 1 levee fill, primarily used as a clay core for the reconstructed levee above the cutoff wall and for the soil-bentonite mix, and Type 2 levee fill, primarily used for shells for the reconstructed levee above the cutoff wall.

As part of SBFCA's early implementation project for the Feather River West Levee Project (FRWLP), 13 sites were identified as potential borrow areas, 5 of which were eliminated as a result of a preliminary screening process. The screening criteria include contamination level, and relative location to the levee or seepage berm. SBFCA and USACE will sample and test the sites to ensure they meet material requirements. It was estimated that the borrow sites can provide up to 1,349,900 cubic yards of Type 1 fill material, 459,800 cubic yards of Type 2 fill material, and 330,800 cubic yards of Random fill material.

Alternative SB-8 may require up to 629,810 cubic yards of Type 1 fill material, 809,845 cubic yards of Type 2 fill material, and 179,520 cubic yards of Random fill material. All are included in the total project cost.

Alternative SB-7 may require up to 419,760 cubic yards of Type 1 fill material, 579,045 cubic yards of Type 2 fill material, and no Random fill material. All are included in the total project cost.

3.8.1.2 Disposal Requirements

Implementation of Alternatives SB-7 and SB-8 may generate up to 813,000 cubic yards of solid waste that would require disposal. Solid waste related to construction activities would include levee material, structural debris from removal of residences and agricultural structures, and roadway pavements.

The solid waste facilities nearest to the project area are the Ostrom Landfill (located east of the project site, approximately 30 miles south of Reach 2) and the Neal Road Landfill (located 25 miles north of Reach 40).

The 225-acre Class II Ostrom Landfill is permitted to accept the following types of waste: solid waste; wastewater treatment sludge; construction debris; food and green waste; some types of contaminated soils; and nonfriable asbestos. The Neal Road Landfill is permitted to accept the following types of waste: municipal solid waste, inert industrial waste, demolition materials, special wastes containing nonfriable asbestos; and septage.

3.8.2 Right-of-Way (ROW) Requirements, Relocations, and Encroachments

The existing FRWL's ROW corridor includes O&M corridors that vary in width along the alignment and that are discontinuous for a significant distance at some locations. The minimum levee design criteria require the project levee to have an O&M corridor along the levee toes of a minimum of 15 feet on each side of the levee. The O&M corridors are necessary for O&M and flood fighting purposes. Therefore, to implement the SBPFS, additional real estate would be acquired to provide sufficient space for the O&M corridors. Acquiring additional real estate would result in relocation of physical structures (e.g., buildings, canals) along the alignment. Where it is impractical to acquire the additional real estate, the levee would be relocated toward the river.

There would be one exception to the minimum requirement of 15 feet for the O&M corridor. The exception covers the area between station 1904+00 and station 1957+00 where the Sutter Butte Canal encroaches into the proposed 15-foot minimum landside easement. For this area, an existing 10-foot minimum natural berm, on the levee's landside slope, would be utilized for O&M purposes without any further actions.

3.8.2.1 Relocations

To meet the minimum ROW requirements as stated above, acquisition of additional real estate would be necessary and would require relocations of certain physical structures. Any physical structures falling within the proposed ROW would be considered potential relocations under the Relocation Assistance Act, except for the encroachment of the utilities/facilities of the Sutter Butte Canal.

Under Alternative SB-8, 34 physical structures fall within the proposed ROW and, therefore, would be demolished. Twenty-seven of these structures are within Reach 16 (Yuba City). The remaining structures are in Reaches 26 to 31. Approximately 2,196 acres would be acquired and 468 parcels would be affected. However during the preconstruction engineering design phase of project implementation, a more detailed case-by-case evaluation will be made of the ROW requirements and resulting relocations.

Under Alternative SB-7, a total of 27 physical structures fall within the proposed ROW and, therefore, would be demolished. All of these structures are within Reach 16 (Yuba City). Approximately 2,110 acres would be acquired and 292 parcels would be affected.

In the case of the Sutter Butte Canal, which encroaches into the proposed ROW at four locations along the FRWL alignment (between stations 1430+00 and 1957+00), four potential measures were considered for each area to address ROW needs: construction of a retaining wall in the landside

slope; construction of a flood wall; levee relocation; and canal relocation. The proposed measures were also coordinated with the USFWS. The flood wall and retaining wall options were eliminated because these structures were deemed to create substantial barriers to movement of terrestrial wildlife species. Each measure was evaluated based on construction cost and impacts with the conclusion that the levee relocation measure would have the least impacts and costs.

Levee relocation was deemed to have the least overall impact and was selected as the primary measure for addressing the issue. The relocated levee is required to meet the minimum levee design criteria and height requirement. The cutoff wall would be constructed at the centerline of the relocated levee sections.

Canal relocation was selected for a small section along the alignment where the FRWL is too close to the Feather River's main channel to relocate the levee. This measure was also selected for a small section of the Sutter Butte Canal near the Sunset Weir Pump Station, around station 1430+00, because it was deemed to be more cost effective than the levee relocation measure which would require relocation of the pump station' electrical system.

At one of the four locations where the Sutter Butte Canal encroaches into the proposed ROW, specifically between station 1904+00 and station 1957+00, an existing 10-foot minimum natural berm, on the levee's landside slope, would be utilized for O&M purposes without any further actions needed.

3.8.2.2 Encroachments

A comprehensive inventory of all encroachments (utilities, physical structures, and woody vegetations) was completed based on existing data and field investigations. The existing encroachment data came from multiple sources, including the CVFPB encroachment list, the USACE Periodic Inspection Report, and as-built drawings of various projects located along the FRWL alignment. Field investigations were conducted to validate and improve the existing inventories.

Encroachments include a number of utilities running parallel to the alignment (e.g., power poles, irrigation ditches, pipelines), physical structures (public, residential, and commercial buildings), and woody vegetation (mature trees) currently located within the proposed ROW.

The encroachments were divided into 2 groups.

- Utilities and Physical Structures
- Woody Vegetation

The following two sections outline the approach for addressing levee encroachment issues.

3.8.2.2.1 Utilities and Physical Structures

This group was subdivided into two categories: levee prism encroachments and ROW encroachments.

The levee prism encroachments are utility pipelines and conduits running perpendicular to the levee alignment. Most of these pipeline and conduit crossings are either dated and do not comply with the current standard for levee encroachment, or would be disrupted or otherwise affected by levee construction. These pipelines and conduits, therefore, would be removed before the cutoff wall construction began and replaced with proper materials after the cutoff wall construction was

completed. Gravity lines (storm drain) would be replaced in-place. Pressurized lines (e.g., irrigation and drainage discharge lines, gas pipes, water and sewer lines) and conduits (e.g., electrical and communication lines) would be relocated. Pipes that are known to be recent installations would remain. Abandoned pipelines and conduits would be removed.

ROW encroachments are the utilities and physical structures located outside of the levee prism but within the limits of the proposed ROW. These structures would be relocated outside of the proposed ROW prior to levee and seepage berm construction.

Temporary bypass systems would be provided to minimize disruption to irrigation and other utility services during the farming season.

Under Alternatives SB-7 and SB-8, utilities that run parallel to the levee alignment and within the proposed ROW would be relocated outside of the proposed ROW. Utility pipelines and conduits crossing the existing levee embankment would be removed, modified or replaced to meet the USACE standard for levee penetration.

3.8.2.2.2 Woody Vegetation on Levee

The FRWL currently has mature trees on the both the levee slopes and within 15 feet of both the landside and waterside toes, with the majority of the trees being within 15 feet of the toes. Engineering Technical Letter No. 1110-2-571, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures* (Vegetation ETL) establishes minimum guidelines to assure that landscape and vegetation management provide aesthetic and environmental benefits without compromising the reliability of flood damage-reduction projects. The Vegetation ETL establishes a vegetation-free zone to provide a reliable corridor of access to, and along, levees, floodwalls, embankment dams, and apparent structures to assure adequate access by personnel and equipment for surveillance, inspection, maintenance, monitoring, and flood fighting (Figure 3-15). In the case of levees, such as those being evaluated for the Sutter Basin, the vegetation-free zone includes the levee (waterside slope, landside slope, and crown), and 15 feet on both sides of the levee measured from the levee toe.

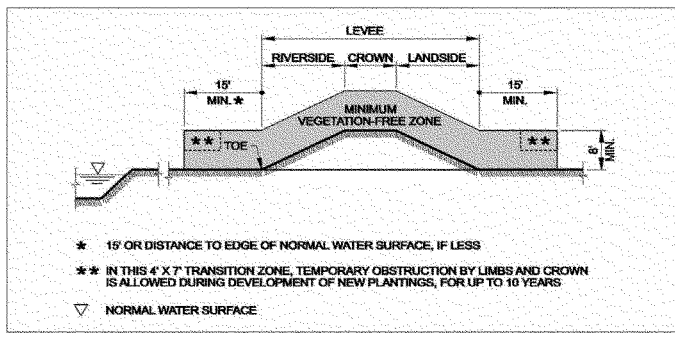


Figure 3-15. Illustration from Chapter 6, Engineering Technical Letter 1110-2-571

In its early implementation project documents for the FRWLP, SBFCA proposed allowing woody vegetation to temporarily remain within the project ROW and adoption of a life cycle adaptive management approach to address noncompliant vegetation removal over time. However, for the

purpose of this feasibility study, the Sacramento District's PDT determined that all alternatives were to be formulated and evaluated under the conservative assumption that each alternative would include necessary work, and costs thereof, for the removal of all vegetation on the levees, with the exception of grasses including 15 feet from the toe of the levee on both the landside and waterside.

On March 28, 2013, the CVFPB submitted a Letter of Intent (LOI) notifying USACE that the local maintaining agencies within the Sutter Basin led by SBFCA intended to develop and implement a System Wide Improvement Framework (SWIF) plan. A SWIF is a plan developed and implemented by levee sponsors to make system-wide improvements to a levee system (or multiple levee systems within a watershed) to address system-wide issues, including correction of unacceptable inspection items (see Section 4.2.2.5.4), in a prioritized way to optimize risk reduction. The SWIF plan would be developed within 2 years and then implemented gradually over time to bring the existing levees into compliance with the existing project O&M manual and is considered part of the without-project condition (SB-1: No Action Alternative). Therefore, while a SWIF is not a component of the LPP, a SWIF is being implemented but by the CVFPB and the local maintaining entities independently from the study.

Based on the LOI to develop a SWIF plan to achieve compliance with the existing O&M requirements, including vegetation removal in accordance with the existing O&M requirements, the SBPFS has assumed that there will be no deferred maintenance; i.e., the without project condition will be fully compliant with existing O&M requirements. During construction, any unacceptable inspection items and deficiencies that have not been addressed in accordance with the SWIF will be included in the Government construction contract as a non-federal expense.

The Vegetation ETL makes allowance for the issuance of variances in certain instances to further enhance environmental values or to meet state or Federal laws and/or regulations, provided that (a) safety, structural integrity, and functionality are retained; and (b) accessibility for maintenance, inspection, monitoring, and flood fighting are retained. During the design phase, all available options and means for achieving Vegetation ETL compliance will be evaluated. The project as designed and constructed would be in compliance with the Vegetation ETL guidelines.

3.8.3 Mitigation and Monitoring Plan

3.8.3.1 Mitigation Plan Requirements

The USACE Planning Guidance Notebook (ER 1105-2-100) describes the mitigation process and procedures and content of mitigation plans to be included in feasibility-level reports. The planning of USACE projects must ensure that project-related adverse environmental impacts (i.e., impacts on fish and wildlife resources) have been avoided or minimized to the extent practicable, and that remaining unavoidable significant adverse impacts are compensated to the extent justified.

Under Section 2036(a)(3)(B) of WRDA 2007, Public Law No. 110-114, Section 2036(a)(3)(B), 121 Stat. 1093 (2007), USACE must fully develop a mitigation plan that includes the following: (1) monitoring until successful, (2) criteria for determining ecological success, (3) a description of available lands for mitigation and the basis for the determination of availability, (4) the development of contingency plans (i.e., adaptive management), (5) identification of the entity responsible for monitoring, and (6) establishing a consultation process with appropriate Federal and state agencies in determining the success of mitigation.

ER 1105-2-100 requires that mitigation plans be analyzed for cost effectiveness and incremental cost and benefits. Analysis of cost effectiveness, in general, compares the relative costs and benefits of alternative mitigation plans. The least expensive plan which meets the restoration objective is usually selected. "Incremental cost analysis" is the technique used by USACE to develop cost-effective mitigation plans. Incremental cost analysis calculates the cost per unit of output gained by each successive feature, allowing the planning team to determine the point of diminishing returns. Appendix D contains the Draft Cost Effectiveness Incremental Cost Analysis Report.

3.8.3.2 Fish and Wildlife Mitigation and Monitoring Plan

A mitigation and monitoring plan (MMP) has been developed to compensate for the loss of vegetation and impacts on listed species. The MMP would be finalized following completion of Endangered Species Act Section 7 consultation with the USFWS and National Marine Fisheries Service and completion of Fish and Wildlife Coordination Act coordination with the USFWS and California Department of Fish and Wildlife (CDFW). The MMP accompanies this report in Appendix D.

The MMP is intended to address the following issues.

- Effects on and mitigation for riparian and non-riparian native trees.
- Effects on special-status species habitat for valley elderberry longhorn beetle (VELB) and giant garter snake (GGS).
- Effects on Section 404 jurisdictional features.

The MMP proposes offsite in-kind compensatory mitigation for riparian forest, non-riparian native trees and VELB. Mitigation for these areas will occur on the Feather River at the Star Bend Conservation Area (SBCA) and the proposed Three Rivers Levee Improvement Authority's (TRLIA) Feather River Floodway Corridor Restoration Project (FRFCRP) site. Mitigation for GGS and features subject to Federal jurisdiction under Section 404 of the Clean Water Act will occur at offsite private banking lands as discussed below.

Onsite habitat replacement is generally the preferred approach to habitat mitigation; however, because much of the affected habitat (specifically, woody vegetation) is not compliant in its location with USACE levee vegetation policy, this option was determined to be infeasible. Further, the highly dispersed nature of the impact locations makes efficient replacement infeasible. Therefore, onsite replacement was not considered further as a viable option for this project and offsite, in-kind habitat replacement was selected as the best option for mitigation. It involves replacement of affected habitat with the same type of habitat at a different location offsite. This often allows for consolidation of mitigation at a single or small number of sites, allowing for economy of scale and higher quality habitat due to large patch size.

The MMP proposes two strategies for offsite, in-kind replacement.

- **Agency-responsible mitigation.** This strategy involves replacement of in-kind habitat on habitat lands. The SBCA on the west levee of the Feather River near river mile 18 is an existing floodplain habitat restoration site that was created as part of the Star Bend setback levee project. The Three Rivers restoration site is located within the TRLIA Early Implementation Project (EIP) Feather River Setback levee expanded floodway. These two sites contain sufficient area to accommodate all of the project's upland compensatory mitigation and will be used for

mitigating impacts on: (1) riparian forest, (2) oak woodland (non-riparian native trees), and (3) VELB.

- **Purchase credits at commercial mitigation banks.** This strategy involves replacement of in-kind habitat through purchase of credits issued for habitat lands operated by a commercial mitigation bank. For the aquatic habitat impacts on GGS, the project proposes to purchase credits at the Sutter Basin Conservation Bank, operated by Westervelt Ecological Services in Sutter County, which is the only bank that presently offers GGS credits approved by both the USFWS and CDFW. The project proposes to purchase jurisdictional water credits at the River Ranch Wetland Mitigation Bank, owned and operated by Wildlands, Inc., and located at the confluence of the Sacramento and Feather Rivers in Yolo County. There are currently no mitigation banks that offer oak woodland (non-riparian native tree) credits.

3.8.3.2.1 Habitat Mitigation and Monitoring at the Star Bend Conservation Area and Feather River Floodway Corridor Restoration Project Sites

The proposed actions to enhance habitat at the SBCA and FRFCRP sites are summarized below; additional details are contained in the MMP in Appendix D. This section only addresses agency-responsible mitigation. As described above, mitigation for USACE Section 404 jurisdictional habitat and GGS will occur offsite at commercial mitigation and conservation banks and is deemed satisfied and complete once credits are purchased.

To compensate for fish and wildlife impacts from construction, approximately 88 acres of riparian forest, oak woodland (non-riparian native), and VELB compensation would occur at the SBCA and FRFCRP sites. The SBCA mitigation site is located on the water side (east) of the new setback levee that was constructed in 2009 on the Feather River, approximately 6 miles south of Yuba City. The SBCA project created approximately 48.5 acres of floodplain habitat, which included habitat enhancement and onsite mitigation for impacted VELB habitat. The FRFCRP site is located on the east side of the Feather River in the levee setback area created by the TRLIA EIP Feather River Setback Levee project. The setback levee actions taken by Levee District 1 and TRLIA have together increased the amount of floodplain potentially exposed to inundating flows by approximately 1,649 acres. The floodplain riparian forest proposed by USACE and SBCA in combination with these actions allow for higher quality floodplain habitat for juvenile salmonids and other native species.

At the 48.5-acre SBCA site, approximately 24 acres has already been used for elderberry transplants and associated native plants. Under the SBPFS, the remaining approximately 24.5 acres would be used for mitigating impacts on elderberry shrubs, riparian forest, and non-riparian native trees. The SBCA site will serve as a transplant site for elderberry shrubs that are unable to be avoided by construction. Elderberry seedlings or cuttings and associated native species will also be planted at the SBCA site. The design characteristics used in the initial mitigation work at SBCA serve as a reference site for the additional mitigation. These characteristics are described in the report *Habitat Enhancement Plan for the Feather River Setback Levee and Habitat Enhancement Project at Star Bend*, prepared by River Partners and Stillwater Sciences in 2009 for Levee District 1 and Wood Rodgers.

The target plant communities and species at the SBCA and the FRFCRP sites will include riparian forest, non-riparian native trees, and elderberry shrubs and associated plants for VELB habitat. It is anticipated that both the SBCA and FRFCRP mitigation sites will sustain rapid growth of restored riparian species given the presence of good soils and potential exposure to frequent flooding. The goal for each mitigation site is to become fully self-sustaining. An "over-planting" approach is

proposed to rapidly establish native riparian species. Over-planting of these sites will minimize or eliminate the need for any additional replanting efforts. The ultimate ecological objective for over-planting is that in time the area will thin out and create a complex of open canopy, dense forest, and dead snags, all of which provide benefits to wildlife (River Partners and Stillwater Sciences 2009). Over time, mortality based on differences of soil textures and water table depths will create areas of complex, open canopy, dense forest, and dead snags, all of which create habitat for wildlife (River Partners and Stillwater Sciences 2009).

USACE will be responsible for the design, installation and maintenance of the plantings for a period of 3 years from the end of project construction and then responsibility for operation and maintenance will be transferred to SBFCA. It is anticipated that at the end of the 3-year establishment period, 80% survivorship of woody species will be attained. The riparian tree and non-riparian native tree restoration areas will be monitored annually during Years 1 through 5 following completion of mitigation project implementation. First year monitoring will not be completed until after one full growing season for vegetation has passed since completion of construction. At the end of the first growing season, the restoration contractor will conduct a complete census of all woody species planted. During Years 2 and 3, woody species plantings will be sampled to determine survivorship, growth, and coverage. Irrigation will be applied with the goal that plants will become self-sufficient by the end of the third growing season at which time the SBFCA will assume O&M responsibility from USACE. SBFCA will submit an annual report at the end of each monitoring year and a final report to USACE and other resource agencies for review and approval. These areas will be monitored annually during May or June. Additional monitoring of the riparian tree and non-riparian native tree restoration areas will be conducted in the 10th, 15th, and 20th years. A minimum survival rate of at least 80% must be maintained throughout the first 2 years of the monitoring period. A minimum survival rate of at least 70% must be maintained at the end of the third year, as must a minimum survival rate of at least 60% at the end of 20 years. Within 1 year of discovery that survival has dropped below the respective percentage for each monitoring year, failed plantings will be replaced to bring survival above this level. The resource agencies in consultation with USACE and SBFCA will make any determination as to replacement responsibilities arising from circumstances beyond the project's control, such as plants damaged or killed as a result of severe flooding or vandalism.

A final monitoring report will be submitted after all performance monitoring at the mitigation sites is complete. The final report will be prepared by a qualified biologist and will evaluate whether the mitigation has achieved the goals and success criteria set forth in the approved MMP. If the final report indicates that the mitigation project has been unsuccessful, in part or in whole, based on the approved success criteria, the causes for not meeting the criteria will be evaluated and a revised or supplemental mitigation plan submitted within 90 days of the end of the monitoring period for the review and approval of resource agencies to compensate for those portions of the original program that did not meet the approved success criteria. The approved remedial measures will be developed based on the qualitative and quantitative monitoring results to determine the most effective remedy. If, after all remedial measures have been implemented, it becomes evident that the permit requirements cannot be satisfied according to the proposed mitigation plan, SBFCA will coordinate with USACE and the resource agencies to develop a contingency plan to be approved by all parties.

A long-term management plan will be prepared to ensure the mitigation site is monitored and maintained in perpetuity. This management plan provides management objectives and tasks to monitor, manage, maintain, and report on the mitigated natural resources. Routine monitoring and

minor maintenance tasks are intended to assure the viability of the mitigation site's functions and values. This long-term management plan will take effect after the completion of the monitoring period, once it has been determined by the appropriate resource agencies that the mitigation project has achieved its objectives and that the outlined performance standards for each habitat type have been reached. The designated resource manager(s) will oversee all long-term management activities.

3.8.4 Operations and Maintenance, Repair, Replacement, and Rehabilitation

The OMRR&R requirements, activities, and costs were identified during the final analysis of Alternatives SB-7 and SB-8. Typical OMRR&R activities both with- and without-project are those listed below.

- Vegetation removal and control in compliance with the Vegetation ETL.
- Rodent control and repair of rodent damage.
- Slope re-grading and reseeding.
- Repair of waterside erosion.
- Maintenance of relief wells and collection ditches.
- Maintenance and repair of flap gates to minimize internal drainage.
- Patrol road and ramp maintenance.
- Inspection/patrolling including participation in Federal and state inspection programs, routine patrolling to identify maintenance needs and to assure flood worthiness, and continuous patrolling during high water conditions.
- Flood fighting.
- Sandbagging of the gap in the levee crown for passage of the railroad during high water conditions to prevent flooding of Yuba City and vicinity.

3.8.5 Environmental Commitments

Environmental commitments are measures incorporated as part of the project description, meaning they are proposed as elements of the proposed project and are to be considered in conducting the environmental analysis and determining effects and findings.

3.8.5.1 Stormwater Pollution Prevention Plan

Because ground disturbance for the project would be greater than 1 acre, a National Pollutant Discharge Elimination System (NPDES) general construction activity stormwater permit would be obtained from the Central Valley Regional Water Quality Control Board (RWQCB). The RWQCB administers the NPDES storm water permit program in Sutter and Butte Counties. Obtaining coverage under the NPDES general construction activity permit generally requires that the project applicant prepare a stormwater pollution prevention plan (SWPPP) that describes the best management practices (BMPs) that would be implemented to control accelerated erosion, sedimentation, and other pollutants during and after project construction. The SWPPP would be prepared prior to commencing earth-moving construction activities.

3.8.5.2 Bentonite Slurry Spill Contingency Plan (Frac-Out Plan)

The construction contractor would be required to prepare and implement a bentonite slurry spill contingency plan (BSSCP) for any excavation activities that use pressurized fluids (other than water). The BSSCP would include measures intended to minimize the potential for a frac-out (short for "fracture-out event") associated with excavation and tunneling activities; provide for the timely detection of frac-outs; and ensure an organized, timely, and *minimum-effect* response in the event of a frac-out and release of excavation fluid (i.e., bentonite).

3.8.5.3 Spill Prevention, Control, and Counter-Measure Plan

A spill prevention, control, and counter-measure plan (SPCCP) is intended to prevent any discharge of oil into navigable water or adjoining shorelines. USACE would require the construction contractor to develop and implement an SPCCP to minimize the potential for and effects from spills of hazardous, toxic, or petroleum substances during construction and operation activities. The SPCCP would be completed before any construction activities begin. Implementation of this measure would comply with state and Federal water quality regulations. The SPCCP would describe spill sources and spill pathways in addition to the actions that would be taken in the event of a spill (e.g., an oil spill from engine refueling would be immediately cleaned up with oil absorbents). USACE inspectors would routinely inspect the construction area to verify that the measures specified in the SPCCP are properly implemented and maintained.

3.8.5.4 Monitoring of Turbidity in Adjacent Water Bodies

Monitoring of turbidity in adjacent water bodies would be required and included in construction plans and specifications to determine whether turbidity is being affected by construction and ensure that construction does not exceed Basin Plan turbidity objectives set by the State Water Resources Control Board (State Water Board). The Basin Plan specifically states that where natural turbidity is between 5 and 50 Nephelometric turbidity units (NTUs), turbidity levels may not be elevated by 20% above ambient conditions. Where ambient conditions are between 50 and 100 NTUs, conditions may not be increased by more than 10 NTUs. If turbidity limits exceed Basin Plan standards, construction-related earth-disturbing activities would slow to a point that results in alleviating the problem.

3.9 Final Array Economic Analysis

For the final array, a Class 3 Analysis (feasibility level) was conducted using the approach required for engineering design, real estate and technical detail efforts (35%), costs, real estate, and economics to assist in determining the Recommended Plan (RP). The updated economic numbers using the pilot process varying confidence intervals methodology are shown in Table 3-21.

Table 3-21. Net Benefits[a,] (Varying Confidence Intervals) of the Final Array of Alternatives Using October 2013 Prices (Values in Millions) and 3.5% Discount Rate

	Alternative						
		NED Plan, SB-7			LPP, SB-8		
Category	SB-1	Low	Mid	High	Low	Mid	High
Total First Costs		355	370	386	632	659	688
Interest during Construction		34	36	37	88	92	96
OMRR&R			0.28			0.45	
Annual Cost		17	17	18	31	32	33
Annual Benefits		43	64	109	46	72	120
Net Benefits[b]		34	54	79	23	47	74
Benefit to Cost Ratio[b]		2.8:1	3.9:1	5.3:1	1.6:1	2.3:1	3.1:1

[a] Refer to Section 3.4.3.1, *Annual Net Benefits*, for economic range explanation.

[b] Net Benefits and Benefit to Cost Ratios are a result of Monte Carlo simulations using triangular distributions of annual benefit and annual cost confidence intervals as inputs in accordance with ER-1105-2-101.

The Class 4 Analysis cost estimate was conducted as required to refine the economic numbers to a feasibility level of confidence. These more refined costs confirmed that the conceptual parametric cost estimate, ranges, and assumptions were valid and accurate. Table 3-22 presents net benefits in standard mean USACE format for the feasibility level cost estimates.

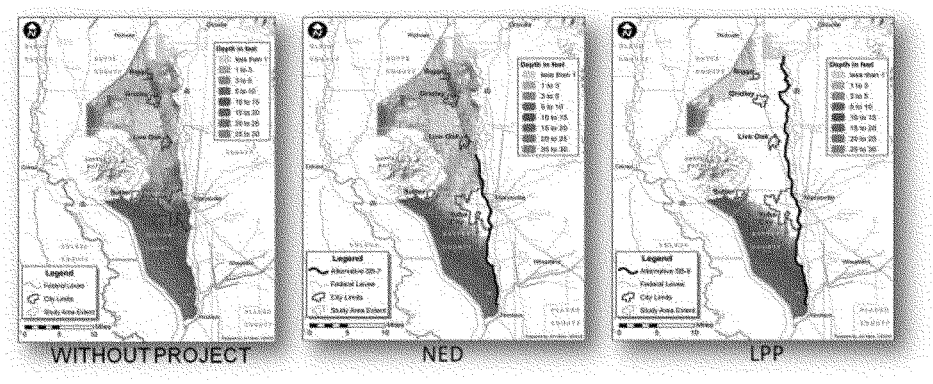
Table 3-22. Net Benefits (Mean, Standard USACE Practice) of the Final Array of Alternatives using October 2013 Prices (Values in Millions) and 3.5% Discount Rate

	Alternative		
Category	SB-1	NED Plan, SB-7	LPP, SB-8
Total First Costs[a]	Not applicable	390	686
Interest during Construction	Not applicable	38	94
O&M	Not applicable	0.28	0.45
Annual Cost	Not applicable	18	33
Annual Benefits	Not applicable	79	87
Net Benefits	Not applicable	61	54
Benefit to Cost Ratio	Not applicable	4.4:1	2.6:1
Benefit to Cost Ratio @7%	Not applicable	2.3:1	1.3:1

[a] Cultural resources data recovery costs ($1.6 million for SB-7 and 3.0 million for SB-8) are not included in economic costs per Corps policy (ER-1105-2-100, Appendix e, paragraph E-63.f.((5)).

3.9.1 Comparison of Accounts and Criteria of the Final Array of Alternatives

As a final comparison for screening for the RP in the multi-objective planning process, a pair-wise comparison and evaluation was completed between the No Action Alternative (SB-1), the NED Plan (SB-7), and the LPP (SB-8) to verify and determine the RP as shown in Table 3-23. Residual 1% ACE floodplains also were used for comparison. See Figure 3-16.



(See the *Figures* folder on the CD for full-sized images.)

Figure 3-16. Final Array of Alternatives with Residual 1% ACE Floodplains

The floodplain comparison shows that the NED Plan would reduce the flood risk only in the Yuba City core area in comparison to the No Action Alternative, resulting in considerable residual risk in terms of public and life safety in the rest of the study area. The LPP addresses the residual NED Plan risk by reducing flood risk and associated public and life safety issues in the northern communities of Live Oak, Gridley, and Biggs while minimizing potentially developable lands in the southern half of the deeper areas of the Sutter Basin. The LPP through previous screening is shown to be the best alternative to provide FRM benefits and best address residual risk of the NED Plan for public and life safety.

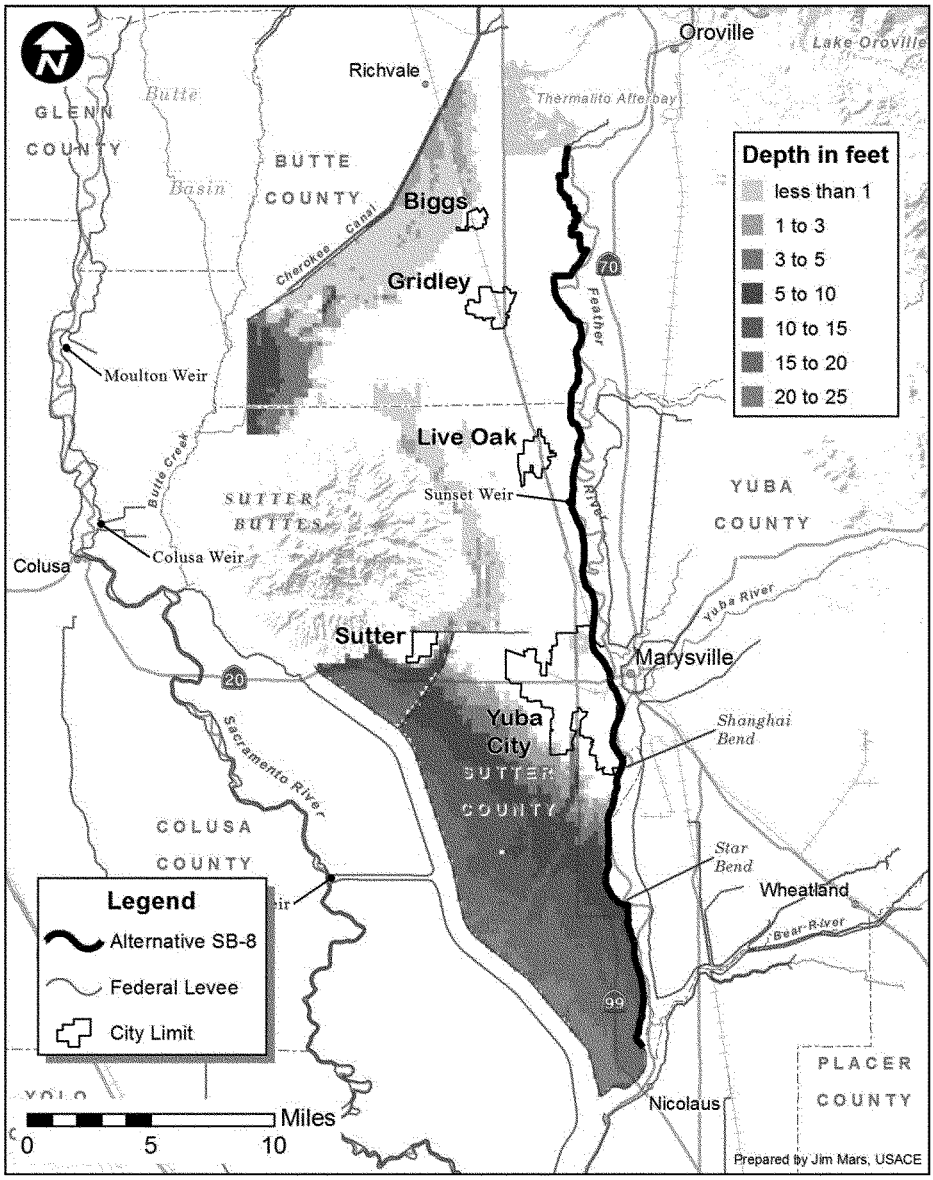
3.10 The Recommended Plan

The multi-objective comparison and assessment between the NED Plan and the LPP was completed. Both the NED Plan and LPP would provide significant benefits that exceed their costs. While the NED Plan is more efficient than the LPP, both plans are efficient. Both the NED Plan and LPP are defined as hydrologically separable because they have separate residual 1% ACE floodplains with resulting distinct economic benefits.

The LPP is supported by the local sponsors SBFCA and CVFPB, and has received ASA(CW) approval with a NED Plan cost-share cap. The LPP will comply with the local sponsor objective to meet the

criteria of the California Government Code requirements for a 200-year level of protection for urban and urbanizing areas by 2025. Refer to Appendix C1b. Hydraulic Design and Analysis.

In a multi-objective context that equally emphasizes the objectives of flood risk management and reducing residual risk to public and life safety across all planning criteria and accounts, the LPP (Alternative SB-8) is recommended as the Recommended Plan (RP) at the NED Plan limit of Federal cost participation. See Figure 3-17.



(See the *Figures* folder on the CD for a full-sized image.)

Figure 3-17. Recommended Plan: Alternative SB-8 (Residual 1% ACE Floodplain)

Table 3-23. Final Array of Alternative Plans—Comparison Summary of Accounts and Criteria

	No Action (SB-1)	NED Plan (SB-7)	LPP (SB-8)
1. PLAN DESCRIPTION			
	Alternative SB-1: The No Action Alternative and future without-project condition provides no physical project constructed by the Federal Government.	Alternative SB-7: The NED Plan is a Feather River levees fix-in-place levee alternative from Sunset Weir to Laurel Avenue.	Alternative SB-8: The LPP is a Feather River levees fix-in-place levee alternative from Thermalito Afterbay to Laurel Avenue.
2. MULTI-OBJECTIVE PLANNING ASSESSMENT			
A. National Economic Development (NED) October 2013 price level, 3.5% Discount Rate			
1. Project Cost (First Cost)[a]	$0	$390,000,000	$686,000,000
2. Annual Cost	$0	$18,000,000	$33,000,000
3. Total Annual Benefit	$0	$79,000,000	$87,000,000
4. Annual Net Benefits	**$0**	**$61,000,000**	**$54,000,000**
5. Benefit – Cost Ratio	**N/A**	**4.4:1**	**2.6:1**
B. Environmental Quality (EQ)			
1. Environmental Safety	The high potential for contaminated floodwaters from the northern community urban facilities (water treatment plants, gas stations, etc.) would remain.	The high potential for contaminated floodwaters from the northern community urban facilities (water treatment plants, gas stations, etc.) would remain.	The LPP would reduce flood risk and reduce risk of potentially contaminated floodwaters from the northern urban community facilities (water treatment plants, gas stations, etc.)
2. Ecosystem	The Sutter Basin is located along the Pacific Flyway, which provides foraging and resting habitat for millions of migrating waterfowl during the winter migration (flooding) season. Flooding would negatively affect "stop-over" feeding and resting areas, and contaminated waters could affect wildlife health.	Residual flooding of thousands of acres would negatively affect "stop-over" feeding and resting habitat, and contaminated waters could affect wildlife health.	Residual flooding would be primarily concentrated in the southern end of the Basin, allowing for significant availability of "stop-over" feeding and resting habitat. There would be a lesser risk of urban area contamination.

	No Action (SB-1)	NED Plan (SB-7)	LPP (SB-8)
C. Regional Economic Development (RED)			
1. RED Effects on Flood Risk Management and Region	Future flooding would destroy part of the infrastructure, resulting in a loss in the region's ability to produce goods and services. Little to no RED benefits.	A 4-year period of construction can result in positive spillovers to suppliers, short-term increases in construction-related employment, increased revenues for local businesses, and a potential increase in wealth for floodplain residents as less is spent on damaged property repairs. Population and economic centers of the basin would be flooded, resulting in slow regional recovery.	Similar to NED Plan, but effects would extend for a 6-year period of construction, resulting in additional RED benefits. Major population and economic centers would have reduced risk of flooding, resulting in faster regional recovery.
D. Other Social Effects (OSE) – Life Safety Evaluation Metrics			
1. Life, Health, and Safety	Continued flood risk and consequences in the Sutter Basin, including the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Significant life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs would be significantly reduced.
1a. Remaining Population at Risk	Approximately **96,600** individuals are within the 1% ACE floodplain.	**38,200** people would remain in the 1% ACE floodplain. 60% of population would be removed from the residual 1% ACE floodplain under the NED Plan.	**6,600** people remain in the 1% ACE floodplain. 93% of population would be removed from the residual 1% ACE floodplain under the LPP.
1b. Loss of Life (See Table 3-15)	Potential loss of lives: Day Flood Event-**388**; Night Flood Event-**489**	Potential loss of lives: Day-**157**; Night-**197**	Potential loss of lives: Day-**27**; Night-**34**
1c. Critical Infrastructure – Public Safety	**28** structures deemed as critical from a national perspective are at risk from floods.	**11** structures would remain at risk from floods.	**1** structure would be at risk from floods.
1d. Evacuation Routes (See Figure 3-9)	In the event of a flood, no evacuation route is available out of the basin.	There would be **one** problematic route for evacuation during a flood event. FWEEP would have limited effectiveness.	**Five** evacuation routes would be available in the event of a flood. FWEEP would have more robustness and redundancy.

	No Action (SB-1)	NED Plan (SB-7)	LPP (SB-8)
1e. Potential Developable Floodplains Note: fix-in-place measures are only bringing levees up to authorized elevation and performance.	Currently, 71,800 acres of land are potentially available for future development.	88,200 acres would be potentially available for future development.	100,200 acres of land would be potentially available for future development.
2. Social Vulnerability (Study Area Resiliency)	The social vulnerability index score indicates the study area has medium to high vulnerability. The No Action Alternative may leave communities unable to cope with the recovery from a flood hazard.	The majority of the community of Yuba City would be afforded flood risk reduction; however the communities of Live Oak, Gridley, and Biggs would remain at risk of flood hazards and may be unable to cope and recover.	The Yuba City, Live Oak, Gridley, and Biggs would be provided flood risk reduction, and social vulnerability would be minimized due to a decrease in the probability of flood hazards occurring.
3. Residual Risk (See Table 3-8)	Residual flood risk would remain high throughout the study area.	Residual flood risk for public and life safety would be reduced for most of the Yuba City urban area.	Residual flood risk for public and life safety would be reduced in the high-risk communities of Yuba City, Live Oak, Gridley, and Biggs.
E. Federal Planning Criteria			
Acceptability	N/A	The local sponsors and public support levee fixes and improvements.	The local sponsors and public support levee fixes and improvements.
Effectiveness	N/A	The NED Plan would address the primary planning objectives of providing FRM and reducing some public and life safety risk.	The LPP would address the primary planning objectives of providing additional FRM and reducing public and life safety risk beyond the NED Plan.
Efficiency	N/A	Economic analysis and outputs identified this alternative as the NED Plan with the highest annual net benefits.	Based on economic analysis and outputs, the LPP is not economically incrementally justified; however, the LPP would provide additional annual benefits with a positive BCR.
Completeness	N/A	Significant residual risk to public and life safety in the northern basin communities of Biggs, Gridley, and Live Oaks would remain.	The LPP would reduce residual risk to public and life safety in Yuba City, Biggs, Gridley, and Live Oaks.

[a] Cultural resources data recovery costs ($1.6 million for SB-7 and 3.0 million for SB-8) are not included in economic costs per Corps policy (ER-1105-2-100, Appendix e, paragraph E-63.f.((5)).

4.1 Introduction

This chapter addresses the affected environment and environmental consequences of each of the alternatives in the final array, mitigation measures for adverse impacts, cumulative impacts, and other environmental considerations.

This final integrated feasibility study report and EIR/SEIS provides a supplemental analysis to the Feather River West Levee Project (FRWLP) Final EIS. This chapter refers to the FRWLP Final EIS, as appropriate, to avoid unnecessary duplication. The alternatives in the final array represent modifications to the alternatives evaluated in the FRWLP Final EIS. Alternative SB-8 is similar to FRWLP Alternative 3, but Alternative SB-8 includes design modifications to meet Federal levee standards as described below in Section 4.1.4, *Comparison of FRWLP and SBPFS Alternatives*. Alternative SB-7 includes the same levee improvements as Alternative SB-8 but excludes Reaches 21–41 above Sunset Weir.

The environmental resources within the study area and along the project levees have received extensive study and have been summarized in a number of comprehensive documents prepared by USACE, SBFCA, and the state. The FRWLP Final EIS and the *Sutter Basin Feasibility Study Environmental Without-Project Conditions Report* (ICF International 2012) contain extensive information on the existing conditions. This final integrated report and EIR/SEIS incorporates those documents and supporting appendices by reference and provides only a brief description of the existing resources.

4.1.1 NEPA and CEQA Requirements

The Council on Environmental Quality's (CEQ's) regulations for implementing NEPA specify that a Federal agency preparing an EIS must consider the effects of the proposed action and alternatives on the environment. Environmental effects are categorized as direct, indirect, or cumulative. An EIS must identify relevant, reasonable mitigation measures not already included in the proposed action or alternatives that could avoid, minimize, rectify, reduce, eliminate, or compensate for the project's adverse environmental effects (40 Code of Federal Regulations [CFR] Sections 1502.14, 1502.16, and 1508.8.).

The State CEQA Guidelines explain that the environmental analysis for an EIR must evaluate impacts associated with the project and identify mitigation for any potentially significant impacts. All phases of a proposed project, including construction and operation, are evaluated in the analysis.

An EIR must describe any feasible measures that could minimize significant adverse impacts, and the measures are to be fully enforceable through permit conditions, agreements, or other legally binding instruments (State CEQA Guidelines Section 15126.4[a]). Mitigation measures are not required for impacts that are found to be less than significant.

Under NEPA, preparation of an EIS is triggered if a Federal action has the potential to "significantly affect the quality of the human environment." *Significance* is based on the context and intensity of each potential effect. *Context* refers the affected environment in which a project is proposed. *Intensity* refers to the severity of the effect, which is examined in terms of the type, quality, and sensitivity of the

resource involved; location and extent of the effect; duration of the effect (short- or long-term); and other considerations. Beneficial effects are identified and described. When there is no measurable effect, an impact is found not to occur. The *intensity* of adverse effects refers to the degree or magnitude of a potential adverse effect, which is described as negligible, moderate, or substantial. Context and intensity are considered together when determining whether an impact is significant under NEPA. Thus, it is possible that a significant adverse effect may still exist when the intensity of the impact is determined to be negligible.

As in the FRWLP Final EIS, this report uses both NEPA and CEQA terminology. The terms *environmental impacts*, *environmental effects*, and *environmental consequences* are used synonymously.

4.1.2 Resource Analysis Structure

The resource impact discussions beginning in Section 4.2 below are based on the following structure.

- **Introduction.** This section introduces the scope of the resource analysis.
- **Affected Environment.** This section discusses the regulatory and environmental setting. This section utilizes incorporation by reference from the FRWLP Final EIS where appropriate.
- **Determination of Effects.** This section provides the criteria used in this document to define the level at which an effect would be considered significant in accordance with CEQA and significant in accordance with NEPA. Significance criteria (sometimes called thresholds of significance) used in this EIR/SEIS are based on the checklist presented in Appendix G of the State CEQA Guidelines; factual or scientific information and data; and regulatory standards of Federal, state, and local agencies. The significance thresholds used in this EIR/SEIS also encompass the factors taken into account under NEPA to evaluate the context and the intensity of the effects of an action.
- **Effects and Mitigation Measures.** To comply with NEPA and CEQA, effects are considered and evaluated as to whether they are direct, indirect, or cumulative. Direct effects are those that are caused by the action and occur at the same time and place. Indirect effects are reasonably foreseeable consequences to the physical environment that may occur at a later time or at a distance from the project area. Because direct and indirect effects are often interrelated, typically there is no distinction made between the two in the effects discussion. Cumulative effects for certain resources are analyzed and discussed at the end of this chapter in Section 4.13, *Cumulative and Growth-Inducing Impacts.*

  Effects are listed numerically and sequentially throughout each section. An effect statement precedes the discussion of each effect and provides a summary of the effect topic. The effect statements generally follow the FRWLP Final EIS. The numbering system provides a mechanism for tracking unique effects by resource area.

  Each effect is accompanied by a finding or conclusion, as required under NEPA and CEQA. For the purposes of the analyses in this document, the effect findings are defined more specifically below (in order of increasing severity to the environment).

  - **Beneficial.** This effect would provide benefit to the environment as defined for that resource.
  - **No Effect.** This effect would cause no discernible change in the environment as measured by the applicable significance criteria; therefore, no mitigation would be required.

- **Less than Significant.** This effect would cause no substantial adverse change in the environment as measured by the applicable significance criteria; therefore, no mitigation would be required.
- **Significant.** This effect would cause a substantial adverse change in the physical conditions of the environment. Effects determined to be significant based on the significance criteria fall into two categories: those for which there is feasible mitigation available that would avoid or reduce the environmental effects to less-than-significant levels and those for which there is either no feasible mitigation available or for which, even with implementation of feasible mitigation measures, there would remain a significant adverse effect on the environment. Those effects that cannot be reduced to a less-than-significant level by mitigation are identified as significant and unavoidable, described below.
- **Significant and Unavoidable**. This effect would cause a substantial adverse change in the environment that cannot be avoided or mitigated to a less-than-significant level if the project is implemented. Even if the effect finding is still considered significant with the application of mitigation, the applicant is obligated to incorporate all feasible measures to reduce the severity of the effect.

- **Effects Not Addressed Further in this Document.** In those instances where effects have been adequately addressed in the FRWLP Final EIS, an effect summary and an explanation of why no further study is needed are provided.
- **Mitigation Measures.** Measures to mitigate (i.e., avoid, minimize, rectify, reduce, eliminate, or compensate for) significant effects accompany each significant effect discussion. Similar to the effect descriptions, mitigation measures are listed numerically and sequentially throughout each section. A mitigation measure statement precedes the discussion of each measure and provides a summary of the measure topic. The numbering system provides a mechanism for tracking unique measures by resource area.

4.1.3 Scope of Environmental Analysis

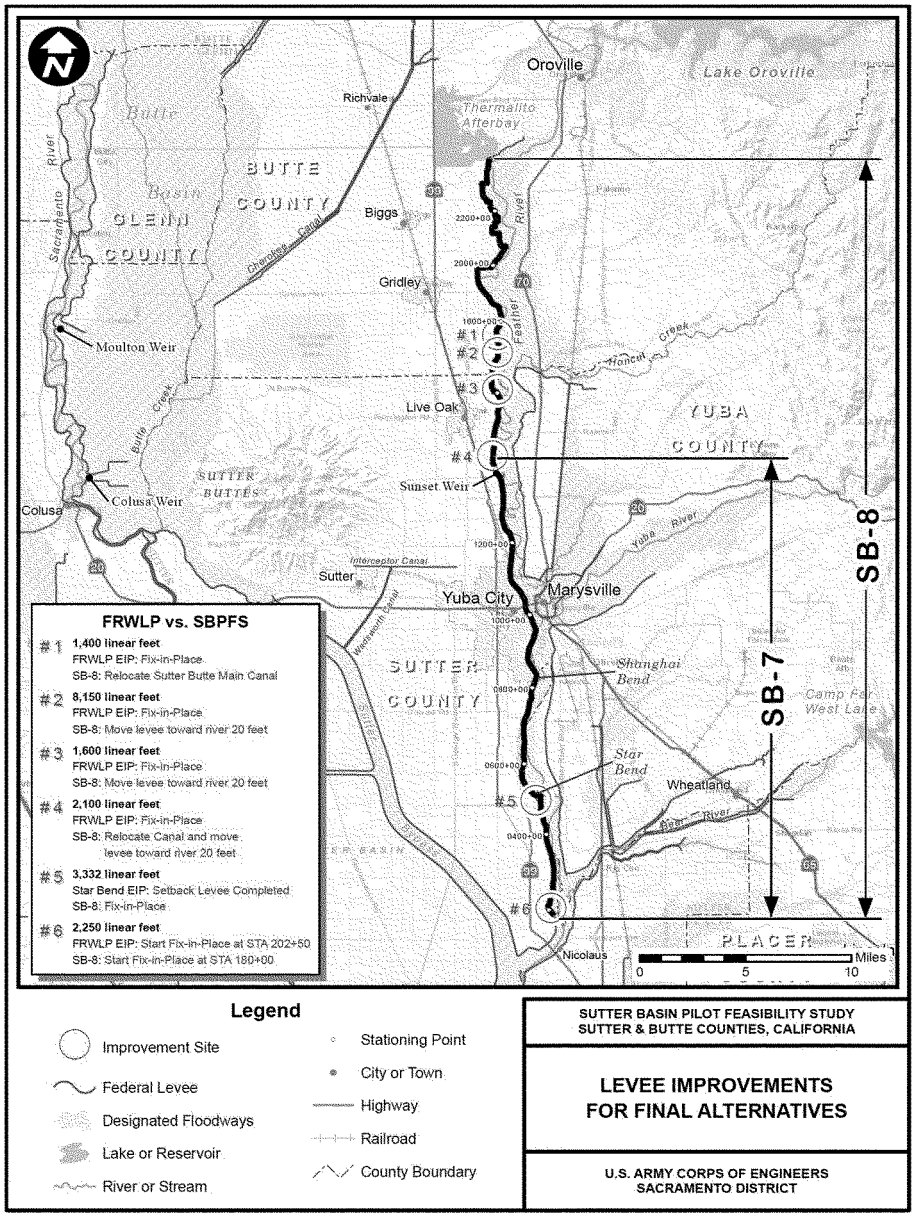
The scope of the integrated Final EIR/SEIS focuses on effects resulting from the alternatives in the final array and the alternatives evaluated in the Final EIS for the FRWLP. All potentially relevant environmental resource areas initially were considered for analysis. In compliance with NEPA and CEQA, the discussion of the affected environment focuses only on those resource areas potentially subject to impacts, and those with potentially significant environmental issues. Section 4.1.6 briefly summarizes the effects on these resources and the rationale for their elimination from detailed analysis.

4.1.4 Comparison of FRWLP and SBPFS Alternatives

The FRWLP Final EIS evaluated the following alternatives to reduce flood risk along the Feather River West Levee from Thermalito Afterbay downstream to approximately 4 miles upstream of the Feather River's confluence with the Sutter Bypass. These alternatives affect the same length of levee but differ between each other primarily in their overall "footprint" of construction (Plate 4-1).

Alternative 1 focuses on those measures predominantly within the existing footprint of the Feather River West Levee. Along with other measures, this alternative primarily proposes cutoff walls as a technique to address the deficiencies while minimizing change in the existing levee footprint. This alternative would minimize real estate acquisition and changes in land use.

Plate 4-1. SBPFS Alternatives and FRWLP Preferred Alternative



Alternative 2 includes measures that would not be constrained by the existing footprint of the Feather River West Levee. Along with other measures, this alternative primarily proposes stability berms and seepage berms, which would substantially extend beyond the current levee footprint.

Alternative 3 is the SBFCA preferred alternative. It is a blend of the flood management measures identified in Alternatives 1 and 2, optimized based on the screening criteria. *Optimized* means a number of factors have been considered, such as effectiveness in addressing the deficiencies, compatibility with land use, minimization of real estate acquisition, avoidance of effects, and cost; the footprint has been considered but not held as a primary constraint. This alternative consists of cutoff walls and berms, along with other measures.

Alternatives SB-8 and SB-7 are similar to SBFCA's preferred alternative evaluated in the FRWLP Final EIS, but there are differences between the alternatives. The following is a summary of the major differences between the FRWLP and SBPFS alternatives. Plate 4-1 identifies some of the key differences.

- **Downstream Levee Improvement Extension.** Alternatives SB-8 and SB-7 extend 2,250 feet further south of Laurel Avenue (Station 180+00). The FRWLP alternatives do not extend below Laurel Avenue.
- **Levee Superiority.** Alternatives S-8 and SB-7 incorporate USACE levee superiority design requirements. Based on hydraulic modeling of the existing levee profile, it is estimated that overtopping upstream of the Yuba River confluence would occur between River Miles 43.5 and 45.5 (FRWLP Station 1582+00 to 1601+00). Downstream of the Yuba River, overtopping would occur between River Miles 19 and 20 (FRWLP Station 547+00 to 604+60). Erosion protection matting will be installed at these two locations on the landside of the levee to control erosion and to allow for more controlled failure of the levee due to overtopping. These locations are in non-urbanized areas and initial overtopping is estimated to occur between the mean 0.5% (1/200) ACE and 0.2% (1/200) ACE events.
- **Sutter Butte Canal.** At several locations where the Sutter Butte Canal and the Feather River West Levee lie adjacent to each other, the levee and/or canal would be relocated under Alternative SB-8 in order to provide an operations and maintenance road between the canal and levee. Under the FRWLP, no canal or levee relocation is proposed. Because SB-7 does not include this reach of levee, no levee or canal relocations are proposed under SB-7.
- **USACE Vegetation Management Levee Safety Policy.** USACE policy requires new federally authorized cost shared levee projects be designed to meet the current vegetation management standards. A Vegetation-Free Zone (VFZ) as described by Engineer Technical Letter ETL 1110-2-571, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures*, (Vegetation ETL) would be established and vegetation removed to bring the levee into Vegetation ETL compliance.
- **Real Estate Requirements.** Under the SBPFS, the lands to be acquired for construction and O&M on the landside of the levee would be less than under the FRWLP.

4.1.4.1 Downstream Levee Improvement Extension

An additional 2,250 feet of levee improvement would be constructed below Laurel Avenue (180+00 to 202+50) and consist of a 100-foot wide undrained seepage berm (5 feet thick at berm toe) in combination with a cutoff wall extending to an elevation of 25 feet. The additional work is proposed

because this area is located in an area that is highly conducive to seepage distress, is at or very close to the downstream end of the supplemental site on the Feather River that SBFCA previously requested USACE to evaluate, and overlaps lightly with a berm and toe drain that USACE constructed after the 1997 flood.

4.1.4.2 Levee Superiority

Alternatives SB-7 and SB-8 address USACE requirements for levee superiority. The definition of levee superiority pursuant to Engineer Circular 1110-2-6066, *Design of I-Walls*, (October 31, 2010) is the increment of additional height added to a flood risk–management system to increase the likelihood that when the design event is exceeded, controlled flooding will occur at the design overtopping section. Because alternative SB-7 is based on an existing levee profile, the design top of levee was reviewed relative to the modeled mean water surface profiles to determine the likely initial overtopping location.

4.1.4.2.1 Alternative SB-7

A single initial overtopping location was determined within the SB-7 project reach. It is estimated that the initial overtopping would likely occur between River Miles 19 and 20 (FRWLP Station 547+00 to 604+60). This location is a non-urbanized area and initial overtopping is estimated to occur between the mean 0.5% (1/200) ACE and 0.2% (1/500) ACE events. Within this 1-mile reach, the landward side of the levee would be covered with anchored High Performance Turf Reinforced Mat (HPTRM). This design would increase the erosion resistance of the levee and allow for more controlled failure of the levee due to overtopping.

4.1.4.2.2 Alternative SB-8

Alternative SB-8 extends upstream and downstream of the Yuba River tributary. Initial overtopping locations were identified upstream and downstream of confluence to account for the uncertainty in the aerial centering of storm events. It is estimated that the initial overtopping location upstream of the Yuba River confluence would occur between River Miles 43.5 and 45.5 (FRWLP Station 1582+00 to 1601+00). This location is a non-urbanized area and initial overtopping is estimated to occur between the mean 0.5% (1/200) ACE and 0.2% (1/500) ACE events.

It is estimated that the initial overtopping location downstream of the Yuba River would occur between River Miles 19 and 20 (FRWLP Station 547+00 to 604+60). This location is a non-urbanized area and initial overtopping is estimated to occur between the mean 0.5% (1/200) ACE and 0.2% (1/500) ACE events. This is identical to the reach identified for the SB-7 alternative.

Within both reaches, the landward side of the levee would be covered with anchored HPTRM. This design would increase the erosion resistance of the levee and allow for more controlled failure of the levee due to overtopping.

4.1.4.3 Sutter Butte Canal

The Sutter Butte Canal is operated by the Joint Water Districts–consisting of Richvale Irrigation District, Biggs-West Gridley Water District, Butte Water District, and Sutter Extension Water District. The canal delivers Feather River water supply to all four districts, which are located generally south and west of Lake Oroville and the Feather River along the eastern side of the Sacramento Valley.

The canal is approximately 17 miles long and is predominately unlined. The existing operating capacity ranges from approximately 1,600 cubic feet per second (cfs) at the upstream end to approximately 500 cfs at the downstream end.

Both the Sutter Butte Canal and the Feather River levee have meandering alignments. The canal is adjacent to the levee in some locations and is up to several hundred feet away from the levee in other locations.

The Sutter Butte Canal is adjacent to the levee at three locations, for a combined length of about 3.5 miles. Seepage and stability issues resulting from the canal being adjacent to the levee would be addressed by the construction of a cutoff wall through the levee; however, in all but one area there is no room for a landside easement due to the location of the adjacent canal. The landside easement is required to accommodate an O&M road. The levee encroachment areas are shown on Plates 4-2 and 4-3.

The proposed action for each area is addressed below.

a. Affected Area 1a (1429+00 to 1433+83, FRWLP Reach 21). The proposed option for this area is to move the canal landward into an adjacent agricultural area to provide space between the canal and the levee for the landside O&M road. See Plate 4-2, Canal Relocation Site B.

b. Affected Area 1b (1430+00 to 1449+00, FRWLP Reach 22). The proposed option for this area is to move the levee waterward into the flood overflow area to provide space sufficient for the landside O&M road. See Plate 4-2, Canal Relocation Site B.

c. Affected Area 2 (1611+00 to 1623+00, FRWLP Reach 24). The proposed option for this area is to move the levee waterward into the flood overflow area to provide space sufficient for the landside O&M road. See Plate 4-2, Canal Relocation Site A.

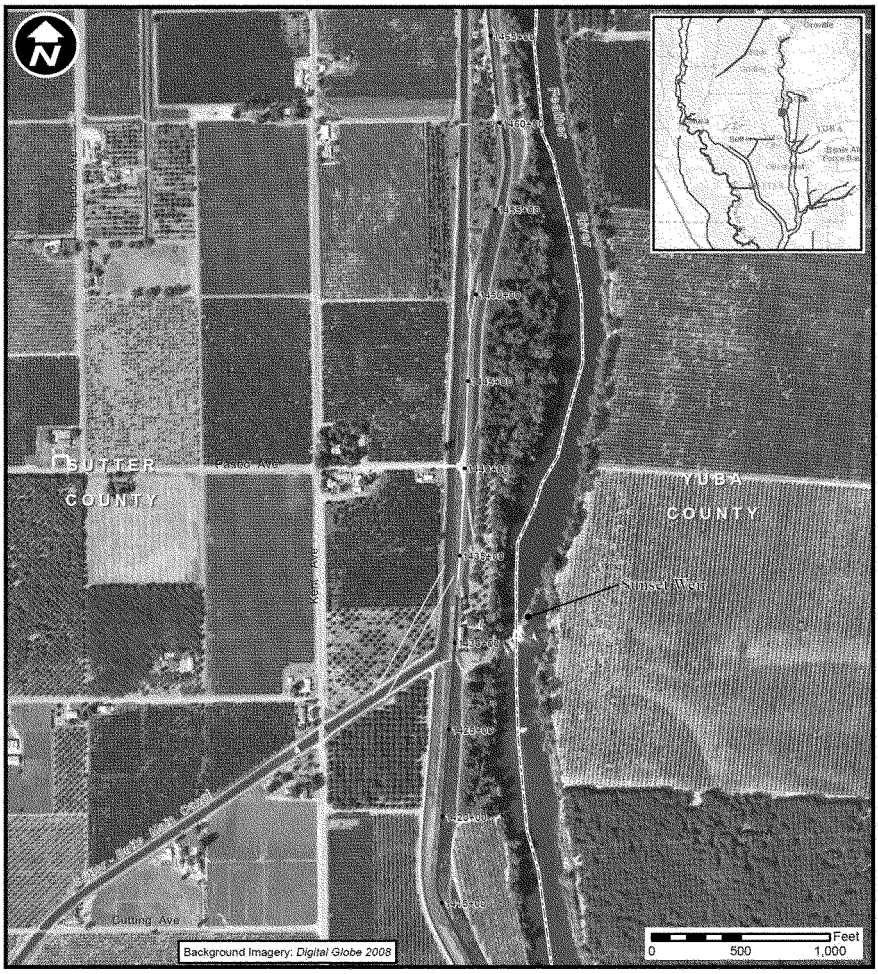
d. Affected Area 3a (1674+00 to 1753+00, FRWLP Reach 28). The proposed option for this area is to move the levee waterward into the flood overflow area to provide space sufficient for the landside O&M road. See Plate 4-3, Canal Relocation Site A.

e. Affected Area 3b (1753+00 to 1765+00, FRWLP Reach 28). The proposed option for this area is to move the canal landward into adjacent agricultural area to provide space between the canal and the levee for the landside O&M road. See Plate 4-3, Canal Relocation Site A.

4.1.4.4 USACE Vegetation Management Levee Safety Policy

The Vegetation ETL, dated April 10, 2009, provides guidance for maintenance of structures in order to provide the authorized level of flood risk management. The Vegetation ETL requires maintenance of a *vegetation-free zone*, consisting of a 3-dimensional zone surrounding all levees, floodwalls, embankment dams, and critical appurtenant structures in all flood damage reduction systems (Figure 4-1). The purpose of the vegetation-free zone is to provide a reliable corridor of access to and along federally authorized and constructed flood risk–management features for surveillance, inspection, maintenance, monitoring, and flood-fighting.

Plate 4-2. Canal Relocation and Levee Realignment (Affected Areas 1a and 1b)



Legend

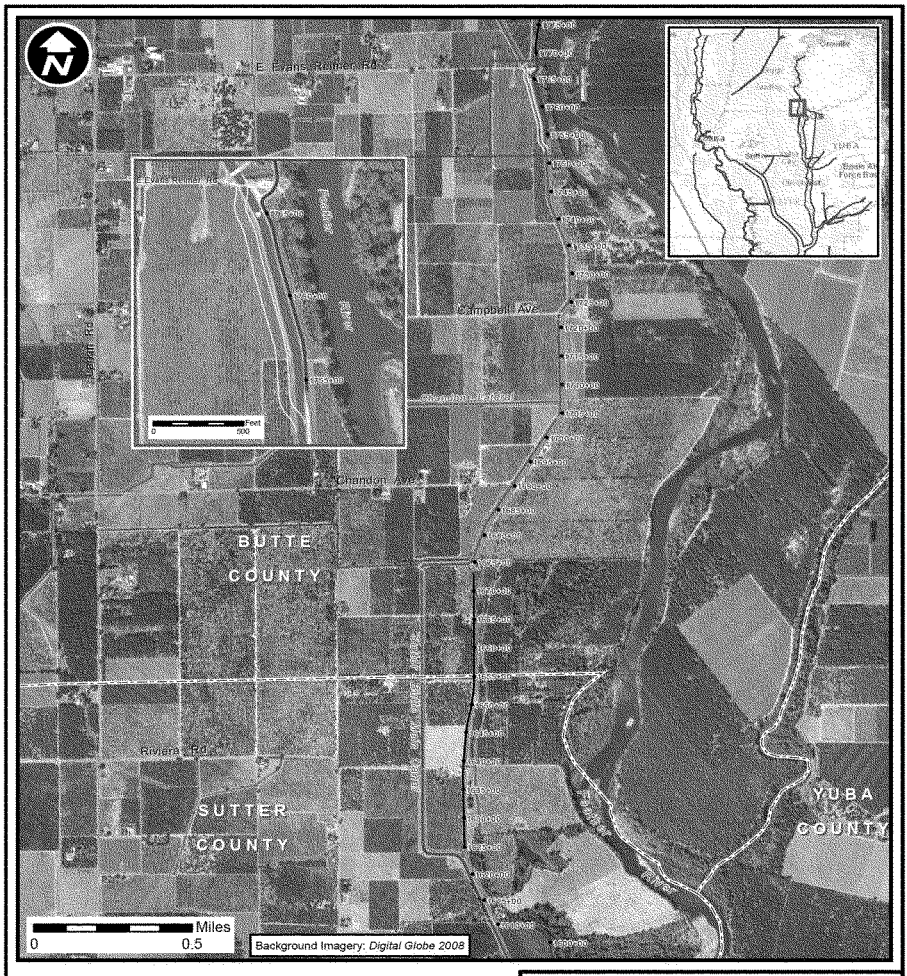
- Canal Realignment
- Cutoff Wall Only
- Levee Realignment w/Cutoff Wall
- Levee Degrade w/Cutoff Wall
- Stationing Point
- Road
- County Boundary

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

SUTTER BASIN
LEVEE IMPROVEMENTS
CANAL RELOCATION SITE B

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Plate 4-3. Canal Relocation and Levee Realignment (Affected Areas 2, 3a, and 3b)



Legend

- Canal Realignment
- Cutoff Wall Only
- Levee Realignment w/Cutoff Wall
- No Fix Required
- Stationing Point
- Road
- County Boundary

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

SUTTER BASIN
LEVEE IMPROVEMENTS
CANAL RELOCATION SITE A

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

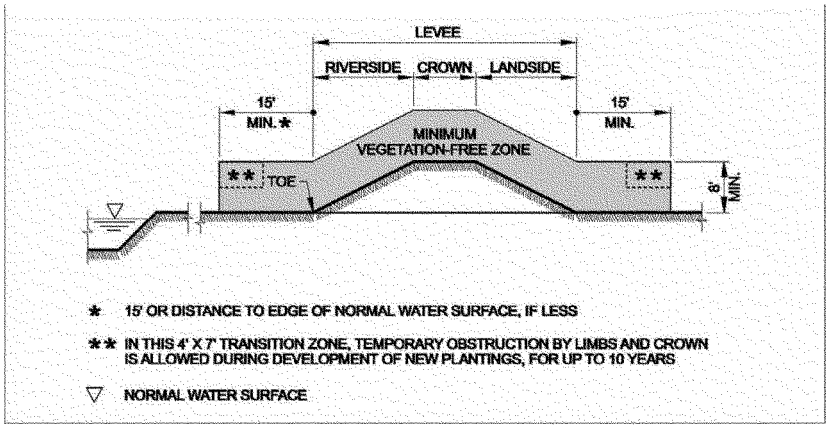


Figure 4-1. Illustration from Chapter 6, Engineer Technical Letter 1110-2-571

This document evaluates alternatives that would comply with USACE's vegetation policy, as established in the Vegetation ETL. Under the FRWLP, no additional vegetation removal would occur solely to comply with USACE's levee vegetation policy. Therefore, alternatives that would confine vegetation losses to the construction footprint have already been evaluated in the FRWLP EIS, and are not evaluated further in this document.

During construction, existing vegetation would be removed adjacent to the riverward and landside toes by root plowing or clearing and grubbing to create the vegetation-free zone. Following construction, disturbed soils including levee side slopes would be seeded with native grass seed to prevent wind and water erosion. A 15-foot-wide vegetation management zone along the riverward and landside toe of the levee would be permanently maintained to be devoid of trees and shrubs.

Approximately 42.00 acres of trees and other vegetation would need to be cleared to construct the levee improvements and to meet USACE vegetation management requirements under SB-8, and 24.40 acres would be cleared under SB-7. Vegetation-free zone requirements account for about 20 acres of vegetation losses under SB-8 and about 12 acres under SB-7.

USACE issued a draft policy guidance letter (Federal Register, February 17, 2012) describing a variance application process under which a levee system may be eligible for a vegetation variance. Under this draft guidance, a vegetation variance can be considered if one of the following conditions applies.

a. The variance is necessary to comply with applicable law concerning the environment, cultural or historic preservation.

b. The variance would protect the right of Tribal Nations, pursuant to treaty, statute, or Executive Order.

c. The variance is necessary to address a unique environmental consideration.

d. A prior vegetation agreement is in place.

However, even if one of the above criteria is met, life safety is still paramount and the vegetation variance must assure that the structural integrity and functionality of the levee are retained. The levee must still be accessible for maintenance, periodic inspection, monitoring during flood events, and access to perform flood-fighting if required. As discussed in Chapter 3, Section 3.8.2.2.2, *Woody Vegetation on Levee*, a variance request or design measures to retain vegetation will be considered during the preconstruction engineering and design phase.

4.1.4.5 Real Estate Requirements for Construction

To construct and operate and maintain the project, USACE would coordinate with SBFCA and the California Department of Water Resources (DWR) to acquire, where existing rights are insufficient, a permanent easement of 15 feet on the waterside and landside of the levee (as opposed to 30-foot permanent right-of-way landside of the levee to be acquired under the FRWLP). In developed areas, the project would seek to acquire rights-of-way to the extent necessary to facilitate construction of the project. For temporary construction purposes, the project would seek to acquire temporary easements at areas proposed as staging areas.

4.1.5 Study Area and Project Area

To assist in the description of existing resources and potential impacts associated with the SBPFS, a project area and a study area have been defined as described in sections below. Specifically, the project area is defined as the footprint of where potential project actions would occur. This project area takes into consideration areas of potential direct impact as well as areas potentially affected by immediate indirect or secondary impacts.

The study area encompasses a much larger area that could potentially be indirectly impacted by the SBPFS. The study area, as described in Chapter 1, is defined as the 326-square-mile Sutter Basin located in Northern California in Sutter and Butte Counties within the 14,000-square-mile Sacramento River Watershed. In addition to Yuba City, communities in the basin include Biggs, Gridley, Live Oak, and Sutter.

The project area is the area directly affected by proposed levee improvements. The project area is located along the west levee of the Feather River from Thermalito Afterbay on the north to approximately 4 miles north of the Sutter Bypass on the south. These levees are the same levees proposed for improvement under the FRWLP as described in the FRWLP Final EIS. The direct effects of levee improvements would be located in a corridor roughly 500 feet toward the landside of the existing levees and 100 feet toward the waterside. This corridor was determined as the area in which levee improvements, such as seepage berms, stability berms, relief wells, setback levees, erosion protection, and slurry cutoff walls, are likely to be constructed. The corridor is approximately 41 miles long. For ease of describing existing conditions and identifying affected reaches, the corridor has been divided into 41 relatively homogeneous reaches, as shown on Plate 4-4. (Note that this number is coincidental and one reach does not consistently correspond to a length of 1 mile; additionally, no levee improvements are proposed in Reach 1.). The project area also includes borrow/spoil sites or project mitigation sites outside of this corridor. The reaches are listed in Table 4-2. Figures 4-2 to 4-8 (located at the end of this chapter) show representative photos of the project area.

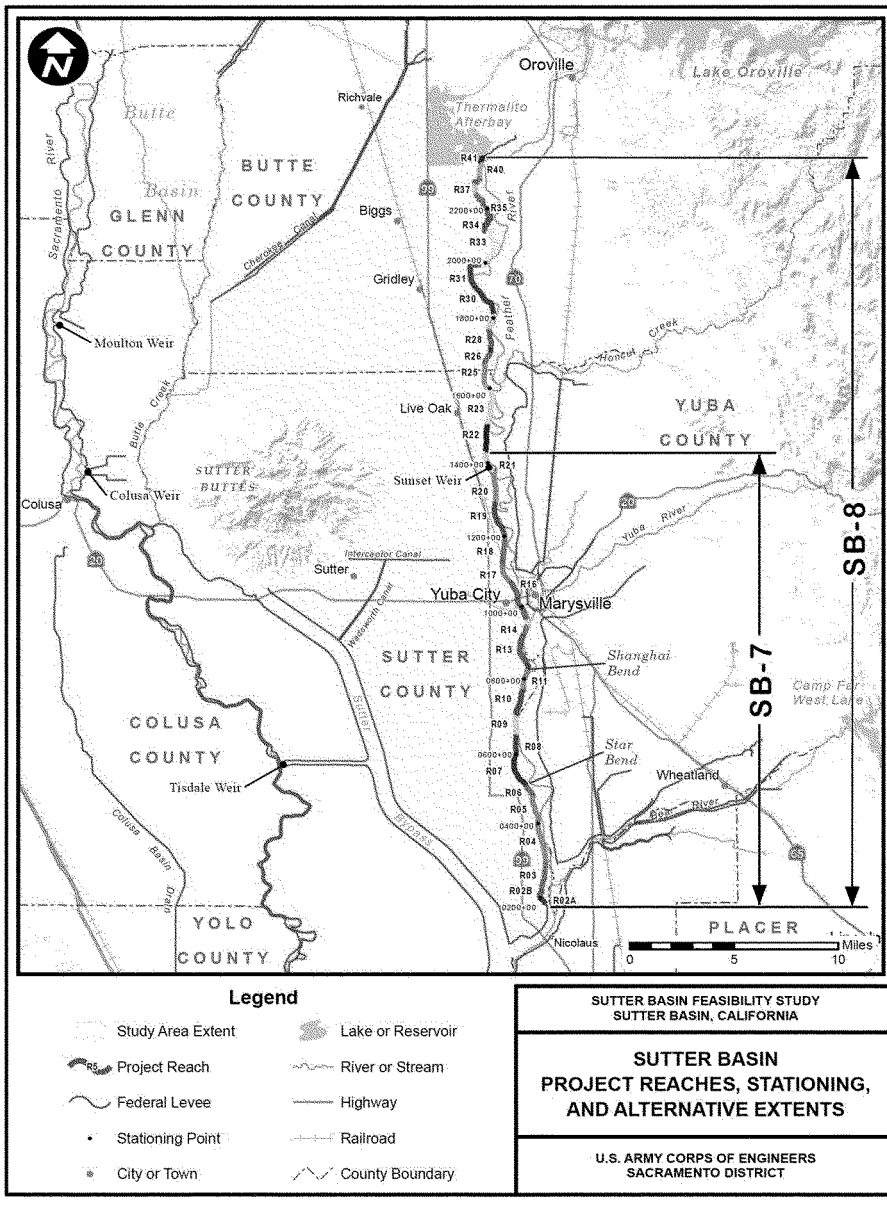


Plate 4-4. Sutter Basin Project Reaches and Alternative Extents

4.1.6 Environmental Resources Eliminated from Detailed Analysis

Certain resources were eliminated from further analysis because they were addressed adequately in the FRWLP Final EIS. Changes to the proposed action would not result in any new or substantially more severe significant direct and indirect effects, including short- and long-term effects, than were analyzed in the FRWLP Final EIS. Table 4-1 summarizes the resources not considered further and the rationale for their elimination. The following is a brief discussion of these resources.

4.1.6.1 Traffic, Transportation, Navigation

The FRWLP Final EIS described the traffic and circulation characteristics of the existing transportation corridors in the project vicinity and analyzed the potential impacts. That information is hereby incorporated by reference.

As described in the FRWLP Final EIS, effects on traffic levels would result primarily from hauling borrow material along highways and local roads from borrow sites to the levee improvement area, and from worker trips to and from the project site. Temporary increases in construction-related traffic, temporary road closures, emergency response times, and other traffic, transportation, and navigation effects from project implementation were determined to be less than significant. Under Alternative SB-8, traffic effects would be comparable in type but potentially of lower magnitude because project construction is anticipated to occur over a 6-year period rather than 3 years under the FRWLP. Alternative SB-7 would have substantially less impact than SB-8 due to SB-7's smaller construction footprint.

4.1.6.2 Noise

Noise impacts would not exceed those previously identified in the FRWLP Final EIS; however, temporary noise effects from construction activities would remain a significant effect of the project. Implementation of SB-8 or SB-7 would result in temporary but significant effects related to construction noise and vibration in the affected area. Construction noise levels are predicted to exceed significance thresholds of 60 dBA-L_{eq} (equivalent continuous noise level) at noise-sensitive uses between the hours of 7:00 a.m. and 10:00 p.m. and 45 dBA-L_{eq} between the hours of 10:00 p.m. and 7:00 a.m. Under Alternative SB-8, the number of sensitive receptors and each receptor's exposure period would be substantially the same as described for the action alternatives evaluated in the FRWLP Final EIS. Alternative SB-7 would also have a significant effect on noise but would affect fewer sensitive receptors than SB-8. Mitigation measures to employ noise-reducing and vibration-reducing construction practices would not be sufficient to reduce the exposure of sensitive receptors to temporary construction noise and vibration to a less-than-significant level. Though temporary, effects would be significant and unavoidable.

Table 4-1. Resources Considered for this Final EIR/SEIS

Resource	Justification
No Further Analysis Needed	
Traffic, Transportation, Navigation	Traffic impacts would not exceed those previously identified. Lengthening the construction period from 3 to 6 years would increase the total duration of traffic impacts, but the magnitude of short-term impacts would be reduced.
Noise	Noise impacts would not exceed those previously identified. Lengthening the construction period from 3 to 6 years would increase the total duration of short-term noise impacts, but the number of sensitive receptors and each receptor's exposure period would be substantially the same due to the linear nature of construction.
Population, Housing, and Environmental Justice	No substantial change in impacts beyond those previously identified in the FRWLP Final EIS.
Utilities and Public Services	No substantial change in impacts beyond those previously identified in the FRWLP Final EIS.
Public Health and Environmental Health	No substantial change in impacts beyond those previously identified in the FRWLP Final EIS.
Further Analysis Conducted	
Flood Risk Management and Geomorphology	At several locations where the existing levee lies directly adjacent to the Sutter Butte Canal, the existing levee would be modified to incorporate a maintenance road to meet USACE levee standards.
Water Quality and Groundwater Resources	Effects on water quality may be greater due to an additional 2,250 feet of levee work proposed downstream of Laurel Avenue and the additional removal of vegetation that provides erosion protection.
Geology, Seismicity, Soils and Mineral Resources	Compliance with USACE levee vegetation management requirements and an additional 2,250 feet of levee work proposed downstream of Laurel Avenue would result in greater land disturbance and potential for soil erosion.
Air Quality and Climate Change	A lengthened construction period of up to 6 years would increase the total duration of construction emissions, but the magnitude of emissions would be reduced. Emission levels would not exceed de minimis thresholds.
Agriculture, Land Use, Socioeconomics	The construction footprint of both action alternatives includes an additional 2,250 feet of levee downstream of Laurel Avenue. Real estate requirements would be less than those of the FRWLP.
Vegetation and Wetlands	Compliance with USACE levee vegetation management requirements would result in greater vegetation impacts than would occur under the FRWLP.
Wildlife	Wildlife would be impacted to a greater degree due to vegetation removal to comply with USACE vegetation management requirements.
Fish and Aquatic Resources	Fish and aquatic resources could be impacted to a greater degree because of the removal of additional vegetation to comply with USACE vegetation management standards.
Visual Resources	Additional vegetation removal may further diminish aesthetics values.
Recreation	Additional vegetation removal may further diminish recreation values.
Cultural Resources	Design modifications could result in additional impacts on cultural resources. The additional work downstream of Laurel Avenue and relocation of the levee and/or the Sutter Butte Canal at several locations would result in additional impacts on the levee and the canal, both of which may be eligible for listing on the National Register for Historic Places, and to prehistoric archaeological sites.

Table 4-2. Summary of Study Reaches

Reach	Beginning Station	Ending Station	Length (feet)	Landmarks	Dominant Adjacent Land Uses
1	0+00	180+50	Not part of the project proposed at this time.		
2	180+50	218+66	3,816	Laurel Avenue	Ruderal grassland; open space
3	218+66	300+66	8,200	Cypress Avenue	Ruderal grassland; open space
4	300+66	410+67	11,001	Central Street; Wilkie Avenue	Orchard; ruderal grassland; riparian forest
5	410+67	478+68	6,801	Wilkie Avenue	Orchard
6	478+68	510+37	3,169	Star Bend	Orchard
7	510+37	596+00	8,563	Abbott Lake	Ruderal grassland; open space
8	596+00	654+75	5,875		Ruderal grassland; open space
9	654+75	706+50	5,175	Boyd's Boat Launch; Nursery	Ruderal grassland; open space
10	706+50	774+00	6,750	Barry Road	Ruderal grassland; open space
11	774+00	830+00	5,600		Ruderal grassland; open space
12	830+00	845+00	1,500	Shanghai Bend	Ruderal grassland; open space
13	845+00	927+00	8,200		Ruderal grassland; open space
14	927+00	954+40	2,740	Airport	Ruderal grassland; open space
15	954+40	968+50	1,410	Airport	Developed; ruderal grassland
16	968+50	1080+00	11,150	Garden Highway: 2nd Street; Twin Cities Memorial Bridge; Colusa Avenue	Developed; ruderal grassland
17	1080+00	1130+86	5,086	Live Oak Boulevard; Union Pacific Railroad	Developed; ruderal grassland
18	1130+86	1213+85	8,299	Live Oak Boulevard; Union Pacific Railroad; Rednall Road	Orchard
19	1213+85	1297+83	8,398		Orchard
20	1297+83	1374+33	7,650		Orchard; ruderal grassland
21	1374+33	1433+83	5,950		Ruderal grassland
22	1433+83	1503+83	7,000		Riparian forest; ruderal grassland
23	1503+83	1609+37	10,554		Orchard
24	1609+37	1623+86	1,449		Riparian forest; ruderal grassland
25	1623+86	1674+37	5,051		Orchard; ruderal grassland
26	1674+37	1707+11	3,274		Orchard
27	1707+11	1721+60	1,449		Ruderal grassland
28	1721+60	1769+31	4,771		Orchard
29	1769+31	1813+33	4,402		Orchard; riparian forest
30	1813+33	1902+00	8,867		Orchard
31	1902+00	1958+00	5,600		Orchard; ruderal grassland
32	1958+00	1989+00	3,100		Orchard
33	1989+00	2122+00	13,300		Orchard
34	2122+00	2182+00	6,000		Orchard
35	2182+00	2224+00	4,200		Orchard; ruderal grassland
36	2224+00	2259+00	3,500		Orchard; ruderal grassland
37	2259+00	2290+00	3,100		Orchard; ruderal grassland
38	2290+00	2303+00	1,300		Ruderal grassland
39	2303+00	2319+00	1,600		Ruderal grassland
40	2319+00	2359+00	4,000		Ruderal grassland
41	2359+00	2368+00	900	Thermalito Afterbay	Ruderal grassland

4.1.6.3 Population, Housing, and Environmental Justice

Effects on population, housing, and environmental justice under Alternatives SB-8 and SB-7 would be similar to effects described in the FRWLP Final EIS, which identified the permanent acquisition of five residences to accommodate project construction of SBFCA's preferred alternative and 17 residences under Alternative 2. For the SBPFS, 31 properties were identified where existing improvements are located within 15 feet of the landside levee toe within the footprint of Alternative SB-8. Seven of the 31 properties have single family homes. Specific project requirements for right-of-way to construct the improvements and remove encroachments that threaten levee integrity would be determined at the final design phase prior to construction. Permanent acquisition, relocation, and compensation services would be conducted in compliance with Federal and state relocation laws (the Federal Uniform Relocation Assistance and Real Property Acquisition Act, the California Relocation Act, and the Relocation Assistance and Real Property Acquisition Guidelines). The displacement of any residences is considered a significant impact, so the permanent acquisition of residences and the potential for temporary displacement of residences under SB-7 and SB-8 would be significant. However, with implementation of Federal and state relocation laws, this impact would be reduced to a less-than-significant level. Pursuant to these Federal and state relocation laws, appropriate compensation would be provided to displaced landowners and tenants, and residents would be relocated to comparable replacement housing. In cases where project construction is temporarily disruptive to nearby residents, assistance would be provided for residents to relocate temporarily during construction activities and compensation would be offered to residents for reasonable rent and living expenses incurred as a result of relocation.

The FRWLP Final EIS evaluated the project's impact on the population to determine whether low-income or minority populations are present and would be adversely affected. That evaluation is incorporated by reference. The proposed action would not disproportionately adversely affect minority or low-income populations because the number of home acquisitions from minority or low-income census blocks would be comparable to home acquisitions in other census blocks. Further, construction-related environmental effects (e.g., temporary exposure to noise, dust, traffic, and hazardous materials) would occur throughout the project area and would not have a disproportionate effect on specific reaches. Implementing the project would protect property, as well as the health and safety of residents. Therefore, the proposed action would reduce the risk of flooding to existing residential, commercial, and industrial development throughout a significant portion of the study area.

Under the No Action Alternative, the additional cost of flood insurance may be absorbed by many low-income populations within the study area and could cause substantial financial hardship on residents' already limited abilities to purchase basic goods and services. Additional costs for low-income residents are more profound than for non-low-income residents because the additional costs would account for a higher proportion of low-income residents' total income, leaving fewer financial resources to address other needs.

4.1.6.4 Utilities and Public Health

Effects on utilities and public health described in the FRWLP Final EIS would be similar under Alternative SB-8. Because of a reduced construction footprint, Alternative SB-7 would have less impact on utilities. As described in the FRWLP Final EIS, construction of the project may damage drainage and irrigation systems and public utility infrastructure, resulting in temporary disruptions to service. Coordination with drainage and irrigation systems users, consultation with service providers, and

implementation of appropriate protection measures would minimize the possibility of any significant effects.

4.1.6.5 Public Health and Environmental Health

The potential effects on public health and safety described in the FRWLP Final EIS would be similar under Alternatives SB-8 and SB-7. Project implementation has the potential to slightly increase risks to the public during construction due to construction activities and the potential for an accidental release of hazardous materials, but the increased risk would be temporary. Effects would be less than significant because risks would be minimized by implementation of a stormwater pollution prevention plan and best management practices to control accelerated erosion, sedimentation, and other pollutants during and after project construction.

4.2 Flood Risk Management and Geomorphic Conditions

4.2.1 Introduction

This section discusses the effects on flood risk management and geomorphic conditions that would result from the No Action Alternative, and Alternatives SB-7 and SB-8, as well as mitigation measures that would reduce significant effects.

4.2.2 Affected Environment

The regulatory and environmental setting for flood risk management and geomorphic conditions are summarized below and are described in greater detail in Section 3.1 of the FRWLP Final EIS, which is incorporated by reference.

4.2.2.1 Watershed

The Sutter Basin study area is situated within the Sacramento River watershed. A map of the Sacramento River watershed is provided as Plate 1-1 in Chapter 1, *Introduction.* The principle watersheds upstream of the study area are the Sacramento River watershed and Feather River watershed. The Sacramento River watershed encompasses the McCloud River, Pit River, and Goose Lake, and Stony Creek. The watershed drains the Sierra Nevada Mountains and Cascade Ranges in the east and the Coast Range and Klamath Mountains in the west. The Feather River watershed encompasses the Yuba and Bear Rivers. These watersheds drain the western slopes of the Sierra Nevada mountain range. The drainage area of the Sacramento River basin upstream of the study area is approximately 12,000 square miles. The drainage area of the Feather River upstream of the study area (including the Yuba and Bear Rivers) is approximately 5,900 square miles.

4.2.2.2 Topography

Elevations within the study area range from 110 feet NAVD88 in the north to 30 feet NAVD88[1] in the south. The study area has a general slope from northeast to southwest. The general slope of the study area is interrupted by two major embankment features which impact hydraulic conveyance within the

[1] The North American Vertical Datum of 1988 (NAVD88) is the vertical control datum of orthometric height established for vertical control surveying in the United States based upon the General Adjustment of the North American Datum of 1988.

floodplain. The raised embankment of the Union Pacific Railroad traverses the study area in a north south alignment and the Sutter Bypass east levee traverses the study area in a north south alignment.

4.2.2.3 Flood Sources

The Sutter Basin study area is susceptible to flooding from multiple sources including Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and interior sources.

4.2.2.3.1 Butte Basin

The northwest portion of the study area is within the Butte Basin. The Butte Basin is a natural overflow and flood storage area northwest of the Sutter Buttes and east of the Sacramento River. The basin provides approximately 1 million acre-feet of transitory storage at flood stage (California Department of Water Resources 2010). Excess floodwaters from the Sacramento River enter the Butte Basin via overbank areas along the river and through the Moulton and Colusa Weirs. Butte Creek and its tributaries, including Cherokee Canal, also flow into the Butte Basin. Outflow from the Butte Basin is naturally regulated by hydraulic conditions of Butte Slough and floodplain topography at the upstream entrance to the Sutter Bypass. In order to maintain the flood storage capabilities within Butte Basin, California has included regulation of the overflow area in Title 23 of the California Code of Regulations. In general these standards require approval from the Central Valley Flood Protection Board for any encroachments that could reduce or impede flood flows or that would reclaim any of the floodplain within the Butte Basin (California Department of Water Resources 2010).

4.2.2.3.2 Sutter Bypass

The southwest portions of the study area including the southern portion of Yuba City are susceptible to flooding from the Sutter Bypass. The Sutter Bypass is a leveed flood control channel approximately three quarters of a mile wide, bordered on each side by levees. The bypass is an integral feature of the Sacramento River Flood Control Project's Flood Bypass System. The Sutter Bypass conveys flood waters from the Butte Basin, Sacramento River, and Feather Rivers to the confluence of the Sacramento River and Yolo Bypass at the Fremont Weir.

Downstream of the Feather River the bypass is separated into two conveyance areas by a low levee. The area east of the middle levee conveys flows from the Feather River. This design maintains higher velocities and sediment transport capacity within the Feather River during low flow events while utilizing the large conveyance of the Sutter Bypass during larger events.

The Sutter Bypass also receives minor natural flow and agricultural return flow from Reclamation District 1660 to the west and from Wadsworth Canal and DWR pumping plants 1, 2, and 3 to the east. The Sutter Bypass is described by four hydrologic reaches based on tributary inflows: Butte Slough to Wadsworth Canal, Wadsworth Canal to Tisdale Bypass, Tisdale Bypass to Feather River, and Feather River to Sacramento River.

4.2.2.3.3 Feather River

Nearly the entire study area is susceptible to flooding from the Feather River. The Feather River is a major tributary to the Sacramento River, merging with the Sutter Bypass upstream from the Sacramento River and Fremont Weir. The Yuba and Bear Rivers are major tributaries to the Feather River. Two major flood management reservoirs are located within the Feather River watershed. Oroville Dam and reservoir was completed on the Feather River in 1967. The reservoir has 3,358,000

acre-feet of storage with 750,000 acre-feet of dedicated flood management space. New Bullards Bar dam and reservoir was completed on the Yuba River 1970. The reservoir has 966,000 acre-feet of storage with 170,000 acre-feet of dedicated flood management space. The Feather River is described by four hydrologic reaches based on significant inflows: Thermalito to Honcut Creek, Honcut Creek to Yuba River, Yuba River to Bear River, and Bear River to Sutter Bypass.

4.2.2.3.4 Cherokee Canal

The northern portion of the study area is susceptible to flooding from Cherokee Canal which is a tributary to Butte Creek and the Butte Basin. The leveed canal was constructed from 1959 to 1960 by USACE under the authorization of the Flood Control Act of 1944. The canal drainage area is 94 square miles and varies in elevation from 70 feet to 2,200 feet. The drainage area is bounded by the Feather River watershed to the east and southeast, Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south. The design capacity along the Cherokee Canal is 8,500 cubic feet per second (cfs) upstream of the junction with Cottonwood Creek, 11,500 cfs from the junction with Cottonwood Creek to the Biggs Princeton Highway (Afton Road) and 12,500 cfs from the Biggs Princeton Highway to Butte Creek. Based upon the flood frequency analysis at the time of design, the canal was estimated to provide levels of performance for a 4% (1/25) ACE event and mitigated sediment transport problems within its watershed.

4.2.2.3.5 Wadsworth Canal

Wadsworth Canal and associated Interceptor Canals are potential sources of flooding in the southwest portion of the study area. The Wadsworth Canal system is a feature of the Sacramento River Flood Control Project and consists of leveed channels that carry rainfall and agricultural runoff from 91 square miles of Butte and Sutter Counties south to the Sutter Bypass.

1. West Interceptor Canal. The West Interceptor Canal begins near the town of Sutter and extends 1.8 miles east to Wadsworth Canal. The canal is approximately 30 feet wide and includes a 4- to 5-foot-tall Federal Project levee along its right bank. There is no Federal levee along the left bank of the canal. The slope of the canal is approximately 25 feet per mile. The purpose of the canal is to intercept rainfall runoff that would otherwise pond against the eastern levee of the Sutter Bypass. The intercepted flow is diverted into the Wadsworth Canal where it is then conveyed to the Sutter Bypass. During extreme floods the peak flow of the canal would be significantly attenuated by the floodplain storage available along the left bank. The canal is also used for irrigation water. The operations and maintenance manual does not list a design flow for the West Interceptor Canal.
2. East Interceptor Canal. The East Interceptor Canal begins near Yuba City and extends 3.1 miles east to the Wadsworth Canal. The canal is approximately 30 foot wide and includes a 4 to 5 foot tall Federal Project levee along its left bank. The purpose of the canal is to intercept rainfall runoff that would otherwise flow southwest and pond against the eastern levee of the Sutter Bypass. There is no Federal levee along the right bank of the canal. The slope of the canal is negligible and the top of levee has a level grade. The intercepted flow is diverted into the Wadsworth Canal where it is then conveyed to the Sutter Bypass. During extreme floods the peak flow of the canal would be significantly attenuated by the floodplain storage available along the right bank. The canal is also used for irrigation water during the summer irrigation season. The operations and maintenance manual does not list a design flow for the East Interceptor Canal.
3. Wadsworth Canal. Wadsworth Canal begins at the East and West Interceptor Canals near Butte House Road. The canal extends 4.5 miles south to the Sutter Bypass and includes Federal Project

levees along the left and right banks. The canal is a fairly uniform trapezoidal type channel. The purpose of the canal levee is to collect and convey rainfall runoff and irrigation water from the East and West Interceptor Canals to the Sutter Bypass. The existing Operations and Maintenance Manual for Wadsworth Canal describes a design capacity of 1,500 cfs.

4.2.2.3.6 Interior Drainage

Localized flooding problems often are caused by storm drain system overload, or an unusually heavy amount of rainfall. Flooding from intense weather events usually occurs in areas experiencing an increase in runoff from impervious surfaces associated with urbanization and development as well as inadequate storm drainage systems. The term *flash flood* describes localized floods of great magnitude and short duration. In contrast to riverine flooding, this type of flooding usually results from a heavy rainfall on a relatively small drainage area. Precipitation of this sort typically occurs in the winter and spring. However, much of the land in the study area is agricultural in nature; consequently, localized flooding does not present as significant a hazard as riverine flooding and is not a significant concern (AMEC 2007:44–45). Runoff from the interior of the study area may result in localized flooding. Interior drainage features include canals and streams tributary to Wadsworth Canal and pumps and culverts along the project levees.

4.2.2.4 Historical Floods

The Feather River near Oroville gage provides an indicator of large historical floods within the study area. The largest 15 floods from 1951 to 2010 are presented in Table 4-3. The magnitudes of historical floods prior to 1967 are not directly comparable to later floods due to significant historical changes in the flood management system. In order to provide a comparison of similar hydrologic conditions, the table includes the estimated unregulated flow for each water year. The ranking of unregulated floods is substantially different than observed flood flows with the 1997 flood being the largest unregulated flood from 1951 to 2010. The following is a description of significant flood events within the study area.

December 1955. The December 1955 flood was the largest peak flow recorded at the Feather River at Oroville gage from 1951 to 2010. Major damage to the study area occurred in December 1955 when the west levee of the Feather River breached near Shanghai Bend, resulting in the deaths of 38 people. The peak flow measured at the Feather River at Oroville stream gage was 203,000 cfs. This flood occurred prior to construction of Oroville Dam (completed 1967) and New Bullards Bar Dam (completed 1970). Therefore, the flood does not reflect existing hydrologic conditions. A hypothetical flood routing of the 1955 flood is presented in the Oroville Dam and Reservoir water control manual. The flood routing indicates the reservoir would have regulated the peak outflow to 150,000 cfs.

December 1964. The December 1964 flood was the fourth largest peak flow recorded at the Feather River at Oroville gage from 1951 to 2010. The main center of precipitation was in the Feather, Yuba, and American River Basins. Rainfall was heaviest on December 22 and 23, 1964. Runoff from streams of the Coast Ranges almost without exception produced peak stages and peak flows that exceeded previous records. Runoff from the Sierra Nevada into the Feather, Yuba and American Rivers surpassed all previous records. This flood occurred during construction of Oroville Dam and was partially regulated to an outflow of 158,000 cfs. A hypothetical flood routing of the 1964 flood is presented in the Oroville Dam and Reservoir water control manual. The flood routing indicates the completed reservoir would have regulated the peak outflow to 150,000 cfs.

Had it not been regulated, the peak flow would have been approximately 260,000 cfs, which would have exceeded the 1955 flood peak by 57,000 cfs.

Table 4-3. Fifteen Largest Annual Maximum Floods, Water Year 1951–Water Year 2010, Feather River at Oroville

	Measured				
Annual Ranking	Water Year	Date of Peak	Peak Flow (CFS)	Regulated Peak Flow (CFS)	Unregulated Peak Flow (CFS)
1	1956	12/23/1955	203,000	150,000	203,000
2	1963	1/31/1963	191,000		191,000
3	1997	1/2/1997	161,000	161,000	312,900
4[a]	1965	12/23/1964	158,000	150,000	260,000
5	1960	2/8/1960	135,000		135,000
6	1986	2/18/1986	134,000	134,000	217,000
7	1953	1/9/1953	113,000		113,000
8	1958	2/24/1958	102,000		102,000
9	1951	11/21/1950	92,100		92,100
10	1957	2/24/1957	83,100		83,100
11	1995	3/14/1995	71,700	71,700	134,200
12	1980	1/15/1980	69,500	69,500	137,600
13	2006	12/31/2005	65,600	65,600	
14	1952	2/1/1952	59,500		59,500
15	1970	1/25/1970	56,300	56,300	117,700

[a] December 1964 flood regulated by a partially completed Oroville Dam.

November 1982–March 1983. Water year 1983 was a result of the "El Niño" weather phenomenon. Northern and Central California experienced flooding incidents from November through March due to numerous storms. In early May, snow water content in the Sierra exceeded 230% of normal, and the ensuing runoff resulted in approximately four times the average volume for Central Valley streams. System failures in the Sacramento River Basin were limited to a private levee on the Sacramento River and one failure on Cache Creek.

February 1986. Flooding in 1986 resulted from a series of four storms over a 9-day period during February. Rains from the first three storms saturated the ground and produced moderate to heavy runoff before the arrival of the fourth storm. Precipitation at Four Trees in the Feather River Basin set both a 24-hour rainfall record for the Sierra Nevada and the monthly record for any station in the state. During the flood, the left levee of the Yuba River failed just upstream of the Feather River confluence. The communities of Linda and Olivehurst were inundated, resulting in one death, 895 destroyed homes, and 150 destroyed businesses.

January 1995. "El Nino" conditions in the Pacific forced major storm systems directly into California during much of the winter and early spring of 1995. The largest storm systems hit California in early January and early March. The major brunt of the January storms hit the Sacramento River Basin and resulted in small stream flooding primarily due to storm drainage system failures.

January 1997. December 1996 was one of the wettest Decembers on record. Watersheds in the Sierra Nevada were already saturated by the time three subtropical storms added more than 30

inches of rain in late December 1996 and early January 1997. The third and most severe of these storms lasted from December 31, 1996, through January 2, 1997. Rain in the Sierra Nevada caused record flows that stressed the flood management system to capacity in the Sacramento River Basin and overwhelmed the system in the San Joaquin River Basin. During the flood, the left levee of the Feather River failed near Arboga. The resulting flood killed one person, destroyed 180 homes and businesses, and prompted evacuation of about 15,000 people from Linda and Olivehurst. Nearly 50,000 people from Yuba City, Marysville, and surrounding areas were evacuated because of fears of additional levee breaks (U.S. Army Corps of Engineers 1998).

December 2005–January 2006. Between December 28, 2005 and January 9, 2006, the state experienced a series of severe storms that impacted the levees within California's Central Valley. Water rose a second time in April 2006 and remained high in some parts of the system until June. Many rivers and streams within the Sacramento and San Joaquin River systems ran above flood stage during these events, and there were significant erosion and seepage problems with the levees. DWR and maintaining agencies conducted the actual flood fight activities while USACE provided technical assistance to the State.

4.2.2.5 Levees and Flood Risk Management

Major storm events can produce high flows throughout the Feather River system. The primary method of flood risk management in the study area is provided by a system of levees or earthen embankments along the Feather River, Sutter Bypass, Wadsworth Canal, and Cherokee Canal that contain high river flows within these constructed channels[2]. Flood risk-management benefits are also provided by flood storage at Oroville Dam and Lake and New Bullards Bar Dam and Lake. There are approximately 72 miles of levees protecting the study area lands from flooding from the Feather, Yuba, and Bear Rivers[3]. All levees on the Feather River within the study area are part of the Sacramento River Flood Control Project (SRFCP) that was constructed by USACE. Some of these levees are now owned and maintained by DWR, while others are maintained by local levee districts.

Recent and ongoing studies have found that some levees in the study area do not meet, or have not been certified as meeting, the current levee design criteria. As a result, much of the study area is considered vulnerable to flooding from levee failure.

4.2.2.5.1 Flood Risk

Maps showing composite floodplains were developed to demonstrate flood risk management assurance relative to a standard assurance criterion. The maps show inundation from any flood source that would not meet a risk and uncertainty based assurance criterion. The assurance criterion was based on the National Flood Insurance Program (NFIP) levee system analysis criteria described in EC 1110-2-6067 and was adopted for use in describing the performance of all ACE events. This criterion is described as "Option 2" in the DWR Urban Levee Design Criteria. The assurance criterion utilized for this study does not account for wind wave overtopping.

- For assurance less than 90% the levee does not pass criteria.

[2] The study area also has a few drainage facilities with pump stations that keep the interior from flooding in certain locations.

[3] The Yuba and Bear Rivers levees are not within the study area; however, the contribution of flows from these rivers directly affects the channel capacity of the Feather River and, thus, the integrity and stability of the Feather River West Levee in the study area.

- For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria.
- For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria.

The composite floodplains are shown in Plates 4-9 through 4-16, which are located at the end of this chapter. All maps include the natural (non-leveed) flood inundation depths. The maps show greater depths in the southern portion of the study area.

4.2.2.5.2 Flood Warning Time

Flood warning time varies throughout the area and is dependent on the source of flooding. The principle sources of flood warnings are advisories by the National Weather Service (NWS) and river stage forecasts by the California Nevada River Forecast Center (CNRFC).

Flood Warnings are issued by the NWS when flooding of main stem rivers is occurring or imminent (California Nevada River Forecast Center 2013). Main stem river flooding refers to flooding of gauged and forecasted rivers (California Nevada River Forecast Center 2013). NWS can also issue Small River and Stream Flood Warnings for smaller rivers and streams that do not have forecast points.

Flash Flood Warnings are issued when flooding is reported; when precipitation capable of causing flooding is observed by radar and/or satellite; when observed rainfall exceeds flash flood guidance or criteria known to cause flooding; or when a dam or levee failure has occurred or is imminent (California Nevada River Forecast Center 2013). A flash flood is defined as a flood caused by heavy or excessive rainfall in a short period of time, and occurring generally within 6 hours of the causative event (California Nevada River Forecast Center 2013).

In addition to the advisories described above, the NWS in coordination with DWR issues forecasts and guidance for river flows through the CNRFC. In general, river forecasts are based on modeled runoff from observed precipitation, snowmelt estimates, and reservoir operations. The forecast length varies depending on the location. River guidance is based on modeled runoff from forecasted precipitation, snowmelt estimates, and reservoir operations. The forecasts and guidance are issued for a forecast site in a graphical format that compares the future river stage with a monitor stage, flood stage, and danger stage. The combined forecast and guidance are made 5 days into the future.

Flooding from interior drainage sources within the study area is likely to be the result of localized concentrated rainfall. It is assumed these floods would be preceded by a general flood watch issued by the NWS 12 to 24 hours in advance and a Flash Flood Warning 6 hours in advance of the localized flooding.

Flooding from a levee overtopping event along the Feather River would result from a large regional storm event in the Feather, Yuba, and Bear River watersheds. CNRFC river flood forecast points on the Feather River are located at Gridley, Yuba City, Boyd's Landing, and Nicholas. It is assumed that an overtopping flood would be preceded by a flood warning and river guidance issued by the NWS and CNRFC 5 days in advance. A more accurate warning of potential levee overtopping, based on river forecasts, would likely be made 24 to 36 hours in advance. This estimate was based on a review of the flood guidance plots for December 2005–January 2006 flood that indicate an approximate 24- to 36-hour lag between observed rain plus snowmelt in the basin and the peak measured stage at the Feather River near Gridley stream gage forecast point.

Flooding from a levee overtopping event along the Sutter Bypass would result from a large regional storm event in Sacramento River watershed. There are no CNRFC forecast points on the Sutter Bypass.

However, the forecast point on the Sacramento River at Fremont Weir represents flood conditions within the Sutter Bypass. It is assumed these floods would be preceded by a flood warning and river guidance issued by the NWS and CNRFC 5 days in advance. A more accurate warning of potential levee overtopping, based on river forecasts, would likely be made 24 to 36 hours in advance. This estimate was based on a review of the flood guidance plots for the December 2005–January 2006 flood which indicate an approximate 24- to 36-hour lag between observed rain plus snowmelt in the basin and the peak measured stage at the Sacramento River at Fremont Weir gage forecast point.

It is estimated that flooding from a geotechnical levee breach would have little to no advance warning (less than 1 hour) and the floodwave would rapidly inundate the adjacent areas. The levee breach that occurred at Shanghai Bend during the December 1955 flood is an indicator of flood warning times associated with geotechnical related failures. The levee failure was preceded by the Governor of the State of California issuing a "Stage of Emergency" on December 22 due to the abnormal and heavy rainfall (Sutter County 1957). However, the general evacuation order was given approximately 1-hour after the break (Sutter County 1957).

4.2.2.5.3 Federal Emergency Management Agency Mapping

Communities within the study area are enrolled in the NFIP administered by the Federal Emergency Management Agency (FEMA). The NFIP issues Flood Insurance Rate Maps (FIRMs) for use in setting insurance rates and defining floodplain management guidelines. NFIP maps are developed following FEMA mapping guidelines, which are specific to their program. The maps developed for the feasibility study use similar assumptions. However, they do not replace the NFIP maps used to define insurance rates. The effective FEMA NFIP maps in the study area are shown on Plate 4-5[4], and are summarized below.

- Most of the northern portion of the study area, especially the interior section, is designated as (Unshaded) Zone X (outside the 0.2% annual chance floodplain) and (Shaded) Zone X (areas of 0.2% annual chance of flood; areas of 1% annual chance of flood with average depths of less than 1 foot or within drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood).
- The remainder of the study area (the northern fringes associated with the Cherokee Canal and the Feather River) is designated as either Zone A (inundated by 100-year flooding; base flood elevations [BFEs] have not been determined), or is currently being revised with up-to-date FIRM mapping (i.e., the central portion of the study area).

It should be noted that FEMA is updating and modernizing existing FIRMs for most of the United States, including California. Accordingly, and given known levee deficiencies relative to FEMA NFIP requirements, FIRM data for Colusa, Glenn, Yolo, and Yuba Counties (last revised in 1996) may not be entirely indicative of the present status of designated floodplains in the study area. Butte County's FIRM data is from 2011 and is considered up-to-date.

[4] Figure 4-5 is derived from a compilation of parcels that encompass the study area.

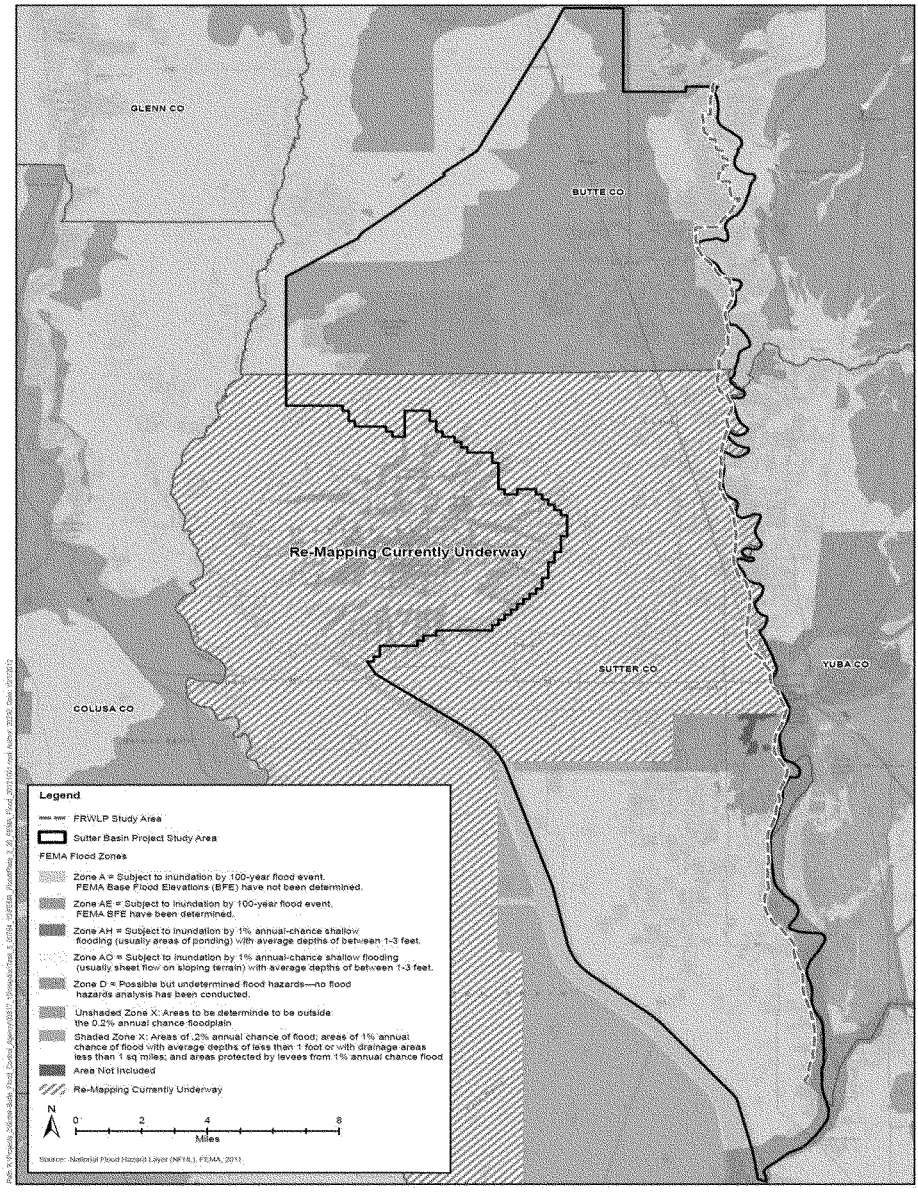


Plate 4-5. FEMA Zones

4.2.2.5.1 USACE Periodic Inspections

The USACE Rehabilitation and Inspection Program (RIP) provides for rehabilitation/repair of Public Law 84-99 eligible (active status) levees that are damaged during flood events. This authority covers post flood repair of both Federally authorized/constructed and non- Federally constructed flood control works. Inspections of Federal levees are funded and conducted under the Inspection of Completed Works (ICW) program. Inspection of non-Federal levees are funded and conducted under the PL 84-99 RIP. As the levees in the Dallas Floodway as described in this report are classified as Federal levees, inspections were funded and conducted under the ICW program.

After Hurricane Katrina struck New Orleans, USACE began assessing the Levee Safety Program (LSP) and reviewing criteria for evaluating levee systems. In January 2010, USACE completed a Periodic Inspection (PI) of the Basin applying the new, more stringent post-Katrina levee rating methods resulting in the *Feather River, Sutter Basin Protection Area, Periodic Inspection, January 2010, Report No. 1.* PI's are conducted to verify proper operation and maintenance; evaluate operational adequacy and structural stability; identify features to monitor over time; and improve the ability to communicate the overall condition. The PI report produced by USACE for the Basin determined that the levee system was "Unacceptable" which resulted with an "Inactive" status for PL 84-99 RIP assistance. Since the PIR was released, a number of the issues have been addressed or repaired by local maintaining entities. Unwanted vegetation growth, encroachments, and erosion are all system-wide issues and make up 97% of Sutter Basin's deficiencies listed in the USACE Unacceptable Items List.

On March 28, 2013, the CVFPB submitted a Letter of Intent (LOI) notifying USACE that the local maintaining agencies within the Sutter Basin led by SBFCA intended to develop and implement a System-Wide Improvement Framework (SWIF) plan. If accepted by USACE, the LOI will allow the Basin's levee system to retain eligibility for RIP assistance for a period of two years while SBFCA develops a SWIF. If the SWIF plan is accepted by USACE, the Basin's levee system will retain eligibility for RIP while the local levee maintainers perform the work described in the SWIF.

4.2.2.6 Geomorphology

In geologic history, the Sacramento and Feather Rivers migrated frequently and freely within their meander belts, which typically exceeded several thousand feet in width (Buer 1984 as cited in North State Resources and Stillwater Sciences 2009: 3-134). Prior to Euroamerican settlement, the mainstem Sacramento and Feather Rivers and tributaries along the valley floor would naturally overtop their banks at regular cycles and flood the adjacent lands, replenishing and depositing sediments.

Since in the late 1800s, the Sacramento and Feather Rivers' channel morphology and sediment transport regime have been progressively altered by human activities, including upstream hydraulic mining and the clearing of riparian vegetation and the construction of levees and upstream dams for flood risk management and water supply.

The geomorphic history of the Feather River has been substantially affected by Nineteenth century hydraulic mining. Prior to the onset of mining, the river was similar to the Sacramento River upstream of Colusa. The rapid introduction of mining debris resulted in extensive shoaling of bendways and a reduction in channel sinuosity. The initial pulse or surge of mining sediment was very fine-grained, silt-dominated material (referred to as *slickens*), which was followed by quartz-dominated sands and gravels. Channel infilling from mining debris resulted in a dramatic decrease in channel capacity on the Feather River. Extensive flooding and overbank deposition onto urban areas and agricultural lands

in the study area resulted. The Feather River subsequently has degraded into these sediments so that hydraulic mining debris presently constitutes the channel banks. The fine-grained slickens form a continuous, cohesive bank toe along the entire study area up to River Mile 28. This erosion-resistant toe generally has resulted in a stable river planform.

If degradation continues, however, coarse-grained, noncohesive pre-mining sediments will be exposed. As a result, channel stability may decrease. Upstream of Marysville, the Feather River is significantly different from the lower Feather River in that it did not receive the tremendous sediment influx introduced by hydraulic and dredge mining. Although hydraulic mining did occur on the upper Feather River, the amount of material introduced was significantly less than that on the Yuba River (Water Engineering & Technology 1990: xix, 1991:137–139).

4.2.3 Determination of Effects

Effects on hydrologic or geomorphic conditions may be considered significant if implementation of an alternative would result in any of the following conditions:

- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on or off site.
- Substantially alter the existing drainage pattern of the site or area, including the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on or off site.
- Place within a 100-year flood hazard area structures that would impede or redirect floodflows.
- Expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam.

Effects on flood risk management may be considered significant if implementation of an alternative would result in the following conditions.

- Significantly raise flood stage elevations.
- Increase the frequency and duration of inundation of lands.
- Expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee.

An effect on the levee system is considered significant if an alternative would substantially increase any of the following.

- Seepage.
- Levee settlement.
- Wind erosion.
- Bank erosion or bed scour.
- Sediment deposition.
- Subsidence of land adjacent to levees.

In addition, an effect on the levee system is considered significant if an alternative would substantially decrease any of the following.

- Levee stability.
- Inspection, maintenance, or repair capabilities.
- Current level of levee slope protection.
- Emergency response capabilities.
- Channel conveyance capacity.
- The ability of the levees to withstand seismic forces.

4.2.4 Effects and Mitigation Measures

Effects and mitigation measure requirements concerning flood control and geomorphic conditions are summarized in Table 4-4.

Table 4-4. Summary of Effects for Flood Risk Management and Geomorphic Conditions

Effect	Finding	Mitigation Measure	Finding with Mitigation
Alternatives SB-7 and SB-8			
Effect FC-1: Change in Water Surface Elevations and Flood Safety Attributable to Project Design	No effect	None required	No effect
Effect FC-2: Increase in Channel Bed Incision and Bank Erosion Attributable to Project Design	No effect	None required	No effect
Effect FC-3: Decrease in Through- and Under-Seepage	Beneficial	None required	Beneficial
Effect FC-4: Decrease in Risk of Levee Failure as a Result of Erosion or Seepage	Beneficial	None required	Beneficial
Effect FC-5: Change in Stream Energy and Modification of Floodplain Scour/Deposition	No effect	None required	No effect
Effect FC-6: Alteration of the Existing Drainage Pattern of the Site or Area	Significant	FC-MM-1: Coordinate with Owners and Operators, Prepare Drainage Studies as Needed, and Remediate Effects through Project Design	No effect
Effect FC-7: Increase in Levee Slope Stability	Beneficial	None required	Beneficial

4.2.4.1 Effects Not Addressed Further in this Document

Effect FC-2: Increase in Channel Bed Incision and Bank Erosion Attributable to Project Design. The FRWLP Final EIS addressed effects on geomorphic conditions (Final EIS, Section 3.1.4)) and that analysis is incorporated by reference. The SBPFS alternatives would not increase or intensify current geomorphic processes. Therefore, this effect is not discussed further.

Effect FC-3: Decrease in Through- and Under-Seepage. The FRWLP Final EIS addressed effects on through- and under-seepage. The SBPFS alternatives would reduce or eliminate the potential for seepage and, therefore, result in beneficial effects on flood conditions in the study area. Extending levee improvements downstream of Laurel Avenue would further reduce potential for seepage and flood risk. Therefore, this effect is not discussed further.

Effect FC-4: Increase in Risk of Levee Failure as a Result of Erosion or Seepage. The FRWLP Final EIS addressed effects of slope flattening and that analysis is incorporated by reference. Slope flattening is anticipated to decrease relative erosion rates by alleviating over-steepened banks and not to adversely affect through- and under-seepage potential. Therefore this effect is not discussed further.

Effect FC-7: Increase in Levee Slope Stability. The FRWLP Final EIS addressed the effects on levee slope stability (Final EIS, Section 3.1.4), and that analysis is incorporated by reference. SBPFS alternatives would benefit levee slope stability. Cut-off walls act to limit the through-flow of water at the levee foundation and improve levee slope stability. Therefore, this effect is not discussed further.

4.2.4.2 No Action Alternative

The No Action Alternative represents the continuation of the existing levee deficiencies within the study area. Current levee operations and maintenance activities would continue, but there would be no change in the geomorphic and flood risk–management regimes relative to existing conditions. However, without levee improvements, there is the continued risk of levee failure. Under-seepage and loss of levee foundation soils would be expected to continue. A catastrophic levee failure would result in collapse of levee slopes and loss of soil. If a levee breach were to occur, emergency construction and repair activities would be implemented. Because of the uncertainty of such an event and its magnitude, the effects are unpredictable and, therefore, a precise determination of significance is considered too speculative and cannot be made.

4.2.4.3 Alternative SB-8

Effect FC-1: Change in Water Surface Elevations and Flood Safety Attributable to Project Design

Alternative SB-8 represents minor design modifications to the proposed action analyzed in the FRWLP Final EIS. SB-8 includes the proposed realignment of 11,600 linear feet of existing levee where it lies directly adjacent to the Sutter Butte Canal. The modification would move the levee about 20 feet waterward to provide a 10-foot maintenance road between the canal and the project levee. To evaluate whether moving the levee waterward would affect water surface elevations and increase the potential risk of flooding, changes to flow, depth, duration, and velocity were estimated using a hydraulic model. The hydraulic model results were also used to perform a transfer of risk analysis using Risk and Uncertainty based methods.

The hydraulic model results indicated no measureable change in flow, depth, duration, and velocity within the Feather River (stage change less than 0.005 feet). The 20-foot realignment is located where the levee toe is higher than the 0.5% (1/200) ACE water surface elevation. Therefore, any change in water surface elevation would only occur for flood events more rare than 0.5% (1/200) ACE. In addition, this reach of river is more than 5,000 feet wide, and the 20-foot realignment of the levee would be a small change in the overall hydraulic cross section.

Transfer of flood risk was evaluated by comparing with-project and without-project levee performance values at index points throughout the system. For purposes of evaluating system impacts, the risk analysis is limited to hydrologic and hydraulic parameters and their uncertainties. This approach is consistent with Section 3.b (2) of the memorandum *Clarification Guidance on the Policy and Procedural Guidance for the Approval of Modifications and Alterations of Corps of Engineers Projects* (U.S. Army Corps of Engineers 2008). The analysis is described in detail in Appendix C1b, *Hydraulic Design and Analysis.*

Analysis of Alternative SB-8 found no transfer of flood risk. As described above, the hydraulic model created for Alternative SB-8 computed the same water surface elevations as Alternative SB-1 (No Action Alternative). Because the water surface elevations are the input to the Risk and Uncertainty model, and they did not change, there would be no change in the project performance and no transfer of flood risk.

Effect FC-5: Change in Stream Energy and Modification of Floodplain Scour/Deposition

Realigning 11,600 linear feet of the levee waterward away from the Sutter Butte Canal could potentially affect scour and/or deposition patterns within the channel. Given the current cross sectional capacity of the channel, moving the levee 20 feet waterward would not have a measurable effect on stream energy or floodplain scour or deposition. As described in the FRWLP Final EIS, floodplain capacity would remain similar to existing conditions under most flows. Alternative SB-8 would, therefore, have no effect related to change in stream energy and modification of floodplain scour/deposition. Mitigation is not required.

Effect FC-6: Alteration of the Existing Drainage Pattern of the Site or Area

Project elements of SB-8 in Reaches 22 and 28 include relocating the Sutter Butte Canal at two locations totaling 1,540 linear feet where the levee runs near the channel and where it is undesirable to move the levee waterward (Plates 4-2 and 4-3). This Sutter Butte Canal is an irrigation canal and realignment of the canal would have no impact on local drainage patterns. Replacement canal sections would be constructed in advance of decommissioning, and canal sections would be filled to ensure there is no loss in service during the irrigation season and to ensure that local drainage and ponding areas would not be adversely affected as a result of project construction.

As described in the FRWLP Final EIS, drainage infrastructure maintained by local landowners or local agencies could be affected in some locations, and local surface runoff patterns could be altered. Because interference with drainage could cause or exacerbate localized flooding, this effect could be significant. The implementation of Mitigation Measure FC-MM-1, identified in the FRWLP Final EIS, would reduce this effect to a less-than-significant level.

Mitigation Measure FC-MM-1: Coordinate with Owners and Operators, Prepare Drainage Studies as Needed, and Remediate Effects through Project Design

During final project design, project engineers will coordinate with owners and operators of local drainage systems and landowners served by the systems to evaluate pre- and post-project drainage needs and design features to remediate any project-related substantial drainage disruption or alteration in runoff that would increase the potential for localized flooding. If substantial alteration of runoff patterns or disruption of a local drainage system could result from a project feature, a drainage study will be prepared as part of final project design. The study will consider the design flows of any existing facilities that would be crossed by project features. Based on the study, project engineers will develop appropriate plans for relocation or other modification of these facilities and construction of new facilities, as needed, to ensure equivalent functioning of the system during and after construction. If no drainage facilities (e.g., ditches, canals) would be affected, but project features would have a substantial adverse effect on runoff amounts and/or patterns, new drainage systems will be included in the design of project alternatives to ensure that the project would not result in new or increased localized flooding. Any necessary features to

remediate project-induced drainage problems will be installed before the project is completed or as part of the project, depending on site-specific conditions.

4.2.4.4 Alternative SB-7

Implementation of Alternative SB-7 would potentially result in effects on flood risk management and geomorphic conditions.

Effect FC-1: Change in Water Surface Elevations and Flood Safety Attributable to Project Design

Under Alternative SB-7, no levee improvements would be made above Reach 21; therefore, no canal or levee realignment modifications to the levees adjacent to the Sutter Butte Canal would be made. The levee improvements within the SB-7 reach would not result in any change in the hydraulic characteristics of the reach. Alternative SB-7 would have no effect related to changes in water surface elevations and flood safety. Mitigation is not required.

Effect FC-5: Change in Stream Energy and Modification of Floodplain Scour/Deposition

Effects associated with Effect FC-5 under Alternative SB-7 are identical to those described above for Effect FC-5 under Alternative SB-8, except that no levee realignments are proposed that could potentially affect channel hydraulics and scour and deposition. Alternative SB-7 would, therefore, have no effect related to change in stream energy and modification of floodplain scour/deposition.

Effect FC-6: Alteration of the Existing Drainage Pattern of the Site or Area

Effects associated with Alternative SB-7 would be comparable in type, but less adverse, than under Alternative SB-8 and the alternatives described in the FRWLP Final EIS because Alternative SB-7 would involve less landward disturbance and no relocation of the Sutter Butte Canal. The implementation of Mitigation Measure FC-MM-1 would reduce this effect to a less-than-significant level.

4.3 Water Quality and Groundwater Resources

4.3.1 Introduction

This section discusses the effects on water quality and groundwater resources that would result from the No Action Alternative and Alternatives SB-7 and SB-8, as well as mitigation measures that would reduce significant effects.

4.3.2 Affected Environment

Section 3.2.2 of the FRWLP Final EIS provided a summary of the regulatory setting applicable to water quality and groundwater resources (Section 3.2.2.1), and a general description of water quality and groundwater resource conditions (climate, Feather River water quality, contaminants, and groundwater quantity and quality) within the study area (Section 3.2.2.2). Updated information concerning the Water Quality Control Plan for the Sacramento and San Joaquin River Basins (Basin Plan) is provided below. Other than an update to the Basin Plan, the information contained in the FRWLP Final EIS is still applicable and is incorporated by reference.

In summary, the Feather River is included on the State Water Resources Control Board's (State Water Board's) Clean Water Act (CWA) Section 303(d) Total Maximum Daily Load list of impaired waters for chlorpyrifos, Group A pesticides, mercury, and unknown sources of toxicity. Table 4-5 summarizes water quality impairments in surface waters in the study area and the sources of these impairments. Agriculture and urban runoff are the main sources for chlorpyrifos and Group A pesticides. Mercury contamination is associated with legacy deposits from gold mining activities. Turbidity and sediment levels spike during heavy storm runoff in the winter and spring. In the spring and early summer, the water quality is primarily affected by agricultural drainage and natural runoff. During periods of low flows, specifically the late summer–early fall, water quality decreases due to high water temperatures and concentrations of pollutants. For more detailed information, see pages 3.2-5 through 3.2-12 of the FRWLP Final EIS.

Table 4-5. Clean Water Act Section 303(d)-Listed Impaired Water Bodies and Associated Potential Sources within the Study Area

Water Body	Listed Pollutants	Associated Potential Sources
Feather River, Lower (Lake Oroville Dam to Confluence with Sacramento River)	Chlorpyrifos	Agriculture
	Group A pesticides	Agriculture
	Mercury	Resource extraction
	PCBs	Unknown
	Unknown toxicity	Unknown
Oroville Wildlife Area Fishing Pond (Butte County)	Unknown toxicity	Unknown
Gilsizer Slough (from Yuba City to downstream of Township Road, Sutter County)	Diazinon	Agriculture
	Oxyfluorfen	Agriculture
	pH	Unknown
Wadsworth Canal	Chlorpyrifos	Agriculture
	Diazinon	Agriculture
Morrison Slough	Diazinon	Unknown
Sutter Bypass	Mercury	Resources extraction
Live Oak Slough	Diazinon	Agriculture
	Oxyfluorfen	Agriculture
	Dissolved oxygen	Unknown

Source: 2010 Integrated Report (State Water Resources Control Board 2010).
PCBs = polychlorinated biphenyls.
Note: SBPFS alternatives would likely affect only the Feather River.

As described in the FRWLP Final EIS, a preliminary Phase I Environmental Site Assessment was conducted in 2009 by USACE to assess the presence or likely presence of any hazardous substance or petroleum products under conditions that indicate an existing release, a past release, or the material threat of a release into structures, the ground, groundwater, or surface waters of the property. Information was gathered for this report by conducting a pre-site visit search, and a site visit to verify listed Hazardous Toxic Radioactive Wastes (HTRW) threats and discover new ones. The Environmental Site Assessment found the following problem areas.

- 51 registered underground storage tanks (USTs) and 3 aboveground storage tanks (ASTs).
- Five sources are listed as small and large generators of EPA-regulated hazardous waste.

- Five sites that had leaking USTs, two of which have or had affected public drinking water.
- Six known or potential hazardous substance sites under investigation or cleanup.
- Two waste discharge systems.
- Two landfills.
- 12 suspected drug labs.
- One pesticide-producing facility.

One additional site not included in the Environmental Site Assessment was a Superfund site (Onstott Dusters, Inc.). For the majority of the sources, no records were found to indicate that these potential sources have actually caused major contamination, although investigations are still on-going. Several areas of concern were revealed during the investigation. Most of these areas of concern involve registered USTs, hazardous waste generators, minor tank leaks, UST removal and remediation, and accidental releases. During records research and field surveys, no known contamination due to HTRW was confirmed within the construction zone. In conclusion, no evidence was found to indicate that any other potential sources of contamination would interfere with any planned construction of the levees. For additional information, see the Preliminary Phase I Environmental Site Assessment in FRWLP Final EIS, Appendix H.

4.3.2.1 Basin Plan

Pursuant to the Porter-Cologne Act, the Central Valley Regional Water Quality Control Board (Central Valley RWQCB) prepares and updates the Basin Plan for the Sacramento and San Joaquin River Basins every 3 years; the most recent update was completed in October 2011 (Central Valley Regional Water Quality Control Board 2011). The Basin Plan describes the officially designated beneficial uses for specific surface water and groundwater resources and the enforceable water quality objectives necessary to protect those beneficial uses. The study area is located within the Central Valley RWQCB's jurisdiction and is subject to the Basin Plan. The Basin Plan includes numerical and narrative water quality objectives for physical and chemical water quality constituents. The Basin Plan sets numerical objectives for temperature, dissolved oxygen, turbidity, and pH; total dissolved solids, electrical conductivity, bacterial content, and various specific ions; trace metals; and synthetic organic compounds. The Basin Plan also sets narrative objectives for parameters such as suspended solids, biostimulatory substances (e.g., nitrogen and phosphorus), oil and grease, color, taste, odor, and aquatic toxicity. Narrative objectives often are precursors to numeric objectives. The primary method used by the Central Valley RWQCB to ensure conformance with the Basin Plan's water quality objectives and implementation policies and procedures is to issue waste discharge requirements (WDRs) for projects that may discharge wastes to land or water. The WDRs specify the terms and conditions that must be followed during implementation and operation of a project.

4.3.3 Determination of Effects

Effects on water quality and groundwater resources may be considered significant if implementation of an alternative would result in any of the following conditions.

- Violate any water quality standards or WDRs.
- Substantially deplete groundwater supplies or interfere substantially with groundwater recharge, resulting in a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g.,

the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted).

- Create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff.
- Substantially degrade water quality.

As part of the project, four environmental commitments could reduce or eliminate water quality and groundwater effects. These environmental commitments call for development and implementation of four plans and were included in the assessment of alternatives' effects.

- Stormwater Pollution Prevention Plan (SWPPP).
- Bentonite Slurry Spill Contingency Plan (BSSCP), also known as a frac-out plan.
- Spill Prevention, Control, and Counter-Measure Plan (SPCCP).
- Turbidity monitoring plan.

4.3.4 Effects and Mitigation Measures

Effects and mitigation measure requirements concerning water quality and groundwater resources are summarized in Table 4-6.

Table 4-6. Summary of Effects for Water Quality and Groundwater Resources

Effect	Finding	Mitigation Measures	Finding with Mitigation
Alternatives SB-7 and SB-8			
Effect WQ-1: Effects on Surface Water Quality from Excessive Turbidity or Total Suspended Solids	Less than significant	None required	Less than significant
Effect WQ-2: Release of Contaminants into Adjacent Surface Water Bodies from Construction-Related Hazardous Materials	Less than significant	None required	Less than significant
Effect WQ-3: Effects on Groundwater or Surface Water Quality Resulting from Contact with the Water Table	Significant	WQ-MM-1: Implement Provisions for Dewatering WQ-MM-2: Complete Phase I and Phase II (if Necessary) Environmental Site Assessment Investigations and Implement Required Measures	Less than significant
Effect WQ-4: Effects on Groundwater Wells Due to Project Encroachment	Less than significant	None required	Less than significant

4.3.4.1 No Action Alternative

The No Action Alternative represents the continuation of the existing levee deficiencies along the portion of the Feather River in the study area. Current levee operations and maintenance activities would continue, but there would be no change in the geomorphic and flood risk–management regimes relative to existing conditions. No levee improvements would be made to increase the level of protection. No construction-related effects relating to water quality and groundwater resources such as release of contaminants or sediments to surface water would occur.

However, without levee improvements, the present risk of levee failure would continue. Under-seepage and loss of levee foundation soils would be expected to continue. A catastrophic levee failure would result in collapse of levee slopes and loss of soil that could result in increased erosion, which could raise turbidity and cause sedimentation in adjacent water bodies. Additionally, adverse water quality effects due to levee failure in which flooding occurs in urban, suburban, and agricultural areas would likely be considerable and could include bacterial and chemical (e.g., pesticides, petroleum products, heavy metals) contamination. Indirect effects to water quality from flooding could include damage to water supply systems, damage to sewage and sewer systems, insufficient supply of drinking water and water for washing, increase in waterborne infections, and overflow of toxic waste sites. Because of the uncertainty of such an event and its magnitude, the effects are unpredictable and therefore a precise determination of significance is considered too speculative and cannot be made.

4.3.4.2 Alternative SB-8

Effect WQ-1: Effects on Surface Water Quality from Excessive Turbidity or Total Suspended Solids

As described in the FRWLP Final EIS, soil-disturbing construction activities (i.e., grading, excavation, vegetation clearing) can result in temporary impacts on surface water from the exposure of bare soils to stormwater. Construction activities would disturb existing vegetation cover and soils, would expose large areas of disturbed ground that then could be subject to rainfall and erosion, and could cause temporary discharges of sediment and other contaminants in stormwater runoff to drainage channels and the Feather River.

Construction-related soil disturbance effects associated with Alternative SB-8 would be comparable in type, but of a greater magnitude, than effects of Alternative SB-7 and slightly greater than the FRWLP preferred alternative, Alternative 3. Table 4-7 identifies the construction area disturbance for each alternative. These areas could be cleared of vegetation or otherwise physically disturbed during construction. Alternative SB-8 includes the removal of vegetation outside the immediate area necessary for construction of levee improvements to create a vegetation-free zone to bring the levees into Federal compliance in accordance with the Vegetation ETL.

Unvegetated and cleared areas are more likely to experience erosion than vegetated areas due to reduced water infiltration and retention. This could cause sedimentation and increased turbidity or total settleable solids (TSS) levels. The affected vegetation does not shade the river so there is no potential for water quality impacts due to loss of shade to the river.

Table 4-7. Acres Disturbed by Construction of Alternatives

Alternative	Disturbed Acres*
SB-7	677.96
SB-8	1,031.45
FWRLP Alternative 1	1,184.11
FRWLP Alternative 2	1,795.66
FRWLP Alternative 3	974.53

* These totals include permanent and temporary work areas but do not include borrow site acreages.

Although the areal extent of the area subject to disturbance is substantial, significant large-scale erosion and generation of contaminated runoff is unlikely because construction would be reduced or would not occur during the winter months and the majority of the construction would occur on the landside of the existing levee. In addition, GIS-based estimates indicate that the distance from the project footprint to the water's edge during typical summer base flows would average approximately 1,400 feet and range from approximately 50 feet to 5,600 feet. Plus, temporary erosion control measures would be implemented during construction to minimize stormwater pollution resulting from erosion and sediment migration from the construction areas.

Best Management Practices (BMPs) would be used to prevent nonpoint source pollution, to control stormwater runoff, and to minimize sediment damage to water quality and aquatic habitats.

Two environmental commitments are targeted at reducing or eliminating erosion and sedimentation effects: the SWPPP environmental commitment (see Section 3.8.5.1) and the turbidity monitoring plan environmental commitment (see Section 3.8.5.4). The SWPPP would include erosion control measures to ensure the land disturbance activities do not cause erosion that would increase sediment in the Feather River. Site-specific erosion control measures would also be developed as part of a SWPPP. A SWPPP typically contains, but is not limited to, the following BMPs.

- **Timing of construction.** The construction contractor will conduct all construction activities during the typical construction season to avoid ground disturbance during the rainy season.
- **Staging of construction equipment and materials.** To the extent possible, equipment and materials will be staged in areas that have already been disturbed.
- **Minimize soil and vegetation disturbance.** The construction contractor will minimize ground disturbance and the disturbance/destruction of existing vegetation. This will be accomplished in part through the establishment of designated equipment staging areas, ingress and egress corridors, and equipment exclusion zones prior to the commencement of any grading operations.
- **Stabilize grading spoils.** Grading spoils generated during construction will be temporarily stockpiled in staging areas. Silt fences, fiber rolls, or similar devices will be installed around the base of the temporary stockpiles to intercept runoff and sediment during storm events. If necessary, temporary stockpiles may be covered with an appropriate geotextile to increase protection from wind and water erosion.
- **Install sediment barriers.** The construction contractor will install silt fences, fiber rolls, or similar devices to prevent sediment-laden runoff from leaving the construction area.
- **Stormwater drain inlet protection.** The construction contractor will install silt fences, drop inlet sediment traps, sandbag barriers, and similar devices.

- **Permanent site stabilization.** The construction contractor will install structural and vegetative methods to permanently stabilize all graded or otherwise disturbed areas once construction is complete. Structural methods may include the installation of biodegradable fiber rolls and erosion control blankets. Vegetative methods may involve the application of organic mulch and tackifier and/or the application of an erosion control seed mix.

Implementation of a SWPPP will substantially minimize the potential for project-related erosion and associated adverse effects on water quality.

As part of a turbidity monitoring plan (see Section 3.8.5.4), USACE or its contractor would monitor turbidity in the adjacent water bodies, where applicable criteria apply, to determine whether turbidity is being affected by construction and to ensure that construction does not result in a substantial rise in turbidity levels above ambient conditions, in accordance with the Basin Plan turbidity objectives. The monitoring program would include monitoring ambient turbidity conditions 200 feet upstream and 200 feet downstream of construction activities. Grab samples would be collected at a downstream location that is representative of the flow near the construction site. If construction is creating a visible sediment plume, the sample would represent the plume. During all in-water construction activities, samples would be collected hourly to ensure compliance. During all other construction activities, samples would be collected on a random weekly basis.

If turbidity exceeds Basin Plan standards, construction-related earth-disturbing activities would be modified to alleviate the problem. USACE or its contractor would notify the Central Valley RWQCB of the issue and provide an explanation of the cause.

The implementation of these environmental commitments would reduce potential effects on surface water quality from construction-related turbidity or TSS to a less-than-significant level. No mitigation is required.

Effect WQ-2: Release of Contaminants into Adjacent Surface Water Bodies from Construction-Related Hazardous Materials

Similar to potential effects on surface water quality from excessive turbidity or total suspended solids, Alternative SB-8 also has a greater potential than SB-7 and the FRWLP preferred alternative for stormwater runoff of construction-related contaminants due to the greater amount of area disturbed by construction (Table 4-7).

As described in the FRWLP Final EIS, construction might involve storage and use of toxic and other harmful substances near the Feather River (or in areas that drain to the Feather River or other water bodies), which could result in discharge of these substances to the Feather River or other water bodies. Construction activities would involve the use of heavy equipment, cranes, compactors, and other construction equipment that use petroleum products such as fuels, lubricants, hydraulic fluids, and coolants, all of which can be toxic to fish and other aquatic organisms. The use of this equipment could contribute a direct source of contamination if equipment and construction practices were not properly followed. An accidental spill or inadvertent discharge from such equipment could affect the water quality of the river or water body.

The combination of the environmental commitments described in Section 3.8.5 would reduce the effect of any release, as well as reduce the likelihood that a release would occur. These environmental commitments require the development of the SWPPP, an SPCCP, a BSSCP, and a turbidity monitoring plan. All plans would be prepared prior to the commencement of construction activities.

An SPCCP is intended to prevent discharge of petroleum products into navigable water or adjoining shorelines. USACE or its contractor would develop and implement an SPCCP to minimize the potential for effects from spills of hazardous, toxic, or petroleum substances during construction and operation activities. The SPCCP would be completed before construction activities begin. Implementation of this measure would comply with state and Federal water quality regulations. The SPCCP would describe spill sources and spill pathways, methods to reduce the likelihood of spills, and actions that would be taken in the event of a spill (e.g., an oil spill from engine refueling would be immediately cleaned up with oil absorbents). The SPCCP would outline descriptions of containment facilities and practices such as doubled-walled tanks, containment berms, emergency shut-offs, drip pans, fueling procedures, and spill response kits. It would also describe how and when employees are trained in proper handling procedures and spill prevention and response procedures.

A BSSCP is typically developed for activities that involve the use of bentonite materials (e.g., the construction of slurry walls). The BSSCP is intended to minimize the potential for accidental release of bentonite (which is used in excavation and tunneling activities), provide for timely detection of accidental bentonite release, and ensure a *minimum-effect* response in the event of an accidental bentonite release. If the SWPPP and SPCCP fail to prevent a spill, then construction would stop, and the spill would be properly cleaned up.

Adherence to these environmental commitments would reduce the effect on surface water bodies from construction-related hazardous materials use to a less-than-significant level. No mitigation is required.

Effect WQ-3: Effects on Groundwater or Surface Water Quality Resulting from Contact with the Water Table

Alternative SB-8 would be expected to have similar potential impacts on groundwater as described in the FRWLP Final EIS for FRWLP Alternative 3 because the amount of cutoff wall construction and the construction methods would be nearly identical.

As described above, a preliminary Phase I Environmental Site Assessment has been conducted to identify potential HTRW sites. No known contamination due to HTRW was confirmed within the construction zone; however, a full Phase I Environmental Site Assessment has not been conducted.

As described in the FRWLP Final EIS, trenching and excavation associated with a cutoff wall and levee reconstruction could extend to a depth that would expose the water table, creating an immediate and direct path to the groundwater basin that would allow contaminants to enter the groundwater system. Primary construction-related contaminants that could reach groundwater include increased sediment, oil and grease, and hazardous materials. The release of contaminants into the groundwater and surface waters would constitute a significant effect. Dewatering of the construction area (i.e., removing groundwater that may fill trenches dug for cutoff wall construction) is not expected to occur during project construction. However, if dewatering became necessary, it could result in the release of contaminants to surface or groundwater. Mitigation Measure WQ-MM-1 would address these effects.

The construction of a cutoff wall is not expected to require digging or trenching at depths where groundwater aquifers are used for drinking water. Even if trenching activities were to reach a groundwater aquifer used for drinking water, the slurry wall material is relatively benign and would not remain in a liquid state long enough to allow for significant lateral movement within the aquifer.

With the implementation of Mitigation Measures WQ-MM-1 and WQ-MM-2 and the environmental commitments for a SWPPP, SPCCP, and BSSCP, effects on groundwater or surface water quality resulting from contact with the water table would be reduced to less than significant.

Mitigation Measure WQ-MM-1: Implement Provisions for Dewatering

Before discharging any dewatered effluent to surface water, USACE or its contractors will obtain a Low Threat Discharge and Dewatering NPDES permit from the Central Valley RWQCB if the dewatering is not covered under the Central Valley RWQCB's NPDES Construction General Permit. Under the dewatering permit, discharging activities involve extensive water quality monitoring in order to adhere to the strict effluent and receiving water quality criteria outlined in the permit. As part of the permit, the permittee will design and implement measures as necessary so that the discharge limits identified in the relevant permit are met.

For example, if dewatering is needed during the construction of any cutoff walls, the Low Threat Discharge and Dewatering NPDES permit would require treatment or proper disposal of the water prior to discharge. Treatment measures will be selected to achieve maximum sediment removal and represent the best available technology that is economically achievable. Implemented measures could include the retention of dewatering effluent until particulate matter has settled before it is discharged, use of infiltration areas, and other BMPs.

Final selection of water quality control measures will be subject to approval by USACE. USACE will verify that coverage under the appropriate NPDES permit has been obtained before allowing dewatering activities to begin. USACE will perform routine inspections of the construction area to verify that the water quality control measures are properly implemented and maintained. USACE will notify its contractors immediately if there is a noncompliance issue and will require compliance.

Mitigation Measure WQ-MM-2: Complete Phase I and Phase II (if Necessary) Environmental Site Assessment Investigations and Implement Required Measures

To further investigate the potential for hazardous toxic radioactive wastes (HTRW) in the project area, a full Phase I Environmental Site Assessment would be performed during the project design phase. If the Phase I Environmental Site Assessment indicates the presence of HTRW, a Phase II Environmental Site Assessment would be performed involving chemical analysis for hazardous substances and/or petroleum hydrocarbons. If HTRW is encountered during construction, USACE or the non-federal sponsor will implement required measures for the proper transport and disposal of such materials in accordance with the appropriate local, state, and Federal laws and regulations.

Effect WQ-4: Effects on Groundwater Wells Due to Project Encroachment

Alternative SB-8 would be expected to have potential impacts on groundwater similar to those described in the FRWLP Final EIS for FRWLP Alternative 3 because the amount of cutoff wall construction would be nearly identical and the construction methods are the same.

Because a cutoff wall may block lateral water transfer from the river to an aquifer, cutoff walls could have a significant impact if drinking water wells are located in close proximity to construction zones where a slurry cutoff wall is constructed. Less water may be available to the well and water quality

may be affected because the well pump may take in more sediment due to the potential lowering of the aquifer.

Hydraulic separation causes no reduction in flow or stage in the Feather River. Water exchanges between the river and adjacent aquifer are slow and steady, and continue via deep percolation from the river to the deep aquifer which exists below the cutoff wall.

As described in the FRWLP Final EIS, the potential groundwater effects resulting from the slurry cutoff walls were studied and USACE and SBFCA determined that the effect on groundwater wells would be less than significant. Modeling conducted by HDR for SBFCA and USACE using two models (Central Valley Hydrologic Model (CVHM), which is a U.S. Geological Survey Model, and a locally developed model) found that all scenarios showed a negligible change in groundwater levels. Results of the CVHM model indicated a negligible change in groundwater levels in the northern study area along the Feather River, and a 3-foot increase in groundwater levels in the southern study area. However, the depth to groundwater in the southern area is 10 to 30 feet below the ground surface and a 3-foot change was determined by USACE as likely to not have any significant effect on groundwater in the area.

4.3.4.3 Alternative SB-7

Effect WQ-1: Effects on Surface Water Quality from Excessive Turbidity or Total Suspended Solids

Construction of Alternative SB-7 would have less potential to affect surface water quality than other alternatives. As shown in Table 4-7, construction-related soil disturbance effects associated with Alternative SB-7 would be comparable in type, but would affect substantially less area, than Alternative SB-8 and the alternatives described in the FRWLP Final EIS.

Implementation of the environmental commitments detailed in the Alternative SB-8, Effect WQ-1 discussion above, and Chapter 3, *Plan Formation*, would ensure that water quality is protected from excessive turbidity and TSS from the construction proposed under Alternative SB-7. The effect would be less than significant. No mitigation is required.

Effect WQ-2: Release of Contaminants into Adjacent Surface Water Bodies from Construction-Related Hazardous Materials

Construction of Alternative SB-7 would have less potential to release contaminants to surface waters than other alternatives because the amount of construction would be limited to a shorter reach and, therefore, would disturb less area.

Implementation of the environmental commitments detailed in Chapter 3, *Plan Formation*, would ensure that water quality is protected from construction-related hazardous materials. This effect would be less than significant. No mitigation is required.

Effect WQ-3: Effects on Groundwater or Surface Water Quality Resulting from Contact with the Water Table

Implementation of Alternative SB-7 would have less potential to affect groundwater or surface waters from contact with the water table than SB-8 because construction would be limited to a shorter reach.

Construction practices under this alternative would be similar to those under Alternative SB-8. The release of contaminants would constitute a significant impact.

USACE would adhere to environmental commitments detailed in Chapter 3, Plan Formation. Adherence to the environmental commitments and implementation of Mitigation Measures WQ-MM-1 and WQ-MM-2 would reduce effects on groundwater or surface water quality resulting from contact with the water table to a less-than-significant level.

Effect WQ-4: Effects on Groundwater Wells Due to Project Encroachment

Implementation of Alternative SB-7 would have less potential to affect groundwater wells than Alternative SB-8 would have because the SB-7 cutoff wall construction would affect a shorter reach of levee.

As stated in Effect WQ-4 under Alternative SB-8, the model prepared by HDR estimated a 3-foot change in groundwater levels in the southern portion of the study area, which would be the largest change in the entire study area. Such a change is not anticipated to be a significant effect on groundwater levels. This effect is considered less than significant. No mitigation is required.

4.4 Geology, Seismicity, Soils and Mineral Resources

4.4.1 Introduction

This section evaluates the potential impacts on geology, seismicity, soils and mineral resources that would result from the No Action Alternative and Alternatives SB-8 and SB-7.

4.4.2 Affected Environment

Section 3.3, *Geology, Seismicity, Soils and Mineral Resources*, of the FRWLP Final EIS described existing regulatory and environmental setting for these resources. This information remains unchanged and is hereby incorporated by reference.

4.4.3 Determination of Effects

Effects on geology, seismicity, soils, and minerals may be considered significant if implementation of an alternative would result in any of the following conditions.

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Strong seismic ground shaking.
  - Seismic-related ground failure, including liquefaction.
  - Landslides.
- Result in substantial soil erosion or the loss of topsoil.
- Be located on a geologic unit or soil that is unstable, or that would become unstable as result of the project, and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction or collapse.
- Be located on expansive soil, creating substantial risks to life or property.

- Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state.
- Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other lands use plan.

4.4.4 Effects and Mitigation Measures

Effects and mitigation measure requirements concerning geology, soils, seismicity, and mineral resources are summarized in Table 4-8.

Table 4-8. Summary of Effects for Geology, Soils, Seismicity, and Mineral Resources

Effect	Finding	Mitigation Measures	Finding with Mitigation
Alternatives SB-7 and SB-8			
Effect GEO-1: Beneficial Change in Levee Stability	Beneficial	None required	Beneficial
Effect GEO-2: Increase Exposure of People or Structures to Hazards Related to Strong Seismic Ground Shaking	Less than significant	None required	Less than significant
Effect GEO-3: Cause Accelerated Erosion and Sedimentation Resulting from Construction-Related Ground Disturbance	Less than significant	None required	Less than significant
Effect GEO-4: Cause Structural Damage and Injury Resulting from Development on Expansive Soils	Less than significant	None required	Less than significant
Effect GEO-5: Cause Accelerated Erosion and Sedimentation Resulting from Use of Imported Borrow	Less than significant	None required	Less than significant
Effect GEO-6: Loss, Injury, or Death from Slope Failure at Borrow Sites	Less than significant	None required	Less than significant
Effect GEO-7: Cause the Loss of a Known Mineral Resource of Regional or Local Importance as a Result of Construction of Proposed Project	Less than significant	None required	Less than significant
Effect GEO-8: Cause the Loss of a Known Mineral Resource of Regional or Local Importance as a Result of Placement of Proposed Project	Less than significant	None required	Less than significant

4.4.4.1 Effects Not Addressed Further in this Document

Effect GEO-1: Beneficial Change in Levee Stability

The FRWLP Final EIS addressed effects on levee stability and its conclusions are applicable to SB-8 and SB-7. Proposed levee improvements under the FRWLP alternatives and SB-8 and SB-7 would improve the stability of the Feather River West Levee by reducing through- and under-seepage and improving levee geometry. Alternatives SB-8 and SB-7 would both have a beneficial effect. The proposed modifications in the SBPFS would not change the analysis in the FRWLP Final EIS. Therefore, this issue is not discussed further.

Effect GEO-2: Increase Exposure of People or Structures to Hazards Related to Strong Seismic Ground Shaking

The FRWLP Final EIS addressed effects from seismic ground shaking. The proposed alternatives would not increase the potential for failure or damage of the levees from a seismic event and, therefore, would have a less than significant impact. This issue is not discussed further.

Effect GEO-4: Cause Structural Damage and Injury Resulting from Development on Expansive Soils

The FRWLP Final EIS addressed potential for damage or injury from development on expansive soils. The effect on expansive soils is considered less than significant because modifications to the levee design would be made if expansive or weak soils are documented onsite. Therefore, this issue is not discussed further.

Effect GEO-5: Cause Accelerated Erosion and Sedimentation Resulting from Use of Imported Borrow

The FRWLP Final EIS addressed the effects that excavation of borrow material at offsite locations could have on accelerated erosion and loss of topsoil and determined the effect would be less than significant. The quantity of borrow material required for Alternatives SB-8 and SB-7 would be similar to requirements of the FRWLP. As described in the FRWLP Final EIS, the first choice for borrow material would be a local commercial quarry or other permitted source. USACE would implement soil supply protection measures, such as maximizing onsite use through gradation, placement, and treatment and preserving and replacing topsoil at borrow sites, so that borrow sites could continue in their current use or otherwise be returned to their pre-project condition. Therefore, this issue is not discussed further.

Effect GEO-6: Loss, Injury, or Death from Slope Failure at Borrow Sites

The FRWLP Final EIS addressed the risk to safety from slope failure at borrow sites. Adherence to applicable design specifications and standards would ensure that the hazard of failure of excavations and settlement would be controlled to a safe level. This effect would be less than significant. Therefore, this issue is not discussed further.

Effect GEO-7: Cause the Loss of a Known Mineral Resource of Regional or Local Importance as a Result of Construction of Proposed Project

The FRWLP Final EIS addressed effects on mineral resources. The amount of aggregate needed for the project is not expected to substantially affect the availability of this resource. This effect would less than significant and is not discussed further.

Effect GEO-8: Cause the Loss of a Known Mineral Resource of Regional or Local Importance as a Result of Placement of Proposed Project

The FRWLP Final EIS addressed the issue and determined that there would be no effect on the availability of aggregate resources because no structures would be constructed that would interfere with access to permitted mineral resources and no permitted mineral resource extraction mines exist in the project corridor. Therefore, this issue is not discussed further.

4.4.4.2 No Action Alternative

The No Action Alternative represents the continuation of the existing levee deficiencies in the study area. Current levee operations and maintenance activities would continue, but there would be no change in the geomorphic and flood risk–management regimes relative to existing conditions.

Without levee improvements, there is the continued risk of levee failure, under-seepage and through-seepage, and loss of levee foundation soil. If a levee overtopping or breach were to occur, floodwaters would likely erode topsoil. A catastrophic levee failure could collapse miles of levee slopes, alter regional and local hydrology, and increase erosion and sedimentation. This condition would cause severe damage to soils, scour holes, and eroded and unstable landforms. Moreover, subsequent flooding could occur prior to levee repairs that would result in additional erosion and loss of topsoil. It is assumed that these effects would be significant; however, given the uncertainty of the occurrence or magnitude of such an event, the effects cannot be quantified based on available information.

Furthermore, the beneficial effects of project implementation, such as improved levee stability and decreased levee bank erosion, would not be realized under the No Action Alternative.

4.4.4.3 Alternative SB-8

Effect GEO-3: Cause Accelerated Erosion and Sedimentation Resulting from Construction-Related Ground Disturbance

The ground-disturbing activities associated with construction of SB-8 could potentially cause greater soil erosion and sedimentation of local drainages and waterways than the FRWLP alternatives. Alternative SB-8 would likely require a greater amount of ground disturbance than all other SBPFS and FRWLP alternatives because it would have the largest construction footprint. It has the largest construction footprint because of the 2,250 linear feet of additional levee improvement proposed below Laurel Avenue, the vegetation removal to bring the levees into Vegetation ETL compliance, and the relocation of the Sutter Butte Canal and adjacent levee.

Of primary concern are the ground-disturbing activities associated with vegetation clearing to meet USACE vegetation management guidance. Vegetation would be cleared on levee slopes and 15 feet out from the waterside and landside levee toes, potentially resulting in significant erosion and sedimentation. Although the areal extent of the area subject to disturbance is substantial, significant large-scale erosion and generation of runoff is unlikely because construction would be reduced or would not occur during the winter months.

Site-specific measures that would control erosion would be described in more detail in the SWPPP, which is included in the environmental commitments described in further detail in Chapter 3, *Plan Formation*, and summarized in Section 4.3, *Water Quality and Groundwater Resources*. The SWPPP is also a requirement of the NPDES General Permit.

With implementation of the SWPPP, erosion and sediment-related effects would be less than significant. No mitigation is required.

4.4.4.4 Alternative SB-7

Effect GEO-3: Cause Accelerated Erosion and Sedimentation Resulting from Construction-Related Ground Disturbance

The potential effects related to accelerated erosion and sedimentation under Alternative SB-7 would be substantially less than under SB-8 because of the significantly smaller construction footprint. With implementation of environmental commitments related to water quality, effects would be less than significant. No mitigation is required.

4.5 Air Quality and Climate Change

4.5.1 Introduction

This section discusses the potential effects on air quality and climate change resulting from the No Action Alternative, and Alternatives SB-7, and SB-8, along with mitigation measures to reduce significant effects.

4.5.2 Affected Environment

Section 3.5, *Air Quality*, and Section 3.6, *Climate Change and Greenhouses Gases*, of the FRWLP Final EIS described the existing regulatory (Federal and state laws, and regional and local regulations and policies) and environmental setting for these resource conditions. This information remains unchanged and is hereby incorporated by reference.

4.5.3 Determination of Effects

Effects on air quality would be considered significant if implementation of an SBPFS alternative would result in any of the following conditions.

- Conflict with or obstruct implementation of an applicable air quality plan.
- Violate any local or State air quality management district CEQA standard or contributes substantially to an existing or projected air quality violation.
- Result in a cumulatively considerable net increase of any criteria pollutant for which the project is in nonattainment under applicable Federal or state ambient air quality standards (including releasing emissions which exceed quantitative thresholds for ozone precursors).
- Expose sensitive receptors to substantial pollutant concentrations.
- Create objectionable odors affecting a substantial number of people.
- Generate greenhouse gas (GHG) emissions that exceed thresholds.
- Conflict with an applicable plan, policy, or regulation adopted for the purpose of reducing the emissions of GHGs.
- Fail to address changes in flood frequency and floodwater elevation caused by global climate change.

4.5.4 Effects and Mitigation Measures

Effects and mitigation measure requirements concerning air quality and climate change are summarized in Table 4-9.

Table 4-9. Summary of Effects for Air Quality and Climate Change

Effect	Finding	Mitigation Measure	Finding with Mitigation
Alternatives SB-7 and SB-8			
Effect AQ-1: Obstruction of an Applicable Air Quality Plan	Less than significant	None required	Less than significant
Effect AQ-2: Exceedance of Applicable Thresholds for Construction Emissions	Significant	AQ-MM-1 Provide Advance Notification of Construction Schedule and 24-Hour Hotline to Residents AQ-MM-2: Implement Fugitive Dust Control Plan If Unmitigated Emissions Exceed PM_{10} or $PM_{2.5}$ Thresholds AQ-MM-3. General Measures to Reduce Emissions AQ-MM-4: Fleet-Wide Emission Reductions for Large Off-Road Equipment AQ-MM-5: Pay Required Fees to FRAQMD and BCAQMD to Offset Annual Construction NO_X Emissions to Net Zero (0)	Significant and unavoidable
Effect AQ-3: Exceedance of the Federal General Conformity Thresholds during Construction	Less than significant	None required	Less than significant
Effect AQ-4: Long-Term Operations and Maintenance Emissions of ROG, NO_X, and PM_{10}	Less than significant	None required	Less than significant
Effect AQ-5: Exposure of Sensitive Receptors to Toxic Air Emissions	Less than significant	None required	Less than significant
Effect AQ-6: Exposure to Objectionable Odors from Diesel Exhaust	Less than significant	None required	Less than significant
Effect CC-1: Increase in GHG Emissions during Construction Exceeding Threshold	Less than significant	CC-MM-1: Implement Measures to Minimize GHG Emissions during Construction	Less than significant
Effect CC-2: Conflict with an Applicable Plan, Policy, or Regulation Adopted for the Purpose of Reducing the Emissions of GHGs	Less than significant	None required	Less than significant
Effect CC-3: Failure to Address Changes in Flood Frequency and Floodwater Elevation Caused by Global Climate Change	Less than significant	None required	Less than significant

4.5.4.1 No Action Alternative

Under the No Action Alternative, USACE and SBFCA would not implement the proposed 41 miles of remediation work along the Feather River West Levee system. Current levee operations and maintenance activities would continue, but no levee improvements would be made to increase the level of performance. Potential flood fighting activities would result in temporary effects on air quality that would likely be less than effects analyzed under construction of the SBPFS alternatives. The types of construction equipment would be similar, but the flood fighting activities would be expected to be a shorter duration. The No Action Alternative would likely result in a continuation of the current air quality standards violations. Because of the uncertainty of such an event (levee overtopping or levee breach) and its magnitude, the effects are unpredictable and therefore a precise determination of significance is considered too speculative and cannot be made.

4.5.4.2 Alternatives SB-7 and SB-8

Alternative SB-7 consists of Contracts A, B, C1, and C2. Alternative SB-8 consists of Contracts A, B, C1, C2, D1, and D2 (see Table 4-10). Alternatives SB-7 and SB-8 would create short-term effects on air quality in Sutter and Butte County. This section describes the potential air quality effects of Alternatives SB-7 and SB-8 by yearly contract, including exhaust emissions from construction equipment and worker commute and delivery vehicles, fugitive dust generated by construction activities, and vehicle travel over unpaved roads. To complete the analysis, information was collected on projected construction activities, duration, and timing, equipment use, and activities for each construction year.

Table 4-10. Construction Contract by Corresponding Reach and Year

Contract	A	Star Bend[a]	B	C1	C2	D1	D2
Corresponding Reach	2–5	6	7–12	13–18	19–25	26–33	34–41
Proposed Year of Construction	2018–2019	2018–2019	2017–2018	2013–2014	2014–2015	2015–2016	2016–2017

[a] Included as part of Contract A analysis.

Emissions associated with vehicle exhaust for employee commute vehicles and delivery trucks were estimated using Sacramento Metropolitan Air Quality Management District's (SMAQMD) Road Construction Emission Model Version 6.3.2, (Appendix D). These emissions were based on assumptions in Table 4-11. Emissions associated with the operation of construction equipment were estimated using the SMAQMD's *Guide to Air Quality Assessment in Sacramento County* (Sacramento Metropolitan Air Quality Management District 2009). Construction equipment usage from similar projects was used to estimate daily and annual exhaust emissions for construction equipment. Emissions are considered significant if emissions exceed local thresholds established by the local air quality management districts, the Feather River Air Quality Management District (FRAQMD) and the Butte County Air Quality Management District (BCAQMD)for construction activities. Tables 4-12 and 4-13 display district thresholds.

Table 4-11. Construction Equipment per Contract

Emission Source	Contract A
Total Soil Import/Export per Day: Total Truck Trips per Day:	Reaches 2–5: 3,054 cubic yards of soil 153 Trips
Emission Source	Contract B
Total Soil Import/Export per Day: Total Truck Trips per Day:	Reaches 6–12: 2,925 cubic yards of soil 146 Trips
Emission Source	Contract C1
Total Soil Import/Export per Day: Total Truck Trips per Day:	Reaches 13–18: 1,720 cubic yards of soil 86 Trips
Emission Source	Contract C2
Total Soil Import/Export per Day: Total Truck Trips per Day:	Reaches 19–25: 2,095 cubic yards of soil 195 Trips
Emission Source	Contract D1
Total Soil Import/Export per Day: Total Truck Trips per Day:	Reaches 26–33: 1,460 cubic yards of soil 73 Trips
Emission Source	Contract D2
Total Soil Import/Export per Day: Total Truck Trips per Day:	Reaches 34–41: 1,601 cubic yards of soil 42 Trips
Employee Commute Trips Per Contract Area:	120 employee trips per day, 20 miles each way
Average Round Trip for Trucks: Average Load Per Truck: Range of Hauling Days:	35 miles 20 cubic yards 60–90
Combustion Engine Construction Equipment	Chain saws (2) Chippers (1) Signal Boards (2) Dump trucks for delivery/hauling (20) Excavators (2) Dozer (2) Pickup trucks (4) Grader (1) Loader (2) Trencher (1) Paving equipment (1 each): rollers, pavers, surfacing machines Heavy-duty water tank trucks (1)

Table 4-12. Maximum Daily Construction Emission Estimates (pounds per day)

Project Component	NO_X	ROG	PM_{10}	PM_{25}	CO	CO_2	Air Quality District/ Agency
Contract A	419.5	53.2	20.8	15	321.2	67,500.9	
Contract B	372.3	49.2	19.1	13.4	290	66,677.1	FRAQMD
Contract C1	300	41.1	16.6	11.3	214.6	59,060.7	
Contract C2	127	18.2	7.2	10.5	98.3	61,466.5	
FRAQMD CEQA Threshold	**25**	**25**	**80**	**N/A**	**N/A**	**N/A**	
Contract D1	247	36.3	14.7	9.5	185.7	13,612.6	BCAQMD
Contract D2	229.8	34.9	14	8.9	180.5	55,336.2	
BCAQMD CEQA Threshold	**137**	**137**	**137**	**N/A**	**N/A**	**N/A**	

N/A = not applicable. California Ambient Air Quality Standards not based upon emission rate, but prohibit increases in ambient CO concentrations by 5% or more.
FRAQMD = Feather River Air Quality Management District.
BCAQMD = Butte County Air Quality Management District.

Potential air pollutants generated during construction include emissions of particulate matter of 10 microns in diameter or less (PM_{10}) from debris moving activities and vehicle travel on unpaved roads, and exhaust emissions from the operation of construction equipment, delivery and haul trucks, and employee vehicles. Tailpipe exhaust emissions include ozone precursors (nitrogen oxides [NO_X] and reactive organic gases [ROG]) and PM_{10}. The air quality estimates are based on construction equipment emissions for Contracts A, B, C1, C2, D1, and D2 which would be constructed from 2013 through 2019 (one contract per year). Table 4-10 shows the reaches and years that correspond to each construction contract.

Remediation work would include levee degradation, cutoff wall installation, seepage berm construction and levee prism reconstruction with existing and borrow materials. Estimated equipment used would include a hydraulic crane, generator, excavators, loaders, rollers, blades, transit mixer, water tank, end-dump truck, 6 x 4 3-axle trucks, asphalt finisher, a street sweeper, and a generator. Some equipment would be used to remove trees and other vegetation at the sites, the crane and excavators would be used for the cutoff walls, loaders to move levee material, and large trucks to transport soil and aggregate. A water truck would be used to control dust. Table 4-11 shows a list of construction equipment to be used.

The FRWLP preferred alternative proposes a 3-year construction schedule, which would result in significant impacts on air quality over a shorter time frame. Alternatives SB-7 and SB-8 construction schedules would not exceed general conformity thresholds, resulting in less severe impacts on air quality over a longer time (4 and 6 years, respectively).

The estimated maximum daily emissions in pounds per day for construction of all contracts are displayed in Table 4-12. The estimated average annual emissions in tons per year for the construction period are displayed in Table 4-13.

Table 4-13. Average Annual Construction Emission Estimates (tons per year)

Project Component	NO_X	ROG	PM_{10}	PM_{25}	CO	CO_2	Air Quality District/Agency
Contract A	14.7	11.9	.9	.6	11.2	2,434.8	Federal
Attainment Status	Severe Nonattainment	Severe Nonattainment	Attainment	Nonattainment	Moderate Attainment	N/A	
De minimis Threshold	25	25	N/A	100	100	N/A	
Contract B	13.2	1.7	.8	.5	10.2	2,413.1	
Contract C1	11	1.5	.7	.4	8	2,212	
Contract C2	10.2	1.4	.7	.4	8	2,275.5	
Contract D1	9.2	1.3	.7	.4	7	2,250	
Contract D2	7.9	1.3	.6	.4	6.9	2,113.6	
Attainment Status	Nonattainment	Nonattainment	Attainment	Nonattainment	Moderate Attainment	N/A	
De minimis Threshold	100	100	N/A	100	100	N/A	

N/A = Not applicable due to being unclassified for all criteria pollutants based on Federal standards or unclassified for PM_{10}.

The U.S. Environmental Protection Agency developed the General Conformity Rule (40 CFR Section 93.153), which became effective on January 31, 1994, to implement Section 176(c) of the Federal Clean Air Act (42 USC Section 7506(c)). The underlying principle of the General Conformity Rule is that Federal actions must not cause or contribute to any violation of a National Ambient Air Quality Standards (NAAQS). A conformity determination is required for each pollutant where the total of direct and indirect emissions caused by a Federal action in a nonattainment area exceeds de minimis threshold levels listed in the General Conformity Rule. If the total direct emissions associated with the project are below the de minimus levels indicated in Table 4-13, general conformity requirements do not apply, and the project is considered in conformity and would not result in an adverse effect.

Based on the analysis, construction of Alternatives SB-7 or SB-8 would result in the temporary increase in emissions of ROG, CO, NO_X, and PM_{10}. Estimated daily emissions of NO_X for Contracts A, B, C1, D1, and D2 would exceed FRAQMD and BCAQMD CEQA thresholds. Estimated daily emissions of ROG for Contracts A, B, C1, would exceed FRAQMD and BCAQMD CEQA thresholds (Table 4-12). These temporary increases in emissions are considered to be significant without mitigation. The conformity de minimis thresholds for NO_X, ROG, particulate matter that is 2.5 microns or less in diameter ($PM_{2.5}$), and carbon monoxide (CO) would not be exceeded (Table 4-13). The proposed BMPs included in Section 4.5.4.2.1, *Mitigation,* below would reduce any temporary increases in emissions that effect air quality.

Effects on Air Quality

Alternatives SB-7 and SB-8 would not exceed Federal de minimis thresholds. Based on the above discussion of Tables 4-12 and 4-13, construction would result in the temporary increase in emissions of ROG, CO, NO_X, and PM_{10}. Estimated daily emissions of NO_X for Contracts A, B, C1, D1, and D2 would

exceed FRAQMD and BCAQMD thresholds. Estimated daily emissions of ROG for Contracts A, B, C1, would exceed FRAQMD thresholds (Table 4-12).

Alternative SB-7 (Contracts A, B, C1, and C2) would exceed FRAQMD thresholds for ROG only. Daily construction NO_X emissions would be mitigated to zero by paying fees to FRAQMD (approximately $8,700). Temporary emissions increases of ROG, CO, NO_X, and PM_{10} would occur over 4 years.

Alternative SB-8 (Contracts A, B, C1, C2, D1, and D2) would exceed FRAQMD thresholds for ROG only. Daily construction NO_X emissions would be mitigated to zero by paying fees to FRAQMD and BCAQMD (approximately $12,200). Based upon the increased project extents, SB-8 would result in 2 more years of temporary emissions increases of ROG, CO, NO_X, and PM_{10} and require approximately $3,500 more in mitigation fees.

Effect AQ-1: Obstruction of an Applicable Air Quality Plan

The project construction process and equipment will normally have a significant effect on the environment if it will violate any ambient air quality standard, contribute substantially to an existing or projected air quality violation, or expose sensitive receptors to substantial pollutant concentrations, or fugitive dust. A project is deemed inconsistent with an air quality plan if it would result in population or employment growth that exceeds the growth estimates in the applicable air quality plan—thus generating emissions not accounted for in the applicable air quality plan emissions budget. Consequently, proposed projects need to be evaluated to determine whether they would generate population and employment growth and, if so, whether that growth would exceed the growth rate included in the relevant air quality plan.

As described in Section 4.13, *Cumulative and Growth-Inducing Impacts*, the implementation of flood risk–reduction measures would maintain or improve the level of performance to the standard upon which county and city general plan growth has been based (i.e., 100-year) and for which effects have been analyzed associated with build-out. Therefore, SB-8 and SB-7 would not conflict with or obstruct the implementation of air quality plans. This effect would be less than significant. No mitigation is required.

Effect AQ-2: Exceedance of Applicable Thresholds for Construction Emissions

The project construction process and equipment will normally have a significant effect on the environment if it will violate any ambient air quality standard, contribute substantially to an existing or projected air quality violation, or expose sensitive receptors to substantial pollutant concentrations. Without mitigation, construction-related emissions would exceed emission thresholds for NO_X, ROG thresholds in the FRAQMD, and NO_X thresholds in the BCAQMD, which would result in a significant effect. Mitigation Measures AQ MM-1 through AQ-MM-5, described below, would help to reduce these effects. Table 4-14 through 4-19 shows the unmitigated construction emissions for Construction Contracts A, B, C1, and C2 in FRAQMD's jurisdiction and the unmitigated construction emissions for Construction Contract D1 and D2 in BCAQMD's jurisdiction. After applying Mitigation Measures AQ-MM-1 through AQ-MM-5, NO_X emissions for all contracts would be mitigated to net zero. However, the maximum daily emissions still would exceed the ROG thresholds in the FRAQMD's jurisdiction for Contracts A, B, and C1. Therefore, this effect would be significant and unavoidable after mitigation. Tables 4-14 to 4-19 display mitigated construction emissions in FRAQMD and BCAQMD jurisdictions for all contracts.

Table 4-14. Contract A Mitigated Construction Emissions in Feather River Air Quality Management District Jurisdiction

	Maximum Daily Emissions, lb/day					
Emission Category	**NO_X**	**ROG**	**PM_{10}**	**$PM_{2.5}$**	**CO**	**CO_2**
Total Unmitigated Daily Emissions	419.5	53.2	20.8	15	321.2	67,500.9
Mitigation Measure AQ-MM-4: Fleet-Wide Emission Reductions for Large Off-Road Equipment (20% NO_X Reduction and 45% PM Reduction for Off-Road Equipment)	-83.9	0	-9.36	-6.75	0	0
Emissions after Mitigation Measure AQ-MM-4	335.6	53.2	11.44	8.25	0	67,500.9
AQ-MM-5: Pay Required Fees to FRAQMD and BCAQMD to Offset Annual Construction NO_X Emissions to Net Zero (0) (purchases to mitigate for general conformity)	335.6	0	0	0	0	0
Daily Emissions after Mitigation Measure AQ-MM-5	0	53.2	11.44	8.25	321.2	67,500.9
Feather River AQMD CEQA Threshold	25	25	80	NA	NA	NA
Exceeds Threshold?	No	Yes	No	NA	NA	NA

Table 4-15. Contract B Mitigated Construction Emissions in Feather River Air Quality Management District Jurisdiction

	Maximum Daily Emissions, lb/day					
Emission Category	**NO_X**	**ROG**	**PM_{10}**	**$PM_{2.5}$**	**CO**	**CO_2**
Total Unmitigated Daily Emissions	372.3	49.2	19.1	13.4	290	66,677.1
Mitigation Measure AQ-MM-4: Fleet-Wide Emission Reductions for Large Off-Road Equipment (20% NO_X Reduction and 45% PM Reduction for Off-Road Equipment)	-74.46	0	-8.59	-6.03	0	0
Emissions after Mitigation Measure AQ-MM-4	297.84	49.2	10.51	7.37	0	66,677.1
AQ-MM-5: Pay Required Fees to FRAQMD and BCAQMD to Offset Annual Construction NO_X Emissions to Net Zero (0) (purchases to mitigate for general conformity)	297.84	0	0	0	0	0
Daily Emissions after Mitigation Measure AQ-MM-5	0	49.2	11.44	8.25	290	66,677.1
Feather River AQMD CEQA Threshold	25	25	80	NA	NA	NA
Exceeds Threshold?	No	Yes	No	NA	NA	NA

Table 4-16. Contract C1 Mitigated Construction Emissions in Feather River Air Quality Management District Jurisdiction

	Maximum Daily Emissions, lb/day					
Emission Category	**NO_X**	**ROG**	**PM_{10}**	**$PM_{2.5}$**	**CO**	**CO_2**
Total Unmitigated Daily Emissions	300	41.1	16.6	11.3	214.6	59,060.7
Mitigation Measure AQ-MM-4: Fleet-Wide Emission Reductions for Large Off-Road Equipment (20% NO_X Reduction and 45% PM Reduction for Off-Road Equipment)	-60	0	-7.47	-5.08	0	0
Emissions after Mitigation Measure AQ-MM-4	297.84	41.1	9.13	6.22	0	59,060.7
AQ-MM-5: Pay Required Fees to FRAQMD and BCAQMD to Offset Annual Construction NO_X Emissions to Net Zero (0) (purchases to mitigate for general conformity)	240	0	0	0	0	0
Daily Emissions after Mitigation Measure AQ-MM-5	0	41.1	9.13	6.22	214.6	59,060.7
Feather River AQMD CEQA Threshold	25	25	80	NA	NA	NA
Exceeds Threshold?	No	Yes	No	NA	NA	NA

Table 4-17. Contract C2 Mitigated Construction Emissions in Feather River Air Quality Management District Jurisdiction

	Maximum Daily Emissions, lb/day					
Emission Category	**NO_X**	**ROG**	**PM_{10}**	**$PM_{2.5}$**	**CO**	**CO_2**
Total Unmitigated Daily Emissions	127	18.2	7.2	10.5	98.3	61,466.5
Mitigation Measure AQ-MM-4: Fleet-Wide Emission Reductions for Large Off-Road Equipment (20% NO_X Reduction and 45% PM Reduction for Off-Road Equipment)	-25.4	0	-3.24	-4.72	0	0
Emissions after Mitigation Measure AQ-MM-4	101.6	18.2	3.96	5.77	0	61,466.5
AQ-MM-5: Pay Required Fees to FRAQMD and BCAQMD to Offset Annual Construction NO_X Emissions to Net Zero (0) (purchases to mitigate for general conformity)	101.6	0	0	0	0	0
Daily Emissions after Mitigation Measure AQ-MM-5	0	18.2	3.96	6.22	98.3	61,466.5
Feather River AQMD CEQA Threshold	25	25	80	NA	NA	NA
Exceeds Threshold?	No	No	No	NA	NA	NA

Table 4-18. Contract D1 Mitigated Construction Emissions in Butte County Air Quality Management District Jurisdiction

	Maximum Daily Emissions, lb/day					
Emission Category	**NO_X**	**ROG**	**PM_{10}**	**$PM_{2.5}$**	**CO**	**CO_2**
Total Unmitigated Daily Emissions	247	36.6	14.7	9.5	175.7	13,612.6
Mitigation Measure AQ-MM-4: Fleet-Wide Emission Reductions for Large Off-Road Equipment (20% NO_X Reduction and 45% PM Reduction for Off-Road Equipment)	-49.4	0	-6.61	-4.27	0	0
Emissions after Mitigation Measure AQ-MM-4	197.6	36.6	8.08	5.22	0	13,612.6
AQ-MM-5: Pay Required Fees to FRAQMD and BCAQMD to Offset Annual Construction NO_X Emissions to Net Zero (0) (purchases to mitigate for general conformity)	197.6	0	0	0	0	0
Daily Emissions after Mitigation Measure AQ-MM-5	0	36.6	8.08	5.22	175.7	13,612.6
Butte County AQMD CEQA Threshold	137	137	137	NA	NA	NA
Exceeds Threshold?	No	No	No	NA	NA	NA

Table 4-19. Contract D2 Mitigated Construction Emissions in Butte County Air Quality Management District Jurisdiction

	Maximum Daily Emissions, lb/day					
Emission Category	**NO_X**	**ROG**	**PM_{10}**	**$PM_{2.5}$**	**CO**	**CO_2**
Total Unmitigated Daily Emissions	229.8	34.9	14	8.9	180.5	55,336.2
Mitigation Measure AQ-MM-4: Fleet-Wide Emission Reductions for Large Off-Road Equipment (20% NO_X Reduction and 45% PM Reduction for Off-Road Equipment)	-45.8	0	-6.3	-4	0	0
Emissions after Mitigation Measure AQ-MM-4	184	34.9	7.7	4.9	0	55,336.2
AQ-MM-5: Pay Required Fees to FRAQMD and BCAQMD to Offset Annual Construction NO_X Emissions to Net Zero (0) (purchases to mitigate for general conformity)	184	0	0	0	0	0
Daily Emissions after Mitigation Measure AQ-MM-5	0	34.9	7.7	4.9	180.5	55,336.2
Butte County AQMD CEQA Threshold	137	137	137	NA	NA	NA
Exceeds Threshold?	No	No	No	NA	NA	NA

Effect AQ-3: Exceedance of the Federal General Conformity De Minimis Thresholds during Construction

The SBPFS is subject to the Federal General Conformity Rule, which sets applicability thresholds based on annual-average emissions. Table 4-13 shows the forecast annual-average construction emissions for each construction contract A through D. The conformity de minimis thresholds for NO_X, ROG, $PM_{2.5}$, and CO would not be exceeded (Table 4-13). The proposed BMPs included in Section 4.5.4.2.1,

Mitigation, below would further reduce any temporary increases in emissions that effect air quality. Therefore, the effect relative to the general conformity threshold would be less than significant.

Effect AQ-4: Long-Term Operations and Maintenance Emissions of ROG, NO_X, and PM_{10}

Following project construction, the facilities generally would be maintained as needed. Construction activities involve more equipment over a longer duration. Maintenance work would be less extensive and would take place over a few days per year, as required. In addition, maintenance and operation activities are part of the existing environmental baseline and thus would not create a substantial source of new emissions. The effect relative to the thresholds for construction emissions and general conformity threshold would be less than significant. No mitigation is required.

Effect AQ-5: Exposure of Sensitive Receptors to Toxic Air Emissions

Construction of the SBPFS alternatives would result in short-term diesel exhaust emissions from onsite heavy-duty equipment. Particulate exhaust emissions from diesel-fueled engines (DPM) were identified as a toxic air contaminant by the California Air Resources Board (CARB) in 1998. Construction would result in the generation of DPM emissions from the use of off-road diesel equipment required for site grading and excavation, paving, and other construction activities.

The assessment of health risks associated with exposure to diesel exhaust typically is associated with chronic exposure, in which a 70-year exposure period often is assumed. However, while cancer can result from exposure periods of less than 70 years, acute exposure periods (i.e., exposure periods of 1–3 years) to diesel exhaust are not anticipated to result in an increased health risk, as health risks associated with exposure to diesel exhaust typically are seen in exposures periods that are chronic. Construction of SBPFS alternatives is not expected to take place at the same construction site for more than 1 to 2 years, and the number of pieces of heavy equipment expected to be used at the same construction site would be limited. Furthermore, as required by CARB regulation, no in-use off-road diesel vehicles may idle for more than 5 consecutive minutes. The effect relative to the thresholds for construction emissions would be less than significant. In addition, implementation of Mitigation Measures AQ-MM-3 and AQ-MM-4 would further reduce exhaust emissions during construction. No further mitigation is required.

Effect AQ-6: Exposure to Objectionable Odors from Diesel Exhaust

The SBPFS alternatives would not result in any major sources of odor, nor would it involve operation of any of the common types of facilities that are known to produce odors (e.g., landfill, wastewater treatment facility). In addition, odors associated with diesel exhaust from the use of onsite construction equipment would be intermittent and temporary and would dissipate rapidly from the source with an increase in distance. Furthermore, as required by CARB regulation, no in-use off-road diesel vehicles may idle for more than 5 consecutive minutes. Implementation of Mitigation Measures AQ-MM-1 through AQ-MM-5 would further reduce exhaust emissions during construction. Therefore, the effect would be less than significant.

Effect CC-1: Increase in GHG Emissions during Construction Exceeding Threshold

Construction of each project component would contribute to the generation of GHG emissions through short-term construction activities at the project site. Short-term air pollution in the form of particulate matter (fugitive dust) and carbon dioxide (CO_2) may be caused by construction activity, including truck and equipment movement, grading, and earthwork. CARB has established 7,000 metric tons of

CO_2 per year baseline to provide context to the scale for the proposed project. The alternative contracts are estimated to produce less than 7,000 tons per year of CO_2 based on figures in Table 4-13. The effect relative to project construction activities contributing to the generation of GHG emissions would be less than significant. No mitigation is required.

Effect CC-2: Conflict with an Applicable Plan, Policy, or Regulation Adopted for the Purpose of Reducing the Emissions of GHGs

While no Federal or state agency has established thresholds of significance for GHG or other contributions to global climate change, California Air Resources Board (CARB) has established 7,000 metric tons of CO_2 per year baseline to provide context to the scale for the proposed project. The alternative contracts are estimated to produce less than 7,000 tons per year of CO_2 based on figures in Table 4-13. The effect relative to project construction activities contributing to the generation of GHG emissions would be less than significant. No mitigation is required.

Effect CC-3: Failure to Address Changes in Flood Frequency and Floodwater Elevation Caused by Global Climate Change

The intent of the project is to address inadequacies of the existing project levee system. The primary risk of flooding in the Sutter Basin has been determined to be geotechnical failure of the existing project levees. Recent geotechnical analysis and evaluation of historical performance during past flood events have resulted in a greater understanding of under- and through-seepage modes and a revision of levee design criteria. The project levees within the study area do not meet current USACE levee design criteria and are at risk of breach failure at stages considerably less than levee crest elevations. The risk of unexpected levee failure coupled with the consequence of basin-wide flooding presents a continued threat to public safety, property, and critical infrastructure in the Sutter Basin. The effect relative to project construction activities contributing to the generation of GHG emissions would be less than significant. No mitigation is required.

4.5.4.2.1 Mitigation

To reduce the temporary increase of emissions, BMPs would be implemented by the construction contractor at each repair site. These BMPs include dust and PM_{10} abatement by watering, limiting onsite idling time of heavy equipment, and ensuring that all internal combustion engine equipment is properly tuned to the manufacturer's specification. These practices would result in minimizing emissions during the construction period.

Standard construction practices would ensure that exhaust emissions from all off-road diesel-powered equipment do not exceed 20% opacity for more than 3 minutes in any 1 hour. Opacity is the degree to which smoke blocks light, and the basis for measuring the amount of smoke coming from a diesel-powered vehicle. Poorly maintained or malfunctioning engines are sometimes the cause of excessive smoke. Any equipment found to exceed 20% opacity by a qualified inspector would be repaired immediately. The appropriate local air quality agency would be notified within 48 hours of identification of noncompliant equipment.

USACE or a representative would also be required to provide a plan for approval by FRAQMD and BCAQMD demonstrating that the construction activities would not exceed state and Federal thresholds. The plan would demonstrate that heavy-duty (more than 50 horsepower) off-road vehicles to be used in the construction project, including owned, leased, and subcontractor vehicles, will achieve a project-wide fleet-average 20% NO_X reduction and 45% particulate reduction compared

with the most recent CARB fleet average at time of construction. To reduce emissions for this project, USACE would implement Mitigation Measures AQ-MM-1 through AQ-MM-5.

Mitigation Measure AQ-MM-1: Provide Advance Notification of Construction Schedule and 24-Hour Hotline to Residents

USACE will provide advance written notification of the proposed construction activities to all residences and other air quality–sensitive uses within 500 feet of the construction site. Notification will include a brief overview of the proposed project and its purpose, as well as the proposed construction activities and schedule. It also will include the name and contact information of USACE's project inspector or a representative for ensuring that reasonable measures are implemented to address a problem.

The construction contractor will post a publicly visible sign with the telephone number and person to contact regarding dust complaints. This person will respond and take corrective action within 48 hours. The phone number of the appropriate air quality agency (FRAQMD or BCAQMD) also will be visible to ensure compliance with the agencies' regulations.

Mitigation Measure AQ-MM-2: Implement Fugitive Dust Control Plan If Unmitigated Emissions Exceed PM_{10} or $PM_{2.5}$ Thresholds

The construction contractor will implement all applicable and feasible fugitive dust control measures required by FRAQMD and BCAQMD, including those listed below. This requirement will be incorporated into the construction contract.

- Prior to mobilizing to the job site the construction contractor will submit a dust control plan to FRAQMD and BCAQMD.
- Water active unpaved areas at all construction sites at least twice daily in dry conditions or more frequently as required, with the frequency of watering based on the type of operation, soil, and wind exposure.
- Prohibit all grading activities and water all areas of disturbed soil under windy conditions (more than 20 miles per hour).
- Limit onsite vehicles to a speed that prevents visible dust emissions to extend beyond unpaved roads.
- Cover all trucks hauling dirt, sand, or loose materials.
- Cover active and inactive storage piles where appropriate.
- Cover or hydroseed unpaved areas that will remain inactive for extended periods.
- Apply soil stabilizers to active and inactive areas where appropriate.
- Install wheel washers at the entrance to construction sites for all exiting trucks.
- Sweep streets if visible soil material is carried out from the construction site. Sweeping will be done at least once per day unless conditions warrant a more frequent application.
- Install wind fencing and phase grading operations where appropriate.

Mitigation Measure AQ-MM-3: General Measures to Reduce Emissions

USACE will implement the following mitigation measures.

- No open burning of removed vegetation. Vegetative material will be chipped or delivered to waste or energy facilities.
- Develop a traffic plan to minimize traffic flow interference from construction activities. The plan may include advance public notice of routing, use of public transportation, and satellite parking areas with a shuttle service. Schedule operations affecting traffic for off-peak hours. Minimize obstruction of through-traffic lanes. Provide a flag person to guide traffic properly and ensure safety at construction sites.
- Reduce use, trips, and unnecessary idling of heavy equipment. Shut down idling equipment that is not used for more than 5 consecutive minutes as required by California law.
- Construction equipment exhaust emissions will not exceed 40% opacity or Ringelmann 2.0. Operators of vehicles and equipment found to exceed opacity limits will take action to repair the equipment within 72 hours or remove the equipment from service.
- Maintain all construction equipment in proper tune according to manufacturer's specifications.
- Locate stationary diesel-powered equipment and haul truck staging areas as far as practical from sensitive receptors.
- Use existing power sources (e.g., power lines) or clean fuel generators rather than conventional diesel generators, when feasible.
- Substitute gasoline-powered for diesel-powered equipment when feasible.
- Portable engines and portable engine-driven equipment units used at the project work site, with the exception of on-road and off-road motor vehicles, may require CARB Portable Equipment Registration with the state or a local district permit. The owner/operator will be responsible for arranging appropriate consultations with CARB or the air districts to determine registration and permitting requirements prior to equipment operation at the site.

Mitigation Measure AQ-MM-4: Fleet-Wide Emission Reductions for Large Off-Road Equipment

Prior to mobilizing to the job site, the construction contractor will assemble a comprehensive inventory list (make, model, engine year, horsepower, emission rates) of all heavy-duty off-road (portable and mobile) equipment (50 horsepower and greater) that will be used an aggregate of 40 or more hours for the construction project. The construction contractor then will apply the following mitigation measure to those pieces of equipment.

The construction contractor will provide a plan, for approval by FRAQMD and BCAQMD, demonstrating that the heavy-duty off-road equipment to be used at the project sites, including owned, leased, and subcontractor equipment, will achieve a project-wide fleet-average reduction of 20% for NO_X and 45% for DPM compared with the most recent CARB fleet average at time of construction. USACE will use the construction mitigation calculator downloaded from the Sacramento Metropolitan Air Quality Management District web site (or similar tool approved by FRAQMD and BCAQMD) to perform the fleet average evaluation (Sacramento Metropolitan Air Quality Management District 2009). Acceptable options for reducing emissions may include use of

late model engines, low-emission diesel products, alternative fuels, engine retrofit technology (Carl Moyer Guidelines), or installation of after-treatment emission control devices. FRAQMD and BCAQMD will be contacted to review and approve the alternative measures.

Mitigation Measure AQ-MM-5: Pay Required Fees to FRAQMD and BCAQMD to Offset Annual Construction Emissions to Net Zero (0)

After implementing the general tailpipe emission control measures listed in MM-AQ-4 to reduce daily-average construction emissions, USACE will pay offsite mitigation fees to FRAQMD and BCAQMD to offset annual-average NO_X emissions as required to reduce the maximum annual construction emissions to net zero (0). Prior to issuance of grading permits for the project, USACE will consult with FRAQMD and BCAQMD to define the best construction information and the appropriate computational tools to be used for the calculations. USACE will submit calculations to FRAQMD and BCAQMD documenting the tons of NO_X to be offset over the duration of the construction phase of the project. USACE will consult with FRAQMD and BCAQMD to define the required fee payment based on the most recent Carl Moyer program cost value. Prior to the approval of project plans or the issuance of grading permits, USACE will submit proof that the offsite air quality mitigation fee has been paid to FRAQMD and BCAQMD, and that the construction air quality mitigation plan has been approved by FRAQMD, and BCAQMD.

CC-MM-1: Implement Measures to Minimize GHG Emissions during Construction

To minimize GHG emissions for this project, USACE will implement Mitigation Measures AQ-MM-1 through AQ-MM-5.

4.6 Agriculture, Land Use, and Socioeconomics

4.6.1 Introduction

This section discusses the effects on agriculture, land use, and socioeconomics that would result from the No Action Alternative and Alternatives SB-7 and SB-8. The FRWLP Final EIS describes in greater detail existing conditions and the regulatory setting for these resource conditions. That information is incorporated by reference.

4.6.2 Affected Environment

4.6.2.1 Regional Context

Sutter and Butte Counties are mostly rural, and agriculture is the dominant land use, accounting for nearly 86% of land use in Sutter County (Sutter County 2011a) and nearly 60% of land use in Butte County. Within the Sutter County portion of the study area, the urbanized areas are the incorporated cities of Yuba City and Live Oak and the unincorporated community of Sutter. Within the Butte County portion of the study area, the incorporated areas are Gridley and Biggs.

Yuba City, the Sutter County seat and the most densely populated portion of the study area, lies 42 miles north of Sacramento. Its boundaries encompass approximately 14 square miles (9,355 acres) of land. Portions of the city abut the west bank of the Feather River. As of January 2010, Yuba City's population was 64,929 (California Department of Finance 2011). The majority of Sutter County's population lives in Yuba City, which contains a broad range of residential, commercial, office, industrial, open space, and public facility uses.

The California Department of Conservation's Farmland Mapping and Monitoring Program (FMMP) provides data for use in planning for the present and future of California's agricultural land resources. The FMMP rates agricultural land according to soil quality and irrigation status within the designations discussed below.

Prime Farmland

Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion.

Unique Farmland

Unique farmland is land other than prime farmland that is used for the production of specific high-value food and fiber crops, such as citrus, tree nuts, olives, cranberries, fruits, and vegetables.

Farmland of Statewide Importance

Farmland of statewide importance is land of statewide or local importance identified by state or local agencies for agricultural use, but it is not of national significance.

Farmland of Local Importance

Farmland of local importance is land identified as important to the local agricultural economy by a county's board of supervisors and a local advisory committee.

4.6.2.1.1 Sutter County Agriculture

The dominant crops produced in the county are rice and other field crops, dried plums, English walnuts, almonds and other fruits and nuts, seed crops, tomatoes and other vegetable crops, nursery products, and apiary and livestock products. As of 2010, food and agricultural production accounted for approximately 20% of the total economic output of all industries in the county (Sutter County 2010). Orchards, with their associated fruit and nut crops, predominate within the Sutter County portion of the study area, from Reaches 2 through 11 and north of Yuba City from Reach 18 to the Sutter-Butte County line (Reach 25). Along these reaches, agricultural lands not planted to orchard crops are currently in use for field crops.

The FMMP designates certain parcels of Sutter County farmland as one of the previously discussed classifications. According to the most recent mapping, the county has approximately 162,673 acres of prime farmland, 105,395 acres of farmland of statewide importance, 17,752 acres of unique farmland, and 53,538 acres of grazing land (California Department of Conservation, Division of Land Resource Protection 2011). Within the Sutter County portion of the project area, much of the land along the west bank of the Feather River is classified as prime farmland, with farmland of statewide importance located immediately south of Yuba City and near Live Oak (Plate 4-6).

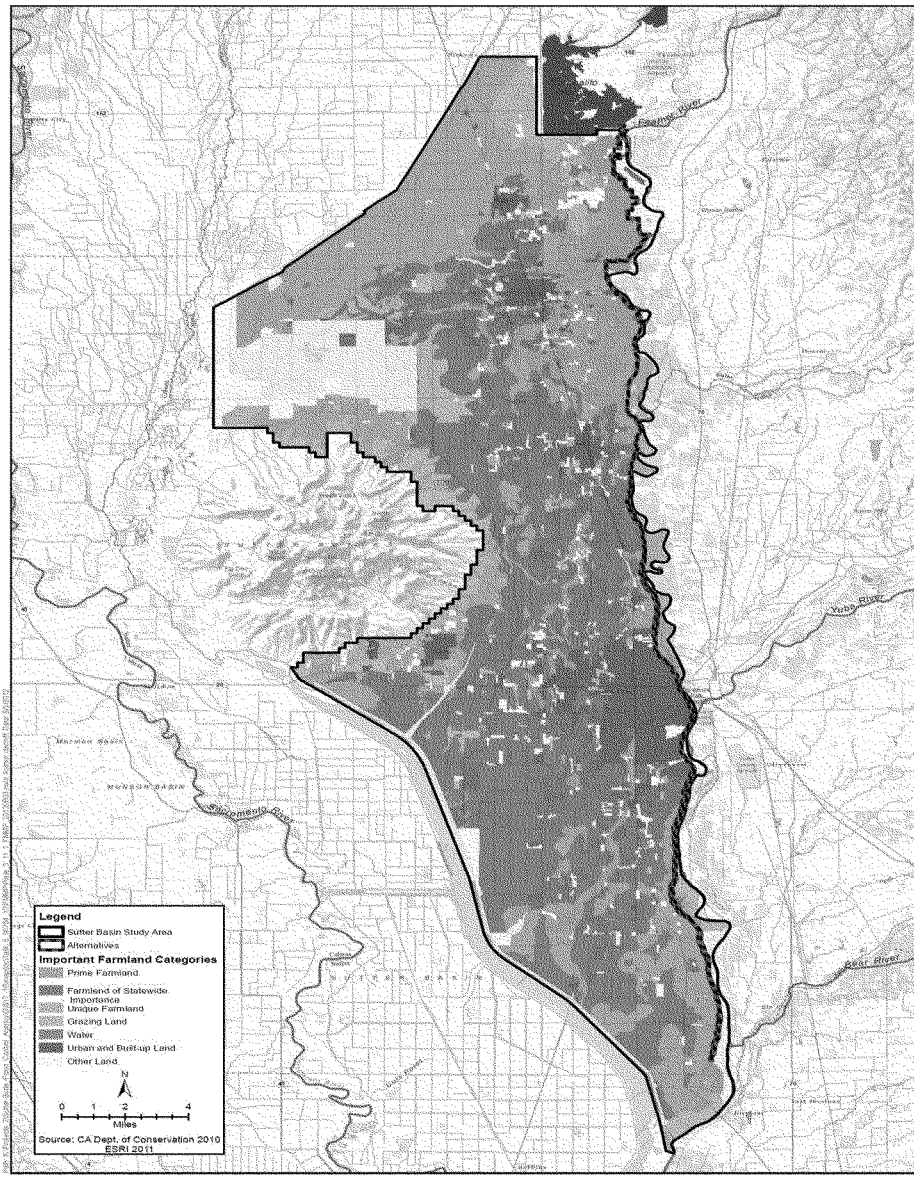


Plate 4-6. Important Farmland in Study Area

Under the California Land Conservation Act of 1965, commonly referred to as the Williamson Act, agricultural and open space lands are preserved through contracts with private landowners. By entering into a Williamson Act contract, the landowner foregoes the possibility of converting agricultural land to nonagricultural use for a rolling period of 10 years in return for lower property taxes. Local governments receive an annual subvention of forgone property tax revenues from the state via the Open Space Subvention Act of 1971. No parcels within the Sutter County portion of the project area are currently under Williamson Act protection.

4.6.2.1.2 Butte County Agriculture

Butte County is mostly rural, and most of the agricultural land is located within the western portion of the county. The main crops produced in Butte County are fruits and nuts. Field, seed, and vegetable crops, and livestock, apiary, and nursery products are also grown in Butte County. The three most land-intensive crops in the county are rice, almonds, and English walnuts, accounting for more than one-third of the agricultural land (Butte County 2011).

Only about one-third of Butte County is designated by the FMMP as important farmland; however, this land is almost exclusively located in the flat, western half of the county. According to the most recent mapping, Butte County has approximately 193,290 acres of prime farmland; 21,792 acres of farmland of statewide importance; 22,190 acres of unique farmland; and 403,078 acres of grazing land (California Department of Conservation, Division of Land Resource Protection 2010). Within the Butte County portion of the project area, prime farmland, located along the western edge of the Feather River between Reaches 25 and 40 (Plate 4-6), is the most common. A small area of unique farmland lies south of Thermalito Afterbay.

Butte County has Williamson Act tracts scattered throughout its western half. As of 2009, the most recent data available, Williamson Act contracts protected 217,151 acres of the county's agricultural land (California Department of Conservation, Division of Land Resources Protection 2010). Within the Butte County portion of the project area, the Williamson Act lands consist primarily of prime farmland (California Department of Conservation, Division of Land Resource Protection 2011).

4.6.2.1.3 Socioeconomics

Sutter County is one of northern California's major agricultural counties (California Employment Development Department 2010), and its traditional job base is agriculture. Agriculture and agriculture-related support industries have been and continue to be the county's top "competitive edge" private industries (California Economic Development Partnership 2009). Sutter County has a labor force of 41,800, and its unemployment rate was 18.7% as of February 2013(California Employment Development Department 2013a).

Agriculture is a major employment sector in Butte County (Butte County 2010:117). According to the Butte County General Plan 2030, in 2008 the estimated gross value of agricultural production countywide was approximately $580 million, an increase of almost $73 million over the 2007 production value. Trends indicate that agriculture will maintain a strong position within Butte County's economy. The county has a total labor force of 104,700, and its unemployment rate was 11.7% as of February 2013 (California Employment Development Department 2013b).

4.6.2.2 Project Area Land Use, Ownership, and Jurisdiction

The proposed project would take place within a narrow strip of Sutter and Butte Counties, including a small area on the eastern edge of Yuba City, approximately 41 miles long and 600 feet wide, along and encompassing the Feather River West Levee. About 71% of the project area is located in Sutter County and 29% of the project area is located in Butte County. Maintenance responsibilities for the project improvements would be located entirely within the area of Levee Districts (LDs) 9 and 1, and DWR's Maintenance Areas (MAs) 3, 7, and 16. MA 3 is responsible for the lowermost reaches of the project area, followed by LD 1, LD 9, MA 16, and MA 7 from south to north. The existing Feather River West Levee is part of the SRFCP within an easement obtained by the State.

With the exception of urbanized Yuba City, agriculture and its accessory use dominates the land use pattern of the Sutter County project reaches. Because the proposed project would primarily affect lands west of the Feather River, this discussion focuses on those areas, with some exceptions. South of Yuba City, most of the project area lands are designated either AG-20 (agriculture, 20-acre minimum parcel size) or AG-80 (agriculture, 80-acre minimum) by Sutter County; lands east of the project area but within the Feather River floodway are primarily designated OS (open space), with a floodplain overlay. In keeping with these designations, agricultural uses predominate west of the Feather River from Reaches 2 through 11, consisting mainly of orchards interspersed with parcels devoted to field crops. A variety of farm structures, including residences, barns, shop buildings, and other agricultural accessory uses, are scattered throughout the project area reaches. Abbott Lake lies immediately east of Reach 7, and Boyd's Boat Launch is located east of Reach 9. From the northernmost section of Reach 11 through Reach 17, the project area follows the eastern edge of Yuba City, with the exception of Reaches 14 and 15, which pass east of the city limit through lands designated open space by Sutter County. Near the northern part of Yuba City, the project area crosses the Union Pacific Railroad line, re-entering unincorporated Sutter County near the transition from Reach 17 to 18, and continues northward, east of Live Oak, to the county line through lands designated AG-20, an area of agricultural uses similar in character to those south of Yuba City. As with the southern Sutter County project area, lands immediately east of the project reaches are designated open space with a floodplain overlay. Reach 25 is the northernmost portion of the project area within Sutter County.

Alternative SB-7 is entirely contained within Sutter County ending at Reach 24. Alternative SB-8 continues further north through Reach 41 at the Thermalito Afterbay.

Project Reaches 25 through 41 are within the boundaries of Butte County, and are characterized by agricultural and open space uses. Agricultural uses in this area consist primarily of orchards, with associated residences and agricultural facilities. Lands between Reaches 25 and 40 carry either an AG-40 or a public/quasi public zone designation, including in the community of East Gridley, located immediately south of East Gridley Road within Reach 30. East Gridley contains a variety of uses, including residential, commercial, and school facilities. North of East Gridley, from Reach 31 to Reach 40, agricultural uses again predominate. The final project reach, 41, is located at the southern edge of Thermalito Afterbay and falls within a Resource Conservation Zone.

4.6.3 Determination of Effects

Effects on agricultural land, land use, and socioeconomics may be considered significant if an alternative would result in any of the effects listed below.

4.6.3.1 Agriculture

For the purposes of this analysis, effects on agriculture are considered significant if implementation of the proposed project would result in any of the following conditions.

- Irretrievable conversion of a substantial acreage of prime farmland, unique farmland, or farmland of statewide importance.
- Conflicts with existing zoning for agricultural use, or a Williamson Act contract.
- Changes to the existing environment which, because of their location or nature, could result in substantial loss of crop production in the project area.

4.6.3.2 Land Use

For the purposes of this analysis, effects on land use are considered significant if implementation of the proposed project would result in any of the following conditions.

- Physically divide an established community.
- Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project adopted for the purpose of avoiding or mitigating an environmental effect.
- Conflict with any applicable habitat conservation plan (HCP) or natural community conservation plan (NCCP).

The actions being studied would not physically divide an established community, because the affected rural areas do not constitute established communities and the structures that would be removed within Yuba City are located at the edge of the city along the Feather River. Consequently, the first criterion above does not apply to the SBPFS and is not considered further in this analysis.

FRWLP Final EIS Section 3.12, *Population, Housing, and Environmental Justice*, addressed the potential displacement of residents and businesses, and that analysis is incorporated by reference.

Implementation of the project would not conflict with any applicable HCP or NCCP. Both the Yuba-Sutter Natural Community Conservation Plan and Habitat Conservation Plan (Yuba-Sutter NCCP/HCP) and the Butte Regional Conservation Plan (BRCP) are currently in development but have not yet been adopted. Consequently, the third criterion above does not apply to the SBPFS and is not considered further in this analysis.

4.6.3.3 Socioeconomics

For the purposes of this analysis, socioeconomic effects are considered significant if implementation of the proposed project would result in any of the following conditions.

- A substantial change in employment.
- Conflict with any applicable socioeconomic plan or policy.

4.6.4 Effects and Mitigation Measures

Effects and mitigation measure requirements concerning agriculture, land use, and socioeconomics are summarized in Table 4-20. Table 4-21 summarizes permanent and temporary impact on prime farmland, unique farmland, and farmland of statewide importance.

Table 4-20. Summary of Effects for Agriculture, Land Use, and Socioeconomics

Effect	Finding	Mitigation Measures	Finding with Mitigation
Alternatives 7 and 8			
Effect AG-1: Temporary Conversion of Prime Farmland, Unique Farmland, or Farmland of Statewide Importance to Accommodate Construction Activities	Less than significant	None required	Less than significant
Effect AG-2: Irretrievable Conversion of Prime Farmland, Unique Farmland, or Farmland of Statewide Importance	Less than significant	None required	Less than significant
Effect AG-3: Conflict with Existing Zoning for Agricultural Use	Less than significant	None required	Less than significant
Effect AG-4: Conflict with Williamson Act Contract	Less than significant	None required	Less than significant
Effect AG-5: Loss of Agricultural Production	Less than significant	None required	Less than significant
Effect LU-1: Conflict with Applicable Land Use Plan, Policy, or Regulation	Less than significant	None required	Less than significant
Effect SOC-1: Employment Effects during Construction	Beneficial	None required	Beneficial
Effect SOC-2: Conflict with Applicable Socioeconomic Plan or Policy	Less than significant	None required	Less than significant

Table 4-21. Summary of Permanent and Temporary Impacts on Prime Farmland, Unique Farmland, and Farmland of Statewide Importance

	Permanent Impacts						Temporary Impacts					
	Sutter County			Butte County			Sutter County			Butte County		
SB-7	Prime	Unique	FSWI	Prime	Unique	FSWI	Prime	Unique	FSWI	Prime	Unique	FSWI
Levee Prism	27.82	--	--	--	--	--	--	--	--	--	--	--
O&M Corridor	2.96	--	--	--	--	--	--	--	--	--	--	--
Canal Realign	--	--	--	--	--	--	--	--	--	--	--	--
Staging	--	--	--	--	--	--	41.79	4.01	4.02	--	--	--
Borrow	--	--	--	--	--	--	271.95	--	678.22	--	--	--
Totals	**30.78**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**313.74**	**4.01**	**682.24**	**0.00**	**0.00**	**0.00**
	Permanent Impacts						Temporary Impacts					
	Sutter County			Butte County			Sutter County			Butte County		
SB-8	Prime	Unique	FSWI	Prime	Unique	FSWI	Prime	Unique	FSWI	Prime	Unique	FSWI
Levee Prism	27.83	3.84	--	0.54	--	--	--	--	--	--	--	--
O&M Corridor	2.97	2.79	--	0.12	2.79	--	--	--	--	--	--	--
Canal Realign	5.83	--	2.69	--	--	--	--	--	--	--	--	--
Staging	--	--	--	--	--	--	46.21	6.91	5.42	12.86	1.42	--
Borrow	--	--	--	--	--	--	54.92	--	758.66	--	--	--
Totals	**36.63**	**6.63**	**2.69**	**0.66**	**2.79**	**0.00**	**101.13**	**6.91**	**764.08**	**12.86**	**1.42**	**0.00**
	Permanent Impacts				Temporary Impacts							
FRWLP	Sutter County			Butte County			Sutter County			Butte County		
(Alternative 3)	Prime & Unique		FSWI	Prime & Unique		FSWI	Prime & Unique		FSWI	Prime & Unique		FSWI
Levee Improvement	122.4		22.8	74		0	unknown			unknown		
Totals	**122.4**		**22.8**	74		**0**						

FWSI = Farmland of Statewide Importance.

4.6.4.1 Effects Not Addressed Further in this Document

The following effects have been addressed in the FRWLP Final EIS and the proposed modifications in the SBPFS would not result in any new or more severe effects than those described in the FRWLP Final EIS.

Effect AG-3: Conflict with Existing Zoning for Agricultural Use

As stated in the FRWLP Final EIS, local jurisdictions recognize flood risk–management measures and facilities as consistent with all zoning districts. Alternatives being considered would, therefore, not conflict with existing agricultural zoning and this issue is not discussed further.

Effect LU-1: Conflict with Applicable Land Use Plan, Policy, or Regulation

The FRWLP Final EIS addressed conflicts with land use plans and policies. Flood risk–management activities are typically considered public uses, which are largely consistent with the land use policies and regulations governing the project area.

Effect SOC-1: Employment Effects during Construction

The FRWLP Final EIS addressed effects on employment that would apply to the SBPFS alternatives. Construction activities would temporarily increase employment and personal income in the local area (SB-8 more than SB-7 because of the greater amount of construction proposed), but the increase in employment is not considered substantial when compared with total employment in the region. This effect on employment would be beneficial. This issue is not discussed further.

Effect SOC-2: Conflict with Applicable Socioeconomic Plan or Policy

As addressed in the FRWLP Final EIS, proposed levee improvements would be generally consistent with the socioeconomic policies of the City of Yuba City, City of Live Oak, Sutter County, and Butte County general plans. Consistency with the relevant socioeconomic plans, policies and regulations would constitute a less-than-significant effect. This issue is not discussed further.

4.6.4.2 No Action Alternative

The No Action Alternative represents the continuation of the existing deficiencies along the portion of the Feather River in the study area. Current levee operations and maintenance activities would continue, but there would be no change in the geomorphic and flood risk–management regimes relative to existing conditions.

In the event of a levee failure, flooding could have severe consequences for agriculture and land use in the study area, thereby affecting economic productivity. Flooding could cause inundation, erosion, sedimentation, or damage to agricultural equipment, outbuildings, and processing facilities, all of which could lead to reduced agricultural productivity. This damage could cause abandonment of or prolonged delay in cultivation of productive lands, which could ultimately result in a change in the use of these lands that may be difficult to reverse. This damage could cause depression of the local economy. In such an event, the effects could be potentially significant; however, because the effects of levee failure are unpredictable, a precise determination of significance cannot be made.

4.6.4.3 Alternative SB-8

Effect AG-1: Temporary Conversion of Prime Farmland, Unique Farmland, or Farmland of Statewide Importance to Accommodate Construction Activities

During construction of Alternative SB-8, temporary staging areas to house construction materials and equipment would be necessary. Temporary earthen access ramps would also be built to facilitate construction activities and allow equipment to access the levees. Because of these construction requirements, implementation of Alternative SB-8 would temporarily convert up to 46.21 acres of prime farmland, 6.91 acres of unique farmland and 5.42 acres of farmland of statewide importance from agricultural use within Sutter County, as well as up to 12.86 acres of prime farmland and 1.42 acres of unique farmland within Butte County. However, all of this farmland in both Sutter County and Butte County could be returned to its original use after completion of project construction. The temporary conversion of this farmland would constitute a less-than-significant effect. No mitigation is required.

Effect AG-2: Irretrievable Conversion of Prime Farmland, Unique Farmland, or Farmland of Statewide Importance

To accommodate the flood risk–management facilities and improvements proposed under Alternative SB-8, 36.63 acres of prime farmland, 6.63 acres of unique farmland, and 2.69 acres of farmland of statewide importance in Sutter County and 0.66 acres of prime farmland and 2.79 acres of unique farmland in Butte County would be permanently converted to nonagricultural use. This acreage represents 0.023% of the prime farmland, 0.034% of the unique farmland, and 0.003% of the farmland of statewide importance acreage in Sutter County and 0.0003% of the prime farmland and 0.013% of the unique farmland acreage in Butte County. The conversion of agricultural land under alternative SB-8 would occur only in a narrow corridor adjacent to the existing levee. Continued farming on the remainder of the affected parcel would be feasible and economically viable. Furthermore, the proposed improvements to the flood risk–management system would indirectly benefit hundreds of thousands of acres of valuable agricultural land in Sutter and Butte Counties, including prime farmland, unique farmland, and farmland of local importance, by providing increased protection from future flood damage. Consequently, the conversion of this farmland would constitute a less-than significant effect. No mitigation is required.

Minimization of farmland effects can be accomplished through spacing of staging areas and using temporary rights-of-way (temporary easements), thereby allowing acreage to return to farm use. BMPs would be used during construction to minimize stormwater runoff and other related impacts on adjoining fields and orchards.

Effect AG-4: Conflict with a Williamson Act Contract

Public agencies may acquire Williamson Act contracted land for a variety of public improvements, including water resource management, provided that there is no other noncontracted land reasonably feasible for the purpose, and that the lower cost of contracted land is not a primary factor in its decision.

No lands in the Sutter County portion of the project area are currently under Williamson Act contract; however, within Butte County, approximately 76.98 acres of contracted lands fall within the footprint of Alternative SB-8. Of these 76.98 acres, 67.18 acres would be permanently converted to flood risk–management uses and 9.75 acres would be returned to agricultural use following project construction.

Implementation of Alternative SB-8 would, therefore, conflict with Williamson Act contracts on 67.18 acres of land within Butte County. The 67.18 acres of permanently converted land represents 0.03% of Butte County's contracted Williamson Act lands. Furthermore, the nature of the proposed project precludes consideration of lands in other areas. Because a substantial amount of farmland would not be lost, this would constitute a less-than-significant effect. No mitigation is required.

Effect AG-5: Loss of Agricultural Production

As discussed above for Effect AG-2, implementation of Alternative SB-8 would involve the permanent conversion of up to 45.95 acres of agricultural land within Sutter County and up to 70.63 acres of agricultural land within Butte County. This loss would primarily consist of orchard and field crop land. The loss of a total of 116.58 acres of productive agricultural land, with associated annual losses in agricultural production, would represent a loss of approximately 0.01% of the total agricultural land under production in Sutter and Butte Counties. This loss in farmland does not represent a substantial loss in agricultural production; therefore, the effect would be less than significant. No mitigation is required.

4.6.4.4 Alternative SB-7

Effect AG-1: Temporary Conversion of Prime Farmland, Unique Farmland, or Farmland of Statewide Importance to Accommodate Construction Activities

The temporary conversion of farmland would be substantially less under Alternative SB-7 than under SB-8 because levee improvements would end at Reach 24 instead of extending upstream to Reach 41. The Sutter-Butte County line is located within Reach 25, meaning that farmland in Butte County would not be affected.

During construction of Alternative SB-7, temporary staging areas to house construction materials and equipment would be necessary. Temporary earthen access ramps would also be built to facilitate construction activities and allow equipment to access the levees. Because of these construction requirements, implementation of Alternative SB-7 would temporarily convert up to 313.74 acres of prime farmland, 4.01 acres of unique farmland, and 682.24 acres of farmland of statewide importance from agricultural use within Sutter County. However, all of this farmland in Sutter County would be returned to its original use after completion of project construction. The temporary conversion of this farmland constitutes a less-than-significant effect. No mitigation is required.

Effect AG-2: Irretrievable Conversion of Prime Farmland, Unique Farmland, or Farmland of Statewide Importance

Implementation of Alternative SB-7 would affect substantially less farmland than SB-8 and the FRWLP would affect. The permanent conversion of farmland would be confined within Sutter County. However, Butte County would receive less indirect flood risk benefit to its agricultural lands.

To accommodate the flood risk–management facilities and improvements proposed under Alternative SB-7, 30.78 acres of prime farmland in Sutter County would be permanently converted to nonagricultural use. This acreage represents 0.018% of the prime farmland acreage in Sutter County. This loss in farmland does not represent a substantial loss in agricultural production. The conversion of agricultural land under Alternative SB-7 would occur only in a narrow corridor adjacent to the existing levee. Continued farming on the remainder of the affected parcels would be feasible and economically viable. Furthermore, the proposed improvements to the flood risk–management system

would indirectly benefit hundreds of thousands of acres of valuable agricultural land in Sutter County and to a lesser extent Butte County, including prime farmland, unique farmland, and farmland of local importance, by providing increased protection from future flood damage. Consequently, the conversion of this farmland would constitute a less-than-significant effect. No mitigation is required.

Effect AG-4: Conflict with a Williamson Act Contract

No lands in the Sutter County portion of the project area are currently under contract; therefore, SB-7 would have no effect on contracted Williamson Act lands.

Effect AG-5: Loss of Agricultural Production

As discussed above for Effect AG-2, implementation of Alternative SB-7 would involve the permanent conversion of up to 30.78 acres of agricultural land within Sutter County. This loss would primarily consist of orchard and field crop land. This loss of productive agricultural land, with associated annual losses in agricultural production, would represent approximately 0.0004% of the total agricultural land under production in Sutter County. This loss in farmland does not represent a substantial loss in agricultural production; therefore the effect would be a less than significant. No mitigation is required.

4.7 Vegetation and Wetlands

4.7.1 Introduction

The following section describes the environmental setting for vegetation and wetlands. The effects on vegetation and wetlands resulting from the No Action Alternative, SB-7, and SB-8 are discussed along with mitigation measures required to reduce significant effects. Additional information on biological resources is provided in Appendix F of the FRWLP Final EIS.

4.7.2 Affected Environment

The FRWLP Final EIS (Section 3.8.2.1) described the Federal, state, regional, and local regulations, laws, policies, and ordinances relevant to this resource. That information is incorporated by reference.

Section 3.8.2.2 in the FRWLP Final EIS described the vegetation and wetland resources in the project area. That information is incorporated by reference in this document. The following is brief summary of that information.

As described in the FRWLP Final EIS, to assess existing conditions and effects, a biological study area was defined consisting of the construction footprint, staging areas, and borrow sites for the alternatives being considered in detail. The biological study area included the alternative with the most expansive footprint plus a 100-foot-wide strip on either side of the levee to account for indirect effects. To assess conditions within this area, ICF International has conducted field surveys consisting of land cover mapping and special-status species wildlife habitat identification. A delineation of wetlands and other waters was also conducted as described in the FRWLP Final EIS.

4.7.2.1 Land Cover Types

The information gathered was used to map the cover types in the biological study area. The approximate acreages of land cover types in the biological study areas are shown in Table 4-22. A description of each land type is provided below.

Table 4-22. Acreages of Land Cover Types in the Biological Study Area

Land Cover Type	Levee Construction Area	Borrow Sites	Total
Wildlands			
Riparian forest	147.11	0	147.11
Riparian scrub-shrub	33.10	7.86	40.96
Oak woodland	0.62	0	0.62
Wetlands and Other Waters of the United States[a]			
Forested/shrub wetlands	41.364	0	41.364
Seasonal wetlands	14.745	0	14.745
Open water	17.374	1.16	18.534
Tailings wetlands	9.175	3.59	12.765
Streams/river	38.911	0	38.911
Ditch/canal	32.067	0	33.247
Pond basin	3.327	0	3.327
Agricultural lands			
Orchard	1,188.29	9.43	1,197.72
Field and row crops	137.00	41.22	178.22
Developed/disturbed areas			
Developed	412.34	0.49	412.83
Ruderal	866.21	105.71	971.92

[a] Wetlands and Other Waters of the United States acreages from the Approved Preliminary Jurisdictional Delineation for the FRWLP dated May 1, 2013

Source: Feather River West Levee Project Final EIS

4.7.2.1.1 Wildlands

Riparian Forest

Riparian forest occurs on both sides of the levee, with most of it occurring along the Feather River. Riparian forest also forms a fringe around some of the tailings ponds. Riparian forests support an overstory dominated by mature native and nonnative trees. The dominant overstory species are valley oak (*Quercus lobata*), Fremont cottonwood (*Populus fremontii* ssp. *fremontii*), and Goodding's black willow (*Salix gooddingii*). Other trees commonly observed in the riparian forest are box elder (*Acer negundo* var. *californicum*), arroyo willow (*S. lasiolepis*), Oregon ash (*Fraxinus latifolia*), black locust (*Robinia pseudoacacia*) and western sycamore (*Platanus racemosa*). The shrub layer of most of the riparian forest in the biological study area is extremely dense, and species commonly observed are Himalayan blackberry (*Rubus armeniacus*), poison oak (*Toxicodendron diversilobum*), button bush (*Cephalanthus occidentalis*), wild rose (*Rosa* spp.) and blue elderberry (*Sambucus nigra* ssp. *caerulea*). Blue elderberry is the host plant for the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), which is Federally listed as threatened. Many of the trees and shrubs in the riparian forest are covered in California grape (*Vitis californica*). The herbaceous understory of riparian forest contains a mixture of native and introduced species. Representative species present include horsetails (*Equisetum* spp.), mugwort (*Artemisia douglasiania*), and curly dock (*Rumex crispus*). Several patches of the invasive giant reed (*Arundo donax*) occur along the edges of riparian areas. Some areas of

riparian forest are considered wetlands and are discussed below under Section 4.7.2.1.2, *Wetlands and Other Waters of the United States*.

Riparian Scrub-Shrub

Riparian scrub-shrub in the biological study area occurs on both sides of the levee and consists of areas that are dominated by shrubs such as willows (*Salix* spp.), blue elderberry, coyote brush (*Baccharis pilularis*), Himalayan blackberry, and button bush. The herbaceous understory of this land cover type is comparable to riparian forest.

Oak Woodland

The biological study area contains two small patches of oak woodland. The oak woodlands are predominately valley oak but some ornamental tree species are also present. The understory of oak woodland contains annual grasses mixed with native and nonnative forbs. Representative understory species are wild oat (*Avena* spp.), soft chess (*Bromus hordeaceus*), ripgut brome (*B. diandrus*), field hedge parsley (*Torilis arvensis*), and the invasive yellow starthistle (*Centaurea solstitialis*).

4.7.2.1.2 Wetlands and Other Waters of the United States

The biological study area contains numerous features that are wetlands and other (i.e., nonwetland) waters of the United States. The information presented in this section pertaining to wetlands and other waters is based on summarized findings and data from the delineation conducted by HDR in 2012 and revisions made based a field review of the delineation by USACE.

Wetlands are defined as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (33 CFR Section 328.3[b]). In order for an area to be considered a wetland, it must exhibit positive indicators of all three Federal wetland criteria (hydrophytic vegetation, hydric soils, and wetland hydrology) as cited in 33 CFR Section 328.3[b]. For other water features such as rivers, streams, and ditches, the extent of potential USACE jurisdiction is determined by identification of the ordinary high water mark (OHWM), which is defined as "that line on shore established by the fluctuations of water and indicated by physical character of the soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas" (33 CFR Section 328.3[e]). The types and acreages of the wetlands and other waters of the United States in the biological study area are listed above in Table 4-22. The descriptions of wetland and other waters below are based on summarized information from HDR.

Forested/Shrub Wetlands

Forested/shrub wetlands occur on the waterside of the levee along the margins of the Feather River, but are outside the OHWM of the river and are concentrated in the southern half of the biological study area. The vegetation in riparian forest wetlands is comparable to that of nonwetland riparian forest and nonwetland riparian scrub-shrub (described above); however, the forested/shrub wetlands exhibit positive indicators of all three Federal wetland criteria.

Seasonal Wetlands

Areas categorized as seasonal wetlands consist of areas that are predominantly vegetated by either floating vegetation or emergent (rooted) vegetation. Common floating vegetation is filamentous algae,

common duckweed (*Lemna minor*), and bladderwort (*Utricularia* sp.). Typical emergent vegetation present is floating primrose willow (*Ludwigia peploides*), tall flatsedge (*Cyperus eragrostis*), lady's thumb (*Persicaria maculosa*), and narrowleaf cattail (*Typha angustifolia*). Seasonal wetlands are scattered throughout the southern half of the biological study area. Based on the absence of a plant community with species that are typically found only in vernal pools (e.g., coyote thistle [*Eryngium* sp.]), the seasonal wetlands in the biological study area were determined not to be vernal pools.

Open Water

Areas categorized as open water following the USACE field review of the delineation consist of features where water is flowing or standing that contain sparse, if any, emergent vegetation. Open water features occur in tailings at the northern end of the biological study area and are interspersed with riparian habitats in the southern end of the biological study area.

Tailings Wetland

Tailings wetlands occur at the northern end of the biological study area and contain a mixture of floating and emergent vegetation bounded by shrubs and trees. Common floating and emergent species are common rush (*Juncus effusus*), tall flatsedge, lady's thumb, spikerush (*Eleocharis* spp.) floating primrose willow, and common duckweed. Typical shrubs and trees are Pacific willow (*Salix lasiandra*), Goodding's black willow, and valley oak.

Stream/Rivers

The biological study are contains two unnamed streams and the Feather River. The unnamed streams are located in the Feather River floodplain within Reach 16 and convey water at least seasonally (i.e., during the wetter winter months). The streams do not have an apparent link to the Feather River but likely have a hydrologic connection during times of high flow. The Feather River connects to the Sacramento River outside the biological study area.

Ditch/Canal

The drainage ditches and canals scattered within the biological study area are anthropogenic features that drain water from active agricultural lands during the growing season or following a rain event. They consist of the Sutter Butte Canal, and other linear, concrete-lined features that convey water across multiple parcels. Many of these features are unvegetated; however, some support emergent vegetation or shrubs along their margins.

Pond/Basin

Ponds and basins in the biological study area consist of artificial and excavated depressions, some of which contain water year-round.

4.7.2.1.3 Agricultural Lands

Most of the biological study area consists of agricultural lands (i.e., orchards and field and row crops).

Orchards

Orchards are the dominant land cover type and occur throughout the biological study area. The majority of the orchards are almonds, English walnuts, plums, or peaches that are actively maintained (i.e., irrigated, pruned). The age of the orchards ranges from small, immature trees in protective

sheaths to mature, established trees. The density of herbaceous vegetation in the areas between tree rows is highly variable and depends on the type and frequency of maintenance (e.g., mowing, herbicide application). Where present, the herbaceous vegetation is dominated by nonnative, weedy species.

Field and Row Crops

Most of the field and row crops are located in the southern portion of the biological study area (south of Barry Road). Field and row crops include both active and fallow fields that exhibit indicators of tillage. Common field and row crops in the biological study area are sweet corn, alfalfa, wheat, and tomatoes. Active field and row crops are maintained with irrigation and herbicide application. Alfalfa hay is harvested several times during the growing season. The margins of field and row crops typically support weed species.

4.7.2.1.4 Developed/Disturbed Areas

Developed

Developed areas in the biological study area consist of urban areas (residential and commercial development), ranchettes, rural neighborhoods, agricultural outbuildings, farm equipment storage areas, pumping stations, and a plant nursery.

Ruderal

Most of the areas mapped as ruderal occur as swaths on both sides of the centerline of the levee where the native soil has been substantially altered. The largest ruderal areas are located between Vance Avenue and the north terminus of the biological study area. Ruderal areas reflect past and ongoing disturbance associated with agriculture, levee construction and maintenance, and excavation (e.g., dredge tailings). Scattered trees observed in ruderal areas are typically valley oak, Fremont cottonwood, and Goodding's black willow. Shrubs are scattered in ruderal areas, and species commonly observed are coyote brush, invasive tree tobacco (*Nicotiana glauca*), and Himalayan blackberry. Blue elderberry shrubs are also present in ruderal areas. The herbaceous layer of ruderal areas is dominated by annual grasses such as wild oat, soft chess, ripgut brome, and foxtail barley (*Hordeum murinum* ssp. *leporinum*). Numerous nonnative forbs such as yellow starthistle, prickly lettuce (*Lactuca serriola*), field hedge parsley, mustard (*Brassica* spp.), and rose clover (*Trifolium hirtum*) occur throughout ruderal areas. Native forbs observed in ruderal areas are Spanish lotus (*Lotus purshianus*), California poppy (*Eschscholzia californica*), annual fireweed (*Epilobium brachycarpum*), and western verbena (*Verbena lasiostachys*).

4.7.2.1.5 Sensitive Natural Communities

Sensitive natural communities are designated as such because of their high level of species diversity, high productivity, unusual nature, limited distribution, or declining status. Local, state, and Federal agencies consider these habitats important. California Department of Fish and Wildlife (CDFW) maintains the California Natural Diversity Database (CNDDB), a current list of rare, natural communities throughout the state. Three sensitive natural communities recognized by the CNDDB have been reported in the 7.5-minute U.S. Geological Survey (USGS) quadrangles that overlap the biological study area: Great Valley cottonwood riparian forest, Great Valley mixed riparian forest, and northern hardpan vernal pool (California Department of Fish and Game 2012). The riparian forest in the biological study area could be considered either Great Valley cottonwood riparian forest or Great

Valley mixed riparian forest; therefore, the riparian forest in the biological study area is a sensitive natural community. The riparian scrub-shrub, forested/shrub wetlands, and seasonal wetlands would also be considered sensitive natural communities. No vernal pools were observed in the biological study area field surveys.

4.7.2.2 Special-Status Plant Species

Special-status plant species are plants that are legally protected under the federal Endangered Species Act (ESA), the California Endangered Species Act (CESA), or other regulations, and species considered sufficiently rare by the scientific community to qualify for such listing. For the purposes of this document, special-status plant species fall into the following categories.

- Species listed or proposed for listing as threatened or endangered under ESA (50 CFR Section 17.12 [listed plants]) and various notices in the Federal Register (FR) (proposed species).
- Species that are candidates for possible future listing as threatened or endangered under ESA (76 FR 66370, October 26, 2011).
- Species listed or proposed for listing by the State of California as threatened or endangered under CESA (California Code of Regulations, Title 14, Section 670.5).
- Species that meet the definitions of rare or endangered under CEQA (State CEQA Guidelines Section 15380).
- Plants listed as rare under the California Native Plant Protection Act (California Fish and Game Code Section 1900 et seq.).
- Plants considered by CDFW and the California Native Plant Society (CNPS) to be "rare, threatened, or endangered in California" (Rare Plant Ranks 1B and 2) (California Department of Fish and Game 2010; California Native Plant Society 2012).
- Plants identified by CDFW and CNPS about which more information is needed to determine their status, and plants of limited distribution (Rare Plant Ranks 3 and 4), which may be included as special-status species on the basis of local significance or recent biological information (California Department of Fish and Game 2010; California Native Plant Society 2012).

Nine special-status plant species have been reported in the seven USGS quadrangles that overlap the biological study area (California Department of Fish and Game 2010, 2012; California Native Plant Society 2012; U.S. Fish and Wildlife Service 2012). Table 4-23 lists the scientific name, common name, status, distribution, habitat requirements, and known/potential presence in the biological study area. Two species, slender Orcutt grass (*Orcuttia tenuis*) and Greene's tuctoria (*Tuctoria greenei*), are vernal pool species that lack potential habitat in the biological study area. Vernal pools were not observed in the biological study area during the 2010 and 2011 contractor field surveys.

Table 4-23. Special-Status Plants Identified during Prefield Investigation as Having Potential to Occur in the Biological Study Area

Common and Scientific Name	Legal Status[a] Federal/State/ Rare Plant Rank	Geographic Distribution/Floristic Province[b]	Habitat Requirements	Reported Blooming Period	Potential for Occurrence in Biological Study Area
Ferris's milk-vetch *Astragalus tener* var. *ferrisiae*	–/–/1B.1	Historical range was the Central Valley from Butte County to Alameda County but currently occurs only in Butte, Glenn, Colusa, and Yolo Counties.	Seasonally wet areas in meadows and seeps, subalkaline flats in valley and foothill grassland; 2–75 meters in elevation.	Apr–May	Low potential to occur in ruderal areas outside the toe of the levee, but habitat conditions are of poor quality and suitable microhabitat may not be present.
Recurved larkspur *Delphinium recurvatum*	–/–/1B.2	Central Valley from Colusa* to Kern Counties.	Alkaline soils in valley and foothill grassland, saltbush scrub, cismontane woodland; 3–750 meters in elevation.	Mar–Jun	Low potential to occur in oak woodland and ruderal areas outside the toe of the levee, but habitat conditions are of poor quality and suitable microhabitat may not be present.
Ahart's dwarf rush *Juncus leiospermus* var. *ahartii*	–/–/1B.2	Eastern Sacramento Valley, northeastern San Joaquin Valley with occurrences in Butte, Calaveras, Placer, Sacramento, and Yuba Counties.	Mesic areas in valley and foothill grassland, vernal pool margins; 30–229 meters in elevation.	Mar–May	Low potential to occur in ruderal areas outside the toe of the levee, but habitat conditions are of poor quality and suitable microhabitat may not be present.
Veiny monardella *Monardella douglasii* ssp. *venosa*	–/–/1B.1	Occurrences in the northern and central Sierra Nevada foothills; also historically known from the Sacramento Valley.	Heavy clay soils in cismontane woodland, valley and foothill grassland; 60–410 meters in elevation.	May–Jul	Low potential to occur in oak woodland and ruderal areas outside the toe of the levee, but habitat conditions are of poor quality and suitable microhabitat may not be present.
Baker's navarretia *Navarretia leucocephala* ssp. *bakeri*	–/–/1B.1	Inner North Coast Ranges, western Sacramento Valley.	Mesic areas in cismontane woodland, lower montane coniferous forest, meadows and seeps, valley and foothill grassland, vernal pools; 5–1,740 meters in elevation.	Apr–Jul	Low potential to occur in oak woodland and ruderal areas outside the toe of the levee, but habitat conditions are of poor quality and suitable microhabitat may not be present.

Common and Scientific Name	Legal Status[a] Federal/State/ Rare Plant Rank	Geographic Distribution/Floristic Province[b]	Habitat Requirements	Reported Blooming Period	Potential for Occurrence in Biological Study Area
Slender Orcutt grass *Orcuttia tenuis*	T/E/1B.1	Sierra Nevada and Cascade Range foothills from Siskiyou to Sacramento Counties.	Vernal pools; 35–1,760 meters in elevation.	May–Sep	No potential habitat in the biological study area.
Hartweg's golden sunburst *Pseudobahia bahiifolia*	E/E/1B.1	Central Sierra Nevada foothills, eastern San Joaquin Valley.	Clay soils in cismontane woodland, valley and foothill grassland; 15–150 meters in elevation.	Mar–Apr	Low potential to occur in ruderal areas outside the toe of the levee, but habitat conditions are of poor quality and suitable microhabitat may not be present.
Sanford's arrowhead *Sagittaria sanfordii*	–/–/1B.2	Scattered locations in Central Valley and Coast Ranges from Del Norte to Fresno Counties.	Freshwater marshes, sloughs, canals, and other slow-moving water habitats; below 650 meters in elevation.	May–Oct	Low potential to occur in ponds, inundated floodplain, and irrigation canals.
Greene's tuctoria *Tuctoria greenei*	E/R/1B.1	Scattered distribution along eastern Central Valley and foothills from Shasta to Tulare Counties.	Dry vernal pools; 30–1,070 meters in elevation.	May–Jul (uncommon in Sep)	No potential habitat in the biological study area.

[a] Status explanations:

Federal
E = listed as endangered under the Federal Endangered Species Act.
T = listed as threatened under the Federal Endangered Species Act.
– = no listing.

State
E = listed as endangered under the California Endangered Species Act.
– = no listing.

California Rare Plant Rank[5]
1B = List 1B species: rare, threatened, or endangered in California and elsewhere.
0.1 = seriously endangered in California.
0.2 = fairly endangered in California.
* = presumed extirpated from that County.

[b] Floristic provinces as defined in Baldwin et al. 2012.

[5] In March, 2010, CDFW changed the name of "CNPS List" or "CNPS Ranks" to "California Rare Plant Rank" (or CRPR). This was done to reduce confusion over the fact that CNPS and CDFW jointly manage the Rare Plant Status Review groups (300+ botanical experts from government, academia, nongovernmental organizations, and the private sector) and that the rank assignments are the product of a collaborative effort and not solely a CNPS assignment.

Six species were determined to have low potential for occurrence because the potential habitat in oak woodland and ruderal areas outside the toe of the levee constitutes a relatively small portion of the biological study area and has been reduced in value by past and ongoing disturbance (e.g., agricultural activities, dredging). Additionally, suitable microhabitat requirements, such as subalkaline flats, heavy clay soils, and acidic clay soils, for these species may not be met. Sanford's arrowhead was determined to have low potential to occur along the edges of irrigation canals, inundated areas of the river's floodplain within riparian forest, and ponds on the land side of the levee that support a fringe of riparian forest.

4.7.3 Determination of Effects

Effects on special status plant species may be considered significant if an alternative would result in any of the following conditions.

- A substantial adverse effect, either directly or through habitat modification, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations or by CDFW, USFWS or the National Marine Fisheries Service (NMFS).
- A substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations or by CDFW or USFWS.
- A substantial adverse effect on federally protected wetlands as defined by CWA Section 404 (including, but not limited to, marshes and vernal pools) through direct removal, filling, hydrological interruption, or other means.
- A conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance.
- A conflict with the provisions of an adopted HCP, NCCP, or other approved local, regional, or state habitat conservation plan.

4.7.4 Effects and Mitigation Measures

Effects and mitigation measure requirements concerning vegetation and wetlands are summarized in Table 4-24.

4.7.4.1 No Action Alternative

The No Action Alternative represents the continuation of the existing deficiencies in levees along 41 miles of the west bank of the Feather River between the Sutter Bypass and Thermalito Afterbay. No levee improvements would be made to increase the level of flood protection. No construction-related effects on vegetation or wetlands would occur.

Because no levee improvements would be made under the No Action Alternative, the risk that the Feather River West Levee could fail because of seepage or slope stability/geometry issues would continue. These effects could include significant loss of vegetation and habitat quality because of both the hydraulic forces of the flood itself and the clean-up efforts. The effects could be potentially significant; however, given the uncertainty of the occurrence or magnitude of such an event, potential effects on vegetation and waters of the United States cannot be fully quantified based on available information.

Table 4-24. Summary of Effects on Vegetation and Wetlands

Effect	Finding	Mitigation Measure	Finding with Mitigation
SB-7 and SB-8			
Effect VEG-1: Disturbance or Removal of Riparian Trees	Significant	VEG-MM-1: Compensate for the Loss of Woody Riparian Trees VEG-MM-2: Install Exclusion Fencing and/or K-rails along the Perimeter of the Construction Work Area and Implement General Measures to Avoid Effects on Sensitive Natural Communities and Special-Status Species VEG-MM-3: Conduct Mandatory Contractor/Worker Awareness Training for Construction Personnel VEG-MM-4: Retain a Biological Monitor	Significant and unavoidable (short term) and less than significant (long term after establishment of compensatory vegetation)
Effect VEG-2: Loss of Wetlands and Other Waters of the United States as a Result of Project Construction	Significant	VEG-MM-2: Install Exclusion Fencing and/or K-rails along the Perimeter of the Construction Work Area and Implement General Measures to Avoid Effects on Sensitive Natural Communities and Special-Status Species VEG-MM-3: Conduct Mandatory Contractor/Worker Awareness Training for Construction Personnel VEG-MM-4: Retain a Biological Monitor VEG-MM-5: Compensate for the Loss of Wetlands and Other Waters	Less than significant
Effect VEG-3: Disturbance or Removal of Protected Trees as a Result of Project Construction	Significant	VEG-MM-1: Compensate for the Loss of Woody Riparian Trees VEG-MM-2: Install Exclusion Fencing and/or K-rails along the Perimeter of the Construction Work Area and Implement General Measures to Avoid Effects on Sensitive Natural Communities and Special-Status Species VEG-MM-3: Conduct Mandatory Contractor/Worker Awareness Training for Construction Personnel VEG-MM-4: Retain a Biological Monitor	Less than significant
Effect VEG-4: Potential Loss of Special-Status Plant Populations Caused by Habitat Loss Resulting from Project Construction	Significant	VEG-MM-2: Install Exclusion Fencing and/or K-rails along the Perimeter of the Construction Work Area and Implement General Measures to Avoid Effects on Sensitive Natural Communities and Special-Status Species VEG-MM-3: Conduct Mandatory Contractor/Worker Awareness Training for Construction Personnel VEG-MM-4: Retain a Biological Monitor VEG-MM-6: Retain Qualified Botanists to Conduct Floristic Surveys for Special-Status Plants during Appropriate Identification Periods VEG-MM-7: Avoid or Compensate for Substantial Effects on Special-Status Plants	Significant and unavoidable
Effect VEG-5: Introduction or Spread of Invasive Plants as a Result of Project Construction	Less than significant	None required	Less than significant
Effect VEG-6: Conflict with Provisions of an Adopted HCP/NCCP or Other Approved Local, Regional, or State Habitat Conservation Plan	No effect	None required	No effect

Effect VEG-1: Disturbance or Removal of Riparian Trees

Implementation of the USACE levee vegetation policy under the No Action Alternative is characterized by three possible scenarios.

- Full application of the Vegetation ETL, meaning prohibition and removal of woody vegetation within the levee prism or within 15 feet of the landside or waterside levee toes.
- Modified application of the Vegetation ETL, assuming the continued existence into the future of the vegetation conditions at the time of the analysis. This may include future application of a variance (not as part of this Sutter Basin project) or application of the Central Valley Flood Protection Plan concepts for management of woody vegetation, meaning trimming and thinning to allow visibility and accessibility, selective retention and removal based on engineering inspection and evaluation, and Life Cycle Management. A System Wide Improvement Framework (SWIF) may also be a component of future compliance.
- Continuation of existing maintenance requirements in accordance with the SRFCP operations and maintenance manual.

A tree survey was conducted by ICF International in fall 2012. Arborists with ICF collected data on location, species, size (diameter at breast height), overall health, and dripline diameter of trees. As described in the FRWLP Final EIS, approximately 7,600 trees are located in the biological study area, including riparian trees, orchards, and nonnative or ornamental trees.

Under full implementation of the Vegetation ETL, the only plant species permitted in the vegetation-free zone would be nonirrigated perennial grasses, with preference given to native species that are appropriate to local climate, growth conditions, and surrounding or adjacent land uses. Table 4-25 identifies the number of native or nonnative trees observed within the ETL vegetation-free zone and the number located within various areas of the levee cross section. As shown, 1,178 native trees and 1,636 nonnative trees are located within the ETL vegetation-free zone of the existing levee within Reaches 2–41. Of the 2,814 trees in total, 544 native trees and 401 nonnative trees are located on the levee itself. There are 397 native trees on the waterside levee slope and 560 native trees within the 15-foot zone out from the waterside levee toe. The 957 native trees on the waterside of the levee averaged about 16 inches in diameter at breast height (dbh).

Permanent loss of woody vegetation to comply with USACE levee vegetation policy would result in significant effects on riparian habitat. These effects are considered significant and unavoidable in the short term, although it is assumed that compensation vegetation would be required by the regulatory agencies and the long-term effect would be less than significant after establishment of compensatory vegetation.

Under the modified Vegetation ETL application scenario, the number of trees that would be removed to comply with a variance or levee inspection criteria is unknown, but would be expected to be relatively low. Over time, much of the woody vegetation may be lost due to the natural life-cycle of each tree if not replaced; however, substantial loss would not be expected to occur within 50 years or considerably longer in the case of long-lived riparian trees such as oaks and cottonwoods. Therefore, these effects are considered less than significant.

Table 4-25. Trees and Shrubs within ETL Vegetation-Free Zone for Reaches 2-41

Reach	Waterside Levee Slope				Waterside Offset[a]				Landside Levee Slope				Landside Offset[a]			
	Native	dbh	Nonnative	dbh	Native	dbh	Nonnative	dbh	Native	dbh	Nonnative	dbh	Native	dbh	Nonnative	DBH
Reach 2	1	11			46	786							4	82	2	16
Reach 3	2				97	1,971	2	17								
Reach 4	86	2,229			32	310									22	255
Reach 5	31	567	10	43	14	168	4	20	1		7	30	5		10	57
Reach 6																
Reach 7	2	18			18	278	1	18								
Reach 8	4	61	4	33	18	286	4	37							7	12
Reach 9	1				2	12	3	18							8	64
Reach 10					5	27			2	40	7	71	6	169	24	300
Reach 11	2	97			23	208			1	18			2	41	1	16
Reach 12					4	33	1	34								
Reach 13	8	216			7	96										
Reach 14	5	215			16	321										
Reach 15	1	48														
Reach 16	130	3,043	9	61	21	254	7	59	28	346	63	559	2	23	35	320
Reach 17	1	56							1	43						
Reach 18			1	3	106	528									17	134
Reach 19					10	97	6	52	2						54	411
Reach 20	4						1	18							11	94
Reach 21	2		6	84	2	12	6	37								
Reach 22	6	44			37	359	17	230	11	73	15	248	9	87	40	422
Reach 23	12	178	3	25	17	140	54	950	3	48	5	28	4	72	167	1,140
Reach 24	9	186	6	70	13	158	5	35	2	88						
Reach 25	2	21	2	15	3	60	17	209	1	3	24	130			77	323
Reach 26	3	14	1	36	2	62	4	62								
Reach 27																

Reach	Waterside Levee Slope				Waterside Offset[a]				Landside Levee Slope				Landside Offset[a]			
	Native	dbh	Nonnative	dbh	Native	dbh	Nonnative	dbh	Native	dbh	Nonnative	dbh	Native	dbh	Nonnative	DBH
Reach 28	6	118	8	94	12	122	32	450								
Reach 29	1	6	22	243	1		13	183			5	28			8	126
Reach 30	1	34	6		9	166	62	988	12	238	5	62			10	80
Reach 31	32	259	16	126	6	53	40	533	11	147	5	96	5	51	4	46
Reach 32							19	276	4	126			1	18	36	668
Reach 33	5	14	43	211	3	46	61	910			3	46			121	1,761
Reach 34	2	115	5	85			44	511			24	332			92	1,252
Reach 35	15	255	1	15	27	418	14	78			21	306			11	136
Reach 36	2	14	3	36	1	28			8	170	32	360	2	49	8	71
Reach 37	7	92	3	28	1	16	2	48	40	366	5	49	1	3	35	345
Reach 38			4	30					5	26	3	27	1		1	10
Reach 39	2															
Reach 40	7	48	1	2	2	16			15	196	10	133	12	333	12	166
Reach 41	5	65			5	49	1	3			13	164	20	239	2	12
Total[b]	397	8,024	154	1,240	560	7,080	420	5,776	147	1,928	247	2,669	74	1,167	815	8,237

[a] The landside and waterside offset is the area extending 15 feet out from the levee's waterside and landside toes.
[b] The totals at the bottom of the table represent the total number of trees and tree diameters (dbh) for all reaches within each levee cross-section location.

Under the continued O&M maintenance scenario, it is anticipated that some vegetation removal would occur to bring the levee system into compliance with the existing SRFCP O&M manual. The amount of tree removal that would be required is unknown but would likely be similar to conditions under the Central Valley Flood Protection Plan for vegetation and less than under the Vegetation ETL. SBFCA has submitted a Letter of Intent to USACE under USACE's SWIF program which would result in development of a plan by SBFCA to comply with vegetation maintenance requirements in the O&M manual. It is anticipated that the loss of vegetation under the No Action Alternative could be a significant effect; however, with the implementation of compensation required by regulatory agencies, the effect in the long term would be less than significant.

4.7.4.2 Alternatives SB-8 and SB-7

Implementation of SB-8 or SB-7 would potentially result in effects on vegetation and wetlands. Because of its smaller construction footprint, SB-7 would affect less acreage of wildland land cover types, including habitats such as riparian forest that are sensitive natural communities or that represent potential habitat for special-status species. Plate 4-7 shows the affected cover types within the construction footprints of SB-8 and SB-7. Plate 4-7, which is composed of 28 sheets, is located at the end of this chapter.

Effect VEG-1: Disturbance or Removal of Riparian Trees

Both SB-8 and SB-7 would have a significant adverse impact on riparian vegetation if the losses are not compensated for. Implementation of SB-8, which includes the proposed improvements from SB-7, would result in the same types of effects (i.e., Effect VEG-1 through Effect VEG-6) on vegetation and wetland resources. Implementation of SB-8 would result in a greater loss of riparian habitats than SB-7 (Table 4-26).

Table 4-26. Vegetation and Land Type Effects by Alternative Scenario

Land Cover Types	FRWLP (acres)	SB-7 with Vegetation ETL (acres)	SB-7 with Vegetation ETL Variance (acres)	SB-8 with Vegetation ETL (acres)	SB-8 with Vegetation ETL Variance (acres)
Wildlands					
Riparian forest	22.19	24.40	22.12	42.00	32.28
Riparian scrub-shrub	1.29	0.02	0.02	0.50	0.50
Oak woodland	0.22	1.00	1.00	1.30	1.30
Subtotal	*23.70*	*25.42*	*23.14*	*43.80*	*34.08*
Agricultural Lands					
Orchards	101.71	37.80	37.80	85.80	85.80
Field and row crops	4.75	0.70	0.70	3.80	3.80
Subtotal	*106.46*	*38.50*	*38.50*	*89.60*	*89.60*
Developed/ Disturbed Areas					
Developed	196.00	125.00	125.00	199.00	199.00
Ruderal	550.80	395.50	395.50	552.00	552.00
Subtotal	*746.80*	*520.50*	*520.50*	*751.00*	*751.00*
Total	**876.96**	**584.42**	**582.14**	**884.40**	**874.68**

The greatest impact on wildland acreage under SB-8 would result from Vegetation ETL compliance (43.80 acres). Compared with SB-7, SB-8 would result in an additional 0.48 acre impact on riparian scrub-shrub, 17.6 acres of impact on riparian forest, and 0.3 acre of impact on oak woodlands. FRWLP Alternative 3 would impact the least amount of wildlands at 23.70 acres. If not for removal of vegetation to comply with the Vegetation ETL, vegetation losses under SB-8 would be similar to the FRWLP. Vegetation ETL variance scenarios for SB-7 and SB-8 would reduce impacts by 1.7 and 9.72 acres, respectively.

The total number of riparian trees to removed on the waterside of the levee would be approximately 891 for SB-8, and 652 for SB-7 as shown in Table 4-27. Under the Vegetation ETL, the number of trees that would need to be removed would be approximately 5,294 for SB-8, and 4,616 for SB-7. The FRWLP proposes to remove 6,846 trees. Under an approved Vegetation ETL variance, these losses would be reduced to 1,375 under SB-8 and 911 under SB-7 as shown in Table 4-28. As shown, the majority of trees in the construction footprint are orchard trees.

The project's effect on the spatial distribution of woodland habitat was also evaluted to assess the potential for habitat fragmentation. Historic losses of riparian forest in conjunction with project implementation could cause further fragmentation of floodplain forest leading to constrictions in habitat core areas and increases in overall habitat edges, which, in turn, would affect patch sizes, and distances between patches, and impervious surfaces. This loss of vegetative structure and spatial complexity would leave the remaining floodplain forest susceptible to disease and incursions of nonnative species and exotics leading to increased competition and a general loss of the native-based, functioning community.

The amount of affected riparian habitat is relatively insignificant compared to the amount of existing floodplain riparian habitat. To assess existing habitat acreage, USACE staff calculated riparian and agricultural floodplain acreage numbers using Google Earth area polygon feature in conjunction with the U.S. Fish and Wildlife Wetlands and Riparian map application. Roughly, about 23,030 acres of floodplain area exists along the Feather River within the 41-mile reach, of which about 8,700 acres is riparian forest. Approximately 24 acres of riparian habitat loss would occur on the waterside of the levees. This represents less than 0.3 percent of the total amount of existing riparian forest.

Under SB-8, the USFWS calculated that about 11 discontinuous miles of levee improvements would be constructed within 300 feet of the river's edge (USFWS Final FWCA Report, Appendix D). Under SB-7, about 7 discontinuous miles of levee are within 300 feet. According to the USFWS, removing vegetation from areas where stands' width is already narrow causes a greater loss of habitat and, therefore, a larger effect on wildlife species. According to the USFWS, narrowing of riparian habitat could isolate some species that require larger stands of habitat. While implementation of the Vegetation ETL would narrow the riparian stands in some locations, the project with the proposed mitigation plan would not significantly fragment woodland habitat in the study area. Under the proposed mitigation plan (Mitigatation Measure VEG-MM-1), about 88 acres of floodplain riparian forest at the Star Bend Conservation Area and the Three Rivers Levee Improvement Authority's Feather River Floodway Corridor Restoration Project. In combination together, these mitigation actions will increase the extent of floodplain habitat and improve connectivity along the riparian corridor. Habitat restoration at Star Bend would allow for greater connectivity of riparian habitat between the Abbott and O'Connor Lakes Wildlife Units of CDFW's Feather River Wildlife Area.

Under the existing SRFCP O&M manual, small trees and shrubs are allowed on the waterside levee slope and landside and waterside berm. Existing O&M activities would be modified under the project to reflect current Corps levee maintenance standards as described in Section 4.4.1.4. In those areas where a vegetation ETL variance is not obtained, O&M of the project would include maintenance of a vegetation management zone free of woody vegetation. The levee slopes and a 15-foot zone along the landside and waterside levee toes would be permanently maintained devoid of trees and shrubs by control and eradication via mowing, burning, and/or herbicide application. Because no additional vegetation removal would occur beyond the vegetation removed by construction, O&M activities per se would not result in an additional impact on vegetation, therefore vegetation effects from O&M would be less than significant.

Table 4-27. Effects on Riparian Trees on the Waterside of the Levee by Project Alternative

Tree Species	FRWLP Alternative 3	SB-7 with Vegetation ETL	SB-7 with Vegetation ETL Variance	SB-8 with Vegetation ETL	SB-8 with Vegetation ETL Variance
Riparian Trees	209	652	614	891	753

Table 4-28. Riparian and Nonriparian Tree Comparison

Tree Type	FRWLP	SB-7 with Vegetation ETL	SB-7 with Vegetation ETL Variance	SB-8 with Vegetation ETL	SB-8 with Vegetation ETL Variance
Riparian	1,609	1,139	911	1,629	1,375
Non Riparian	1,132	248	219	259	223
Orchard	4,105	3,229	2,825	3,406	2,999
Total	**6,846**	**4,616**	**3,955**	**5,294**	**4,579**

Implementation of Mitigation Measures VEG-MM-1, VEG-MM-2, VEG-MM-3, and VEG-MM-4 would reduce this effect. Because of the length of time required for newly planted trees to reach mature size, this effect would be significant and unavoidable in the short term and less than significant in the long term after establishment of compensatory vegetation.

Mitigation Measure VEG-MM-1: Compensate for the Loss of Woody Riparian Trees

For direct effects on woody riparian trees, compensation for the loss of riparian habitat will be implemented to ensure no net loss of habitat functions and values. Under the Fish and Wildlife Coordination Act, the USFWS has recommended that USACE compensate for loss of natural habitat at a ratio of at least 2:1 (USFWS Coordination Act Report, Appendix D).

A mitigation and monitoring plan that describes how riparian habitat will be enhanced or recreated and monitored over a minimum period of time, as determined by the appropriate state and Federal agencies, is included in Appendix D. Proposed compensatory mitigation for the Recommended Plan (Alternative SB-8) includes establishment of approximately 88 acres of floodplain riparian forest at the Star Bend Conservation Area and the Three Rivers Levee Improvement Authority's Feather River Floodway Corridor Restoration Project.

SBFCA will monitor and maintain the plantings as necessary for 5 years, including weed removal, irrigation, and plant protection. SBFCA will submit annual monitoring reports of

survival to the regulatory agencies issuing permits related to habitat effects, including CDFW, USACE, NMFS, and USFWS. Replanting will be necessary if success criteria are not met, and replacement plants subsequently will be monitored and maintained to meet the success criteria. The riparian habitat mitigation will be considered successful when the sapling trees established meet the success criteria, the habitat no longer requires active management, and vegetation is arranged in groups that, when mature, replicate the area, natural structure, and species composition of similar riparian habitats in the region.

Onsite areas (adjacent to the levees) that are outside the USACE vegetation-free zone may also be considered in the future detailed design phase; however, mitigation site selection will avoid areas where future levee alternatives or maintenance is likely.

Mitigation Measure VEG-MM-2: Install Exclusion Fencing and/or K-rails along the Perimeter of the Construction Work Area and Implement General Measures to Avoid Effects on Sensitive Natural Communities and Special-Status Species

To clearly demarcate the project boundary and prevent special-status species from moving through the project area, temporary exclusion fencing will be installed along the project boundaries (including access roads and staging areas) prior to the start of construction activities. Temporary fencing will be continuously maintained until all construction activities are completed.

A USFWS- and CDFW-approved biological monitor will be on-site during installation of the fencing to survey and relocate animals outside the work area boundaries. Federally and state-listed species will be relocated only if authorized by USFWS and CDFW. The exclusion fencing will be removed only after construction of the project phase is completed.

Mitigation Measure VEG-MM-3: Conduct Mandatory Contractor/Worker Awareness Training for Construction Personnel

Before any work occurs in the biological study area, including grading, a qualified biologist will conduct mandatory contractor/worker awareness training for construction personnel. The awareness training will be provided to all construction personnel to brief them on the need to avoid effects on sensitive biological resources (e.g., riparian habitat, special-status species, special-status wildlife habitat) and the penalties for not complying with permit requirements. The biologist will inform all construction personnel about the life history of special-status species with potential for occurrence onsite, the importance of maintaining habitat, and the terms and conditions of the biological opinion or other authorizing document. Proof of this instruction will be submitted to USFWS, CDFW, or other overseeing agency, as appropriate.

The training also will cover the restrictions and guidelines that must be followed by all construction personnel to reduce or avoid effects on special-status species during project construction.

Mitigation Measure VEG-MM-4: Retain a Biological Monitor

USACE or its contractors will retain qualified biologists to monitor construction activities adjacent to sensitive biological resources (e.g., special-status species, riparian habitat, wetlands, elderberry shrubs). The biologists will assist the construction crew, as needed, to comply with all project implementation restrictions and guidelines. In addition, the biologists will be

responsible for ensuring that USACE or its contractors maintain the construction barrier fencing adjacent to sensitive biological resources.

Any worker who inadvertently injures or kills a special-status wildlife species or finds an individual dead, injured, or entrapped will immediately report the incident to the biological monitor. The monitor will immediately notify USACE, which will notify the USFWS Endangered Species Office and/or the local CDFW warden or biologist within 3 working days. USACE will follow up with written notification to USFWS or CDFW within 5 working days.

Effect VEG-2: Loss of Wetlands and Other Waters of the United States as a Result of Project Construction.

Construction of SB-7 or SB-8 would result in the fill of features that may be waters of the United States, including irrigation ditches, open water, and seasonal wetlands. Placement of fill would occur in jurisdictional features that are within the footprint of the cutoff wall and seepage berms.

The greatest impact on wetlands and other waters would occur within open waters. SB-8 and SB-7 would affect 7.86 and 5.01 acres, respectively, as shown in Table 4-29. The Vegetation ETL variance scenarios for SB-8 and SB-7 do not result in acreage differences. The Vegetation ETL compliance scenarios would affect woody vegetation within the levee vegetation-free zone but not waters of the United States.

Table 4-29. Wetlands and Other Waters Effects by Alternative

Land Cover Types	Alternative SB-7 (acres)	Alternative SB-8 (acres)
Irrigation/canal ditch	1.4	7.1
Riparian forest wetland	0.324	0.324
Stream	0	0
Tailings wetland	0	0.131
Seasonal wetlands	0.18	0.18
Open water	0.19	0.19
Total	**5.01**	**7.86**

Alternative SB-8 would affect 7.1 acres of irrigation canals and ditches and SB-7 affects 1.4 acres. SB-8 would result in an additional 5.7-acre impact on irrigation canals and ditches. SB-8 would affect 0.131 acres of tailing wetlands at the northern end of the project. SB-7 would not affect tailing wetlands.

Waters of the United States are regulated by USACE and the Environmental Protection Agency. Wetlands are considered sensitive communities. The project would have a substantial adverse effect on federally protected wetlands and other waters of the United States through direct removal, filling, and hydrologic interruption; therefore, this effect would be considered significant. Implementation of the environmental commitment to develop a SWPPP and Mitigation Measures VEG-MM-2, VEG-MM-3, VEG-MM-4, and VEG-MM-5 would reduce this effect to a less-than-significant level.

Mitigation Measure VEG-MM-5: Compensate for the Loss of Wetlands and Other Waters

The proposed Mitigation and Monitoring Plan accompanying the document (Appendix D) will compensate for the loss of wetlands through the purchase of mitigation credits from mitigation

banks in the region. Purchase of credits at a mitigation ratio developed in coordination with regulatory agencies will ensure no net loss of habitat functions and values.

Effect VEG-3: Disturbance or Removal of Protected Trees as a Result of Project Construction

Construction of SB-7 and SB-8 would result in the disturbance or removal of numerous trees that may be protected. The FRWLP Final EIS identified the disturbance or removal of trees as possibly in conflict with Yuba City Ordinance 01-98. Many of these affected trees are in riparian habitat and are included in the discussion in Effect VEG-1 above. Other trees occur in non-riparian valley oak woodland.

The removal or harming of protected trees as a result of construction activities could conflict with local and state codes which could be a significant effect. Implementation of the environmental commitment to compensate for loss of vegetation and Mitigation Measures VEG-MM-1, VEG-MM-2, VEG-MM-3, and VEG-MM-4 would reduce the effects to a less-than-significant level.

Effect VEG-4: Potential Loss of Special-Status Plant Populations Caused by Habitat Loss Resulting from Project Construction

No known occurrences of special-status plants are in the project area; however, blooming-period surveys of the project area have not been conducted for special-status plant species with potential to occur in the region. Surveys would occur before construction, as described in Mitigation Measure VEG-MM-6 below. Because of the historical and ongoing disturbance of most of the project area, there is low potential for the presence of special-status plants. However, if one or more of these species are present in the project area, project construction would result in their removal.

Nearly all improvement measures associated with SB-7 and SB-8 require clearing and grubbing of the project footprint prior to construction. If special-status plants are present within the project footprint, they would be removed.

Plants that may occur in the project area under this alternative include one Federally and state-listed endangered species (Hartweg's golden sunburst) and seven species that are on the CNPS list for rare and endangered plants. Loss of CNPS-listed plant species would be regulated by CDFW if the loss is substantial and could affect the long-term survival of the affected population. Because the presence and extent of any special-status plants in the project construction area are unknown, this effect would be considered significant.

Depending on the plant (listed versus unlisted) and the extent of effect on the population, implementation of Mitigation Measures VEG-MM-2, VEG-MM-3, and VEG-MM-4 may avoid or reduce this effect to a less-than-significant level. The final significance determination will need to be made after floristic surveys have been conducted (Mitigation Measure VEG-MM-6) and through consultation with the appropriate resource agency (USFWS and/or CDFW). In addition, Mitigation Measure VEG-MM-7 requires the project proponent to avoid indirect or direct effects on special-status plants wherever feasible. Because the effectiveness of these measures to reduce this effect to a lesser level is not known at this time, this effect is considered significant and unavoidable.

Mitigation Measure VEG-MM-6: Retain Qualified Botanists to Conduct Floristic Surveys for Special-Status Plants during Appropriate Identification Periods

Qualified botanists will survey the biological study area to document the presence of special-status plants before project implementation. The botanists will conduct a floristic survey that

follows the CDFW botanical survey guidelines (California Department of Fish and Game 2009). All plant species observed will be identified to the level necessary to determine whether they qualify as special-status plants or are plant species with unusual or significant range extensions. The guidelines also require that field surveys be conducted when special-status plants that could occur in the area are evident and identifiable, generally during the reported blooming period. To account for different special-status plant identification periods, one or more series of field surveys may be required in spring and summer.

If any special-status plants are identified during the surveys, the botanist will photograph and map locations of the plants, document the location and extent of the special-status plant population on a CNDDB Survey Form, and submit the completed Survey Form to the CNDDB. The amount of compensatory mitigation required will be based on the results of these surveys.

Mitigation Measure VEG-MM-7: Avoid or Compensate for Substantial Effects on Special-Status Plants

If one or more special-status plants is identified in the biological study area during preconstruction surveys, USACE will redesign or modify proposed project components to avoid indirect or direct effects on special-status plants wherever feasible. If special-status plants can be avoided by redesigning projects, implementation of Mitigation Measures VEG-MM-2, VEG-MM-3, and VEG-MM-4 would avoid significant effects on special-status plants.

If complete avoidance of special-status plants is not feasible, the effects of the project on special-status plants would be compensated through offsite preservation at a ratio to be negotiated with the resource agencies. Suitable habitat for affected special-status plant species will be purchased in a conservation area, preserved, and managed in perpetuity. Detailed information will be provided to the agencies on the location and quality of the preservation area, the feasibility of protecting and managing the area in perpetuity, and the responsible parties. Other pertinent information also will be provided, to be determined through future coordination with the resource agencies.

Effect VEG-5: Introduction or Spread of Invasive Plants as a Result of Project Construction

Invasive plants are already present throughout project area. However, construction activities could introduce new invasive plants to the project area or contribute to the spread of existing invasive plants to uninfested areas outside the project area. Invasive plants or their seeds may be dispersed by construction equipment if appropriate prevention measures are not implemented. The introduction or spread of invasive plants as a result of the project could have a significant effect on sensitive natural communities within and outside the project area by displacing native flora. The implementation of the appropriate BMPs described in the environmental commitment to avoid or minimize the spread or introduction of invasive plants would ensure that the proposed project would not have a significant effect on sensitive natural communities from the introduction or spread of invasive plants. With implementation of the environmental commitment, this would be a less-than-significant effect. No additional mitigation is required.

Effect VEG-6: Conflict with Provisions of an Adopted HCP/NCCP or Other Approved Local, Regional, or State HCP

There are no adopted HCP/NCCPs applicable to the proposed project. There are two plans under development in the region: the Yuba-Sutter NCCP/HCP and the Butte Regional Conservation Plan.

The proposed project is within the planning area of both of these conservation plans. Because these plans are currently under development and neither of these plans has been adopted, the project would not conflict with provisions of these plans, and there would be no effect. No conflict is anticipated should these plans be adopted prior to construction.

4.8 Wildlife

4.8.1 Introduction

The following section describes the regulatory and environmental setting for wildlife. The effects on wildlife species from the No Action Alternative, Alternative SB-8, and Alternative SB-7 are discussed along with mitigation measures to reduce significant effects. Additional information regarding wildlife is provided in Appendix F of the FRWLP Final EIS.

4.8.2 Affected Environment

The regulatory and environmental setting described in the FRWLP Final EIS has remained unchanged and that information is incorporated by reference in this integrated report. The FRWLP Final EIS addressed existing conditions for wildlife habitats and special-status wildlife species.

4.8.2.1 Biological Study Area

The biological study area generally includes the 41 miles of the Feather River's western levee from south of the Thermalito Afterbay to approximately 4 miles north of the Sutter Bypass. The biological study area for the proposed project includes the areas directly affected by construction, plus a 100-foot buffer on either side to account for potential indirect effects on the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) (VELB). The biological study area also includes the Star Bend Mitigation Area, where impacts on VELB and riparian habitat would be compensated.

4.8.2.1.1 Field Surveys

As described in the FRWLP Final EIS, the biological study area has been surveyed to identify habitats for special-status (defined below) wildlife in the affected area and elderberry shrub (habitat for the VELB) surveys. An assessment of habitat for giant garter snake was also conducted by ICF and HDR. Species observed during the surveys are listed in Table 4-30.

Table 4-30. Wildlife Species Observed in the Biological Study Area

Common Name	Scientific Name
Amphibians	
Bullfrog	*Lithobates catesbeianus*
Reptiles	
Western fence lizard	*Sceloporus occidentalis*
Birds	
Acorn woodpecker	*Melanerpes formicivorus*
American crow	*Corvus brachyrhynchos*
American goldfinch	*Carduelis tristis*
American kestrel	*Falco sparverius*
American white pelican	*Pelecanus erythrorhynchos*
Bald eagle	*Haliaeetus leucocephalus*
Barn swallow	*Hirundo rustica*
Belted kingfisher	*Megaceryle alcyon*
Black phoebe	*Sayornis nigricans*
Brewer's blackbird	*Euphagus cyanocephalus*
Bushtit	*Psaltriparus minimus*
California towhee	*Pipilo crissalis*
Canada goose	*Branta canadensis*
Cooper's hawk	*Accipiter cooperii*
Dark-eyed junco	*Junco hyemalis*
Double-crested cormorant	*Phalacrocorax auritus*
European starling	*Sturnus vulgaris*
Great blue heron	*Ardea herodias*
Great egret	*Ardea alba*
Green heron	*Butorides virescens*
Gull sp.	*Larus* sp.
Killdeer	*Charadrius vociferus*
Mallard	*Anas platyrhynchos*
Mourning dove	*Zenaida macroura*
Osprey	*Pandion haliaetus*
Red-tailed hawk	*Buteo jamaicensis*
Red-shoulder hawk	*Buteo lineatus*
Red-winged blackbird	*Agelaius phoeniceus*
Rock dove	*Columba livia*
Snowy egret	*Egretta thula*
Spotted towhee	*Pipilo erythrophthalmus*
Swainson's hawk	*Buteo swainsonii*
Turkey vulture	*Cathartes aura*
Western kingbird	*Tyrannus verticalis*
Western meadow lark	*Sturnella neglecta*
Western scrub jay	*Aphelocoma californica*
Yellow-billed magpie	*Pica nuttalli*
Yellow-rumped warbler	*Dendroica coronata*
Mammals	
Black-tailed deer	*Odocoileus hemionus columbianus*
Black-tailed jack rabbit	*Lepus californicus*
Coyote	*Canis latrans*
Desert cottontail	*Sylvilagus audubonii*
Northern river otter	*Lontra canadensis*

Elderberry shrub surveys were conducted by ICF biologists in 2011 and in 2012 and concurrently with arborist surveys in summer 2012. When the bases of shrubs were accessible, stem counts, heights, and widths of shrubs were recorded, and shrubs were surveyed for VELB exit holes. Where dense poison oak, blackberry, and/or other vegetation surrounds elderberry shrubs, stem counts and exit hole surveys could not be conducted. All visible elderberry shrubs (and shrub clusters) within 100 feet of the maximum extent of the alternative boundaries were recorded using GPS. Where there wasn't property access, or where dense poison oak, blackberry, and/or other vegetation surrounds elderberry shrubs, stem counts and exit hole surveys could not be conducted. All shrubs to be removed will be surveyed prior to removal, as discussed in Section 4.8.4.2.

4.8.2.1.2 Special-Status Wildlife Species

Special-status wildlife species are defined as animals that are legally protected under the ESA, CESA, or other regulations and species that are considered sufficiently rare by the scientific community to qualify for such listing.

Based on the USFWS (2012) species list and CNDDB (California Department of Fish and Game 2012) records search for the quadrangles overlapping the affected area, 23 special-status wildlife species were identified as having potential to occur in the affected area. Of these 23 species, four are known to occur in the affected area (western pond turtle, Swainson's hawk, western yellow-billed cuckoo, and bank swallow). Swainson's hawk was observed in the affected area during 2011 field surveys. Though not reported to occur in the affected area, 10 other special-status wildlife species have a moderate or high potential to occur in the affected area given their known range, reports of occurrence, and/or the presence of suitable habitat. These species are Antioch Dunes anthicid beetle (*Anthicus antiochensis*), Sacramento anthicid beetle (*A. sacramento*), Sacramento Valley tiger beetle (*Cicindela hirticollis abrupta*), VELB, giant garter snake, northern harrier, bald eagle, western burrowing owl, tricolored blackbird, and silver-haired bat. The remaining nine special-status wildlife species have low or no potential to occur. Seven additional species were added as having at least a moderate potential to occur in the affected area based on species habitat requirements and professional judgment (white-tailed kite, loggerhead shrike, purple martin, yellow warbler, pallid bat, hoary bat, and western red bat). All wildlife species considered, as well as regulatory status, distribution, habitat requirements, and potential to occur in the affected area, are listed in Table 4-31. The 21 special-status wildlife species that are known to occur or have a high or moderate potential to occur in the affected area are described in detail in the FRWLP Final EIS.

Table 4-31. Rare and Special-Status Wildlife Species Identified As Having Potential to Occur in SB-7 and SB-8 Affected Area

Common and Scientific Names	Status[a] Federal/ State/Other	Geographic Distribution	Habitat Requirements	Potential Occurrence in Affected Area
Invertebrates				
Antioch Dunes anthicid beetle *Anthicus antiochensis*	-/-/-	Population in Antioch Dunes believed extinct. Present in several localities along the Sacramento and Feather Rivers.	Loose sand on sand bars and sand dunes.	Moderate—suitable habitat may be present in the affected area; known locations within 2 miles south of the affected area.
Sacramento anthicid beetle *Anthicus sacramento*	-/-/-	Dune areas at mouth of Sacramento River; western tip of Grand Island, Sacramento County; upper Putah Creek and dunes near Rio Vista, Solano County; Ord Ferry Bridge, Butte County.	Found in sand slip-faces among willows; associated with riparian and other aquatic habitats.	Moderate—suitable habitat may be present in the affected area; known locations within 2 miles south of the affected area.
Sacramento Valley tiger beetle *Cicindela hirticollis abrupta*	-/-/-	Lower Sacramento Valley (i.e., Sacramento River, lower American River, and Cache Creek).	Found in sandy areas among willows in riverine and riparian habitats.	Moderate—suitable habitat may be present in the affected area; known locations within 2 miles south of the affected area.
Valley elderberry longhorn beetle *Desmocerus californicus dimorphus*	T/-/-	Streamside habitats below 3,000 feet throughout the Central Valley.	Riparian and oak savanna habitats with elderberry shrubs; elderberries are the host plant.	High—suitable habitat present; species occurrences in affected area.
Conservancy fairy shrimp *Branchinecta conservatio*	E/-/-	Disjunct occurrences in Solano, Merced, Tehama, Ventura, Butte, and Glenn Counties.	Large, deep vernal pools in annual grasslands.	None—no suitable habitat present in affected area.
Vernal pool fairy shrimp *Branchinecta lynchi*	T/-/-	Central Valley, central and south Coast Ranges from Tehama County to Santa Barbara County. Isolated populations also in Riverside County.	Common in vernal pools; also found in sandstone rock outcrop pools.	None—no suitable habitat present in affected area.
Vernal pool tadpole shrimp *Lepidurus packardi*	E/-/-	Shasta County south to Merced County.	Vernal pools and ephemeral stock ponds.	None—no suitable habitat present in affected area.

Common and Scientific Names	Status[a] Federal/ State/Other	Geographic Distribution	Habitat Requirements	Potential Occurrence in Affected Area
Amphibians				
California tiger salamander *Ambystoma californiense*	T/T/–	Central Valley, including Sierra Nevada foothills, up to approximately 1,000 feet, and coastal region from Butte County south to northeastern San Luis Obispo County.	Small ponds, lakes, or vernal pools in grasslands and oak woodlands for larvae; rodent burrows, rock crevices, or fallen logs for cover for adults and for summer dormancy.	Low—limited suitable aquatic habitat and unsuitable surrounding upland habitat; no occurrences in affected area.
California red-legged frog *Rana draytonii*	T/SSC/–	Found along the coast and coastal mountain ranges of California from Marin County to San Diego County and in the Sierra Nevada from Tehama County to Fresno County.	Permanent and semi-permanent aquatic habitats, such as creeks and coldwater ponds, with emergent and submergent vegetation. May estivate in rodent burrows or cracks during dry periods.	None—considered extirpated from the valley floor (U.S. Fish and Wildlife Service 2002).
Western spadefoot *Spea hammondii*	–/SSC/–	Sierra Nevada foothills, Central Valley, Coast Ranges, coastal counties in southern California.	Shallow streams with riffles and seasonal wetlands, such as vernal pools in annual grasslands and oak woodlands.	Low—limited suitable aquatic habitat and unsuitable surrounding upland habitat; no occurrences in affected area.
Reptiles				
Western pond turtle *Emys marmorata*	–/SSC/–	Occurs from the Oregon border of Del Norte and Siskiyou Counties south along the coast to San Francisco Bay, inland through the Sacramento Valley, and on the western slope of Sierra Nevada.	Occupies ponds, marshes, rivers, streams, and irrigation canals with muddy or rocky bottoms and with watercress, cattails, water lilies, or other aquatic vegetation in woodlands, grasslands, and open forests.	High—suitable habitat present; one occurrence in the affected area.

Common and Scientific Names	Status[a] Federal/ State/Other	Geographic Distribution	Habitat Requirements	Potential Occurrence in Affected Area
Giant garter snake *Thamnophis gigas*	T/T/–	Central Valley from the vicinity of Burrel in Fresno County north to near Chico in Butte County; has been extirpated from areas south of Fresno.	Sloughs, canals, low gradient streams and freshwater marsh habitats where there is a prey base of small fish and amphibians; also found in irrigation ditches and rice fields; requires grassy banks and emergent vegetation for basking and areas of high ground protected from flooding during winter.	Moderate—suitable habitat present; no occurrences in affected area but numerous occurrence within 5 miles of affected area in water bodies potentially connected to canals and ditches in the affected area.
Birds				
Greater sandhill crane *Grus canadensis tabida*	–/T/–	Breeds in Siskiyou, Modoc, Lassen, Plumas, and Sierra Counties. Winters in the Central Valley, southern Imperial County, Lake Havasu National Wildlife Refuge, and the Colorado River Indian Reserve.	Summers in open terrain near shallow lakes or freshwater marshes. Winters in plains and valleys near bodies of fresh water.	Low—limited suitable wintering habitat; one occurrence within 5 miles of the affected area.
Swainson's hawk *Buteo swainsoni*	–/T/–	Lower Sacramento and San Joaquin Valleys, the Klamath Basin, and Butte Valley. Highest nesting densities occur near Davis and Woodland, Yolo County.	Nests in oaks or cottonwoods in or near riparian habitats. Forages in grasslands, irrigated pastures, and grain fields.	High—suitable nesting and foraging habitat; seven records in and immediately adjacent to the affected area.
Northern harrier *Circus cyaneus*	–/SSC/–	Occurs throughout lowland California. Has been recorded in fall at high elevations.	Nests and forages in grasslands, meadows, marshes, and seasonal and agricultural wetlands.	Moderate—suitable foraging habitat, limited suitable nesting habitat; one occurrence within 5 miles of the affected area.
White-tailed kite *Elanus leucurus*	–/FP/–	Lowland areas west of Sierra Nevada from the head of the Sacramento Valley south, including coastal valleys and foothills to western San Diego County at the Mexico border.	Low foothills or valley areas with valley or live oaks, riparian areas, and marshes near open grasslands for foraging.	Moderate—suitable nesting and foraging habitat; no occurrences in affected area.

Common and Scientific Names	Status[a] Federal/ State/Other	Geographic Distribution	Habitat Requirements	Potential Occurrence in Affected Area
Bald eagle *Haliaeetus leucocephalus*	–/E, FP/–	Nests in Siskiyou, Modoc, Trinity, Shasta, Lassen, Plumas, Butte, Tehama, Lake, and Mendocino Counties and in the Lake Tahoe Basin. Reintroduced into central coast. Winter range includes the rest of California, except the southeastern deserts, very high altitudes in the Sierra Nevada, and east of the Sierra Nevada south of Mono County.	In western North America, nests and roosts in coniferous forests within 1 mile of a lake, reservoir, stream, or the ocean.	High—suitable nesting and foraging habitat along Feather River; one occurrence within 0.5 mile of the affected area.
California black rail *Laterallus jamaicensis coturniculus*	–/T/–	Permanent resident in the San Francisco Bay and eastward through the Delta into Sacramento and San Joaquin Counties; small populations in Marin, Santa Cruz, San Luis Obispo, Orange, Riverside, and Imperial Counties.	Tidal salt marshes associated with heavy growth of pickleweed; also occurs in brackish marshes or freshwater marshes at low elevations.	Low—no suitable nesting and foraging habitat; no occurrences within 5 miles of the affected area.
Western yellow-billed cuckoo *Coccyzus americanus*	C/E/–	Nests along the upper Sacramento, lower Feather, south fork of the Kern, Amargosa, Santa Ana, and Colorado Rivers.	Wide, dense riparian forests with a thick understory of willows for nesting; sites with a dominant cottonwood overstory are preferred for foraging; may avoid valley-oak riparian habitats where scrub jays are abundant.	High—suitable nesting and foraging habitat; two occurrences in the affected area.
Western burrowing owl *Athene cunicularia hypugea*	–/SSC/–	Lowlands throughout California, including the Central Valley, northeastern plateau, southeastern deserts, and coastal areas. Rare along south coast.	Level, open, dry, heavily grazed or low-stature grassland or desert vegetation with available burrows.	Moderate—suitable foraging habitat; limited suitable nesting habitat; no occurrences in affected area.
Loggerhead shrike *Lanius ludovicianus*	–/SSC/–	Resident and winter visitor in lowlands and foothills throughout California. Rare on coastal slope north of Mendocino County, occurring only in winter.	Prefers open habitats with scattered shrubs, trees, posts, fences, utility lines, or other perches.	Moderate—suitable nesting and foraging habitat; no occurrences in the affected area.

Common and Scientific Names	Status[a] Federal/ State/Other	Geographic Distribution	Habitat Requirements	Potential Occurrence in Affected Area
Purple martin *Progne subis*	–/SSC/–	Coastal mountains south to San Luis Obispo County, west slope of the Sierra Nevada, and northern Sierra and Cascade ranges. Absent from the Central Valley except in Sacramento. Isolated, local populations in southern California.	Nests in abandoned woodpecker holes in oaks, cottonwoods, and other deciduous trees in a variety of wooded and riparian habitats. Also nests in vertical drainage holes under elevated freeways and highway bridges.	Moderate—suitable nesting and foraging habitat; no occurrences in the affected area.
Bank swallow *Riparia riparia*	–/T/–	Occurs along the Sacramento River from Tehama County to Sacramento County, along the Feather and lower American Rivers, in the Owens Valley, and in the plains east of the Cascade Range in Modoc, Lassen, and northern Siskiyou Counties. Small populations near the coast from San Francisco County to Monterey County.	Nests in bluffs or banks, usually adjacent to water, where the soil consists of sand or sandy loam.	High—suitable foraging habitat present; suitable nesting habitat may be present but unlikely; eight occurrences within and adjacent to the affected area.
Yellow warbler *Dendroica petechia*	–/SSC/–	Nests over all of California except the Central Valley, the Mojave Desert region, and high altitudes in the Sierra Nevada. Winters along the Colorado River and in parts of Imperial and Riverside Counties.	Nests in riparian areas dominated by willows, cottonwoods, sycamores, or alders or in mature chaparral; also may use oaks, conifers, and urban areas near stream courses.	Moderate—suitable nesting and foraging habitat; no occurrences in the affected area.
Tricolored blackbird *Agelaius tricolor*	–/SSC/–	Permanent resident in the Central Valley from Butte County to Kern County; breeds at scattered coastal locations from Marin County south to San Diego County and at scattered locations in Lake, Sonoma, and Solano Counties; rare nester in Siskiyou, Modoc, and Lassen Counties.	Nests in dense colonies in emergent marsh vegetation, such as tules and cattails, or upland sites with blackberries, nettles, thistles, and grain fields; habitat must be large enough to support 50 pairs; probably requires water at or near the nesting colony.	Moderate—suitable nesting and foraging habitat; no occurrences in the affected area.

Common and Scientific Names	Status[a] Federal/ State/Other	Geographic Distribution	Habitat Requirements	Potential Occurrence in Affected Area
Mammals				
Western red bat *Lasiurus blossevillii*	–/SSC/ WBWG: High priority	Scattered throughout much of California at lower elevations.	Found primarily in riparian and wooded habitats. Occurs at least seasonally in urban areas. Day roosts in trees in the foliage. Found in fruit orchards and sycamore riparian habitats in the Central Valley.	Moderate—suitable roosting and foraging habitat; no occurrences within 5 miles of the affected area probably because of the lack of bat surveys in the affected area.
Hoary bat *Lasiurus cinereus*	–/–/ WBWG: Moderate priority	Occurs throughout California from sea level to 13,200 feet.	Found primarily in forested habitats. Also found in riparian areas and in park and garden settings in urban areas. Day roosts in foliage of trees.	Moderate—suitable roosting and foraging habitat; no occurrences have been recorded within 5 miles of the affected area (probably due to the lack of bat surveys in the affected area).
Silver-haired bat *Lasionycteris noctivagans*	–/–/WBWG: Moderate priority	Found from the Oregon border south along the coast to San Francisco Bay and along the Sierra Nevada and Great Basin region to Inyo County. Also occurs in southern California from Ventura and San Bernardino Counties south to Mexico. Has been recorded in Sacramento, Stanislaus, Monterey, and Yolo Counties.	During spring and fall migrations, may be found anywhere in California. Summer habitats include coastal and montane coniferous forests, valley foothill woodlands, pinyon-juniper woodlands, and valley foothill and montane riparian habitats. Roosts in hollow trees, snags, buildings, rock crevices, caves, and under bark.	Moderate—suitable roosting and foraging habitat; two occurrences within 5 miles of the affected area.
Pallid bat *Antrozous pallidus*	–/SSC/ WBWG: High priority	Occurs throughout California, except the high Sierra, from Shasta to Kern County and the northwest coast, primarily at lower and mid elevations.	Occurs in a variety of habitats from desert to coniferous forest. Most closely associated with oak, yellow pine, redwood, and giant sequoia habitats in northern California and oak woodland, grassland, and desert scrub in southern California. Relies heavily on trees for roosts.	Moderate—suitable roosting and foraging habitat; no occurrences have been recorded within 5 miles of the affected area (probably due to the lack of bat surveys in the affected area).

Common and Scientific Names	Status[a] Federal/ State/Other	Geographic Distribution	Habitat Requirements	Potential Occurrence in Affected Area
Western mastiff bat *Eumops perotis californicus*	–/SSC/ WBWG: High priority	Occurs along the western Sierra primarily at low to mid-elevations and widely distributed throughout the southern coast ranges. Recent surveys have detected the species north to the Oregon border.	Found in a wide variety of habitats from desert scrub to montane conifer. Roosts and breeds in deep, narrow rock crevices, but also may use crevices in trees, buildings, and tunnels.	Low— uncommon in the Central Valley and roost sites primarily associated with crevices in cliff faces and boulders. No occurrences within 5 miles of the affected area.
Ringtail *Bassariscus astutus*	-/FP/-	Found throughout most of California except for the San Joaquin Valley and portions of southern deserts.		High-known to occur along the Feather River within the study area

[a] Status explanations:

Federal

E = listed as endangered under the Federal Endangered Species Act.

T = listed as threatened under the Federal Endangered Species Act.

C = candidate species for which USFWS has on file sufficient information on biological vulnerability and threat(s) to support issuance of a proposed rule to list, but issuance of the proposed rule is precluded.

– = no listing.

State

E = listed as endangered under the California Endangered Species Act.

T = listed as threatened under the California Endangered Species Act.

FP= fully protected under the California Fish and Game Code.

SSC = species of special concern in California.

– = no listing.

Other

WBWG = Western Bat Working Group 2007. Available: <http://www.wbwg.org/spp_matrix.html>.

Moderate priority = species status is unclear because of a lack of data; this designation indicates a level of concern that should warrant (1) closer evaluation and more research of the species and possible threats and (2) conservation actions benefiting the species.

High priority = species are imperiled or at high risk of imperilment.

4.8.3 Determination of Effects

Effects on wildlife may be considered significant if implementation of an alternative would result in any of the following conditions.

- Have a substantial adverse effect, either directly or through habitat modification, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations or by CDFW or USFWS.
- Interferes substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites.
- Conflicts with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance.
- Conflicts with the provisions of an adopted HCP, NCCP, or other approved local, regional, or state habitat conservation plan.
- Contributes to a substantial reduction or elimination of species diversity or abundance.

4.8.3.1 Assessment Methods

Potential direct effects (permanent and temporary) on wildlife habitat were quantified based on estimated habitat losses within proposed construction footprints and staging areas by alternative. Potential indirect effects of each project alternative were evaluated more qualitatively because they would occur farther from the project area or later in time, and are more difficult to evaluate quantitatively. As mentioned above, borrow sites recently were identified and have not been surveyed yet. Depending on the habitats present at these sites, additional wildlife species may be affected. Information collected during surveys will be needed to determine effects and appropriate mitigation measures.

Direct effects can be either temporary (return to baseline conditions within a year of disturbance) or permanent in duration. These effects were used to assess effects on wildlife resources.

4.8.4 Effects and Mitigation Measures

Effects and mitigation measure requirements concerning wildlife resources are summarized in Table 4-32.

Table 4-32. Summary of Effects on Wildlife

Effect	Finding	Mitigation Measure	Finding with Mitigation
SB-7 and SB-8			
Effect WILD-1: Potential Mortality of or Loss of Habitat for Antioch Dunes Anthicid, Sacramento Anthicid, and Sacramento Valley Tiger Beetles	Significant	WILD-MM-1: Fence and Avoid Habitat for Antioch Dunes Anthicid, Sacramento Anthicid, and Sacramento Valley Tiger Beetles and Implement Protective Measures	Less than significant
Effect WILD-2: Potential Mortality or Disturbance of VELB and its Habitat (Elderberry Shrubs)	Significant	WILD-MM-2: Conduct VELB Surveys Prior to Elderberry Transplantation WILD-MM-3: Implement Protect VELB and its Habitat WILD-MM-4: Compensate for Effects on VELB and its Habitat	Less than significant
Effect WILD-3: Potential Mortality or Disturbance of Western Pond Turtle	Significant	WILD-MM-5: Conduct Preconstruction Surveys for Western Pond Turtle and Monitor Construction Activities if Turtles are Observed	Less than significant
Effect WILD-4: Potential Disturbance or Mortality of and Loss of Suitable Habitat for Giant Garter Snake	Significant	WILD-MM-6: Avoid and Minimize Construction Effects on Giant Garter Snake WILD-MM-7: Compensate for Permanent Loss of Suitable Giant Garter Snake Habitat	Less than significant
Effect WILD-5: Potential Loss or Disturbance of Nesting Swainson's Hawk and Loss of Nesting and Foraging Habitat	Significant	WILD-MM-8: Conduct Vegetation Removal Activities outside the Breeding Season for Birds WILD-MM-9: Conduct Focused Surveys for Nesting Swainson's Hawk prior to Construction and Implement Protective Measures during Construction	Less than significant
Effect WILD-6: Potential Mortality or Disturbance of Nesting Special-Status and Non–Special Status Birds and Removal of Suitable Breeding Habitat	Significant	WILD-MM-8: Conduct Vegetation Removal Activities outside the Breeding Season for Birds WILD-MM-10: Conduct Nesting Surveys for Special-Status and Nonspecial-Status Birds and Implement Protective Measures during Construction	Less than significant
Effect WILD-7: Potential Loss or Disturbance of Western Burrowing Owl and Loss of Nesting and Foraging Habitat	Significant	WILD-MM-8: Conduct Vegetation Removal Activities outside the Breeding Season for Birds WILD-MM-11: Conduct Surveys for Western Burrowing Owl prior to Construction and Implement Protective Measures if Found WILD-MM-12: Compensate for the Loss of Occupied Western Burrowing Owl Habitat	Less than significant
Effect WILD-8: Potential Injury, Mortality or Disturbance of Tree-Roosting Bats and Removal of Roosting Habitat	Significant	WILD-MM-8: Conduct Vegetation Removal Activities outside the Breeding Season for Birds WILD-MM-13: Identify Suitable Roosting Habitat for Bats and Implement Avoidance and Protective Measures	Less than significant
Effect WILD-9: Potential Injury, Mortality or Disturbance of Ringtail and Removal of Habitat	Significant	WILD-MM-14: Identify Suitable Shelter and Denning Habitat for Ringtail and Implement Avoidance and Protective Measures	Less than significant

Effect	Finding	Mitigation Measure	Finding with Mitigation
Effect WILD-10: Disturbance to or Loss of Common Wildlife Species and Their Habitats	Significant	WILD-MM-8: Conduct Vegetation Removal Activities outside the Breeding Season for Birds WILD-MM-9: Conduct Focused Surveys for Nesting Swainson's Hawk prior to Construction and Implement Protective Measures during Construction WILD-MM-10: Conduct Nesting Surveys for Special-Status and Nonspecial-Status Birds and Implement Protective Measures during Construction	Less than significant
Effect WILD-11: Potential Disruption of Wildlife Movement Corridors	Less than significant	None required	Less than significant

4.8.4.1 No Action Alternative

The No Action Alternative represents the continuation of the existing deficiencies in levees along 44 miles of the west bank of the Feather River between the Sutter Bypass and Thermalito Afterbay. Current levee O&M activities would continue, but there would be no change in the geomorphic and flood risk–management regimes relative to existing conditions. No construction-related effects on wildlife, such as displacement or loss of habitat, would occur.

Because no levee improvements would be made under the No Action Alternative, the risk that the levees along the west bank of the Feather River could fail because of seepage or slope stability/geometry issues would continue. A catastrophic levee failure would result in flooding and inundation that could significantly affect wildlife and upland or wetland habitats, resulting in mortality of individuals, physical displacement, and temporary loss or permanent alterations of habitat. In addition, cleanup and repair activities could result in physical displacement for extended periods of time and significant effects on habitat. A major flood event along the Feather River corridor could result in damage to the riparian forest between the river and the levees. Given the importance of this riparian corridor for numerous special-status species and for the Pacific flyway (a major travel route for migratory birds in North America) in general, loss or fragmentation of this habitat would be a significant effect, and it could take decades for a mature riparian forest to reestablish itself in the affected areas. Given the uncertainty of the occurrence or magnitude of such an event, potential effects on wildlife and its habitats cannot be quantified based on available information.

4.8.4.2 Alternatives SB-8 and SB-7

USACE reinitiated Section 7 Endangered Species Act consultation with the USFWS and the NMFS for the project. USACE prepared biological assessments to assess effects to listed species for submittal to USFWS and NMFS. The USFWS issued an amended biological opinion and NMFS issued a letter concurring with the USACE's determination that implementation of SB-8 is not likely to adversely affect listed fish species (Appendix D). Implementation of this alternative would potentially result in effects on the Federally-listed giant garter snake (GGS) and the valley elderberry longhorn beetle

(VELB). Below is the list of Terms and Conditions included in the Incidental Take Statement accompanying the USFWS BO that will be implemented to protect the federally-listed GGS and VELB.

USFWS Incidental Take Terms and Conditions:

All the conservation measures as described in the project description, and as restated here in this biological opinion, must be fully implemented and adhered to.

The Corps, SBFCA, and PG&E shall include full implementation and adherence to the conservation measures as outlined in the biological opinion as a condition of any permit or contract issued for the project.

In order to monitor whether the amount or extent of take anticipated from implementation of the proposed project is approached or exceeded, the Corps and SBFCA shall adhere to the following reporting requirement. Should this anticipated amount or extent of incidental take be exceeded, the Corps must immediately reinitiate formal consultation as per 50 CFR 401.16.

a. *For those components of the proposed project that will result in habitat degradation or modification whereby incidental take in the form of harm or mortality is anticipated, the Corps and SBFCA will provide weekly updates to the Service with a precise accounting of the total acreage of habitat affected or number of elderberry shrubs and size of stems at ground level transplanted. Updates shall also include any information about changes in the Project Description not analyzed in this biological opinion.*

SBFCA and the Corps shall provide a photo documentation report showing pre- and post-project area conditions for giant garter snake.

The magnitude of the majority of permanent habitat losses would be greater under SB-8 than under SB-7 and, temporary losses of habitat would be greater for some land cover types than under SB-7. Table 4-33 summarizes the specific effects on special-status species habitat for SB-8 and SB-7.

The following mitigation measures, which are described in Section 4.7, *Vegetation and Wetlands*, would apply to the wildlife resources discussed below and would be implemented to avoid and minimize effects on special-status wildlife. For brevity, these measures are not repeated for each species or group of species discussed below.

Mitigation Measure VEG-MM-2: Install Exclusion Fencing and/or K-rails along the Perimeter of the Construction Work Area and Implement General Measures to Avoid Effects on Sensitive Natural Communities and Special-Status Species

Mitigation Measure VEG-MM-3: Conduct Mandatory Contractor/Worker Awareness Training for Construction Personnel

Mitigation Measure VEG-MM-4: Retain a Biological Monitor

Table 4-33. Effects on Special-Status Species Habitat under Alternative SB-8

Special-Status Species	Habitat	Acres of Permanent/ Temporary Effects	
		SB-8	SB-7
Antioch Dunes anthicid, Sacramento anthicid, and Sacramento Valley tiger beetles	Sandy riparian areas	0/0	0/0
Valley elderberry longhorn beetle	Elderberry shrubs	162[a]	79[a]
Giant garter snake and western pond turtle	Aquatic habitat in drainage, canals and irrigation ditches, freshwater emergent areas, and open water	0/11.9	0/0
Giant garter snake	Upland habitat in ruderal areas within 200 feet of aquatic habitat	3.54/96.79	3.54/17.00
Swainson's hawk, white-tailed kite, bald eagle, western yellow-billed cuckoo, purple martin, yellow warbler, and other birds	Nesting and foraging habitat in riparian forest	15.44/7.95	13.12/5.96
Swainson's hawk, white-tailed kite, northern harrier, burrowing owl, and tricolored blackbird	Foraging habitat in field and row crops and in ruderal areas	533.09/104.21	239.09/71.90
Bank swallow	Bluffs and banks of streams/ levees adjacent to water	0/0	0/0
Bats	Roosting habitat in riparian forest and orchard	113.21/14.39	78.11/9.92

[a] For valley elderberry longhorn beetle, effects are given in numbers of shrubs, not acres.

Effect WILD-1: Potential Mortality of or Loss of Habitat for Antioch Dunes Anthicid, Sacramento Anthicid, and Sacramento Valley Tiger Beetles

Construction activities that remove or disturb sandy riparian areas could result in the mortality of larvae or adults of Antioch Dunes anthicid, Sacramento anthicid, and Sacramento Valley tiger beetles. Beetles could be crushed by construction equipment or personnel, and suitable habitat could be modified or removed during ground-disturbing activities. Because these beetle species are rare and are only known from few locations in the project vicinity, loss of individuals and modification or removal of habitat would be considered significant effects. Implementation of the following mitigation measure would reduce these effects to a less-than–significant level.

Mitigation Measure WILD-MM-1: Conduct Focused Surveys for Habitat for Antioch Dunes Anthicid, Sacramento Anthicid, and Sacramento Valley Tiger Beetles and Implement Protective Measures

Wildlife biologists will conduct surveys for suitable habitat for Antioch Dunes anthicid, Sacramento anthicid, and Sacramento Valley tiger beetles. The biologists will map these areas using a GPS unit. If possible, these areas will be avoided during construction. If avoidance is not possible, a qualified entomologist will survey the suitable habitat areas for the presence of these

three beetle species to determine their presence. If recommended by the entomologist and supported by the wildlife agencies, the beetles may be relocated to suitable habitat prior to the start of construction in the habitat to be affected.

Effect WILD-2: Potential Mortality or Disturbance of VELB and its Habitat (Elderberry Shrubs)

Elderberry shrubs, which provide habitat for the VELB, would be removed or disturbed by activities associated with construction of SB-7 or SB-8. Removal or disturbance of elderberry shrubs could result in the mortality or disturbance of VELB. Noise and dust generated during construction also may indirectly affect adult VELB or exposed larvae or eggs (Talley and Holyoak 2009:10). Soil disturbance adjacent to shrubs may affect the roots and subsequent health of elderberry shrubs. Shrubs located farther from the construction area and those sheltered by surrounding vegetation are expected to have fewer construction-related effects than shrubs that are closer to the construction area and in more open areas. Yearly levee maintenance would remove woody vegetation that develops including elderberry shrubs when young and less than 1-inch at ground level, therefore there should be no long-term effects from levee maintenance on VELB. Table 4-34 shows the number of elderberry shrubs directly impacted and estimated compensation. The removal or disturbance of elderberry shrubs (162 for SB-8 and 79 for SB-7) would be considered a significant effect on VELB. Implementation of the following mitigation measures would reduce this effect to a less-than-significant level.

Table 4-34. Permanent Effects on Elderberry Shrubs and Compensation Acreage Requirements

Permanent Effects and Compensation	FRWLP	SB-7	SB-8
Compensation Acreage	11.16	9.94	20.38
Number of Shrubs Affected	91	79	162

Mitigation Measure WILD-MM-2: Conduct VELB Surveys Prior to Elderberry Shrub Transplantation

Surveys of elderberry shrubs to be transplanted will be conducted by a qualified biologist prior to transplantation. Surveys will be conducted in accordance with the Conservation Guidelines for the VELB (U.S. Fish and Wildlife Service 1999). Surveys will consist of counting and measuring the diameter of each stem, and examining elderberry shrubs for the presence of VELB exit holes. Survey results and an analysis of the number of elderberry seedlings/cuttings and associated native plants required as compensation will be submitted to USFWS.

Mitigation Measure WILD-MM-3: Implement Measures to Protect VELB and its Habitat

Complete avoidance of effects on VELB is assumed when a 100-foot buffer around elderberry shrubs is established and maintained during construction (U.S. Fish and Wildlife Service 1999). Elderberry shrubs/clusters within 100 feet of the construction area that will not be removed will be protected during construction. Elderberry shrubs in the construction area that cannot be protected will be transplanted between November 1 and February 14 in accordance with USFWS-approved procedures outlined in *Conservation Guidelines for the Valley Elderberry Longhorn Beetle* (U.S. Fish and Wildlife Service 1999). Elderberry shrubs within 100 feet of the

construction area that will not be removed will be protected with orange construction barrier fencing.

Mitigation Measure WILD-MM-4: Compensate for Effects on VELB and its Habitat

Compensation for direct effects on VELB will be provided for in accordance with the Biological Opinion to be issued by the USFWS. Permanent effects on elderberry shrubs are shown in Table 4-34. Elderberry shrubs that cannot be avoided will be transplanted to a USFWS-approved conservation area (i.e., the Star Bend Conservation Area). Elderberry seedlings or cuttings and associated native species will also be planted in the conservation area. Each elderberry stem measuring 1 inch or greater in diameter at ground level that is adversely affected (i.e., transplanted or destroyed) will be replaced in the conservation area with elderberry seedlings or cuttings at a ratio ranging from 1:1 to 8:1 (new plantings to affected stems). The numbers of elderberry seedlings/cuttings and associated riparian native trees/shrubs to be planted as replacement habitat are determined by stem size class of affected elderberry shrubs, presence or absence of exit holes, and whether the shrub lies in a riparian or nonriparian area. Stock of either seedlings or cuttings would be obtained from local sources. The numbers of elderberry seedlings/cuttings and associated riparian native trees/shrubs will be estimated based on existing elderberry shrub survey data and adjusted according to elderberry survey data collected during implementation of Mitigation Measure WILD-MM-2.

Effect WILD-3: Potential Mortality or Disturbance of Western Pond Turtle

Aquatic and upland (overwintering, nesting) habitat for western pond turtle may be removed or temporarily disturbed by construction activities. Western pond turtles may be killed, injured, or disturbed by activities that remove suitable aquatic or upland habitat. Construction activities (such as grading and movement of heavy equipment) could result in the destruction of pond turtle nests containing eggs or young individuals if affected areas are being used for egg deposition. Declines in populations of western pond turtles throughout the species range have been documented (Jennings and Hayes 1994). Loss of individuals in the project area could diminish the local population and lower reproductive potential, which could contribute to the further decline of this species. The loss of upland nesting sites or eggs also would decrease the local population. This effect would be significant, but implementation of the following mitigation measure would reduce this effect to a less-than-significant level.

Mitigation Measure WILD-MM-5: Conduct Preconstruction Surveys for Western Pond Turtle and Monitor Construction Activities if Turtles are Observed

One week before and within 24 hours of beginning work in suitable aquatic habitat, a qualified biologist (one who is familiar with different species of turtles) will conduct surveys for western pond turtle. The surveys should be timed to coincide with the time of day and year when turtles are most likely to be active (during the cooler part of the day between 8 a.m. and 12 p.m. during spring and summer). Prior to conducting the surveys, the biologist should locate the microhabitats for turtle basking (logs, rocks, brush thickets) and determine a location to quietly observe turtles. Each survey should include a 30-minute wait time after arriving onsite to allow startled turtles to return to open basking areas. The survey should consist of a minimum 15-minute observation time per area where turtles could be observed. If western pond turtles are observed during either survey, a biological monitor should be present during construction activities in the aquatic habitat where the turtle was observed and will capture and remove, if

possible, any entrapped turtle. The biological monitor also will be mindful of suitable nesting and overwintering areas in proximity to suitable aquatic habitat and periodically inspect these areas for nests and turtles. The biological monitor's CDFW scientific collecting permit will include capture and relocation of turtles.

Effect WILD-4: Potential Disturbance or Mortality of and Permanent Loss of Suitable Habitat for Giant Garter Snake

Construction of SB-7 and SB-8 would result in temporary and permanent losses of suitable aquatic and upland habitat for giant garter snake (Table 4-35). Under SB-8 and SB-7, the installation of erosion protection matting on the landside slope of the levee to control erosion in an overtopping event could impact the snake. The erosion protection matting could impact suitable upland habitat by preventing the formation of burrows by ground squirrels which the snake utilizes. Construction activities in suitable habitat could also result in the injury, mortality, or disturbance of giant garter snakes. Loss of habitat and potential injury or mortality of snakes are considered significant effects because the project could reduce the local population size of a federally and state-listed species. This effect would be significant, but implementation of the following mitigation measure would reduce this effect to a less-than-significant level.

Table 4-35. Temporary and Permanent Effects on Giant Garter Snake Habitat

	Levee Construction Area (In Acres)			Borrow Sites	Total Acreage		
Habitat	FRWLP	SB-7	SB-8	In Acres	FRWLP	SB-7	SB-8
Temporary Effects							
Aquatic habitat	9.59	0	11.9	127.72	137.31	0	139.62
Upland habitat (ruderal within 200 feet of aquatic habitat)	96.79	17	96.79	175.47	272.26	17	272.26
Permanent Effects							
Aquatic habitat	0	0	0	0	0	0	0
Upland habitat (ruderal within 200 feet of aquatic habitat)	0	3.54	3.54	0	0	3.54	3.54

Mitigation Measure WILD-MM-6: Avoid and Minimize Construction Effects on Giant Garter Snake

The following conservation measures would be implemented to avoid, minimize, and compensate for effects on giant garter snake and its habitat.

- To the maximum extent possible, all construction activity in giant garter snake aquatic and upland habitat and within 200 feet of aquatic habitat will be conducted during the snake's active period (between May 1 and October 1). During this timeframe, potential for injury and mortality is lessened because snakes are actively moving and avoiding danger. Giant garter snakes are more vulnerable to danger during their inactive period because they are occupying underground burrows or crevices and are more susceptible to direct effects, especially during excavation. Small irrigation ditches on the landside of the levee that need to be moved outward from the existing levee will be completely dried, removed, and relocated during the May 1–October 1 timeframe. For work that cannot be conducted

between May 1 and October 1, additional protective measures will be determined during consultation with USFWS.

- To reduce the likelihood of snakes entering the construction area, exclusion fencing and orange barrier fencing will be installed along the edge of the construction area that is within 200 feet of suitable habitat. The exclusion and barrier fencing will be installed during the active period for giant garter snakes (May 1 to October 1) to reduce the potential for injury and mortality during this activity. The exclusion fencing will consist of silt fencing buried below ground level. The exclusion fencing will ensure that giant garter snakes are excluded from the construction area and that suitable upland and aquatic habitat is protected throughout construction.
- A USFWS-approved biologist will conduct a preconstruction survey in suitable habitat no more than 24 hours before construction. Prior to construction activities each morning, construction personnel will inspect exclusion and orange construction barrier fencing to ensure they are both in good working order. If any snakes are observed in the construction area during this inspection or at any other time during construction, the USFWS-approved biologist will be contacted to survey the site for snakes. The project area will be re-inspected and surveyed whenever a lapse in construction activity of 2 weeks or more has occurred. If a snake (believed to be a giant garter snake) is encountered during construction, activities will cease until appropriate corrective measures have been completed or it has been determined that the snake will not be harmed.
- Vegetation clearing within 200 feet of the banks of suitable giant garter snake aquatic habitat will be limited to the minimum area necessary. Giant garter snake habitat within or adjacent to the project area will be flagged and designated as an environmentally sensitive area, to be avoided by all construction personnel.
- The movement of heavy equipment within 200 feet of potential giant garter snake aquatic habitat will be confined to designated haul routes to minimize habitat disturbance.
- Temporarily affected suitable habitat will be restored to pre-project conditions.

Mitigation Measure WILD-MM-7: Compensate for Permanent Loss of Suitable Giant Garter Snake Habitat

To compensate for the direct and indirect effects on habitat for giant garter snake, USACE proposes to purchase mitigation credits at a USFWS- and CDFW-approved conservation bank (Table 4-36).

Table 4-36. Giant Garter Snake Habitat Mitigation Table

Impact Type	Impact Unit	Impact	Mitigation Ratio	Mitigation Need	Mitigation Area
Aquatic Habitat	Acreage	0 acres	3:1	0 acres	0 acres
Upland Habitat	Acreage	3.54 acres	3:1	10.62 acres	10.62 acres

Effect WILD-5: Potential Loss or Disturbance of Nesting Swainson's Hawk and Loss of Nesting and Foraging Habitat

Construction is anticipated to occur between April 15 and November 30, which is during the breeding season of Swainson's hawks (March through August). Swainson's hawks were flying through the affected area during the 2011 field surveys. There are 12 records of Swainson's hawk nests in the affected area and within 0.5 mile of the affected area (California Department of Fish and Game 2012). The majority of these records are for observations of nesting between 2001 and 2004. Ten of the reported nests are located south of Olivehurst. There are numerous additional records of occurrences within 5 miles of the affected area. The affected area and adjacent areas contain numerous suitable nest trees for Swainson's hawks. Field and row crops and ruderal areas provide suitable foraging habitat for Swainson's hawks in the affected area.

Construction activities and removal of trees could result in the loss or disturbance of Swainson's hawk during the nesting season. Removal of nests or suitable nesting habitat and construction disturbance during the breeding season could result in the incidental loss of fertile eggs or nestlings or otherwise lead to nest abandonment. Removal of active nest trees or anticipated disturbance that may result in nest abandonment would require an incidental take permit from CDFW. Because the availability of foraging habitat has been closely tied to the breeding success of this species, projects that would significantly modify suitable Swainson's hawk foraging habitat are considered to the have potential to significantly affect this species (California Department of Fish and Game 1994). Loss of Swainson's hawk eggs or nests, any activities resulting in nest abandonment, and loss of nesting and foraging habitat would be considered significant effects. Implementation of Mitigation Measure VEG-MM-1, Compensate for the Loss of Woody Riparian Trees, would compensate for the loss of potential nesting habitat for Swainson's hawk. The loss of foraging habitat from conversion of agricultural land would not be significant. Implementation of the following mitigation measures would reduce these effects to a less-than-significant level.

The removal of vegetation is not anticipated to have a significant effect on the regional productivity of Swainson's hawks. Mitigation Measure WILD-MM-8 Conduct Vegetation Removal Activities outside the Breeding Season for Birds and Mitigation Measure WILD-MM-9 Conduct Focused Surveys for Nesting Swainson's Hawk Prior to Construction and Implement Protective Measures during Construction would reduce the potential for shorterm effects to regional productivity of the species. Additionally, the overall longterm regional productivity of Swainson's hawk habitat will be improved by the new 85 acreas of riparian and 2.6 acres of oak woodland mitigation plantings which will offset the 15.44 acres of permenant effects.

Mitigation Measure WILD-MM-8: Conduct Vegetation Removal Activities outside the Breeding Season for Birds

To the maximum extent feasible, vegetation (trees, shrubs, ruderal areas) removal/trimming will be scheduled during the nonbreeding season of birds (September 1–January 31). If vegetation removal cannot be removed in accordance with this timeframe, preconstruction surveys for nesting birds and additional protective measures will be implemented (see Mitigation Measure WILD-MM-9). Removal of trees with active Swainson's hawk nests and active raptors will be avoided. Because white-tailed kite is fully protected, removal of trees with active nests and activities that may result in loss of white-tailed kites are prohibited.

Mitigation Measure WILD-MM-9: Conduct Focused Surveys for Nesting Swainson's Hawk Prior to Construction and Implement Protective Measures during Construction

During the spring prior to construction, focused surveys for Swainson's hawk will be conducted in the project area and in a buffer area up to 0.5 mile around the project area. The size of the buffer area surveyed will be based on the type of habitat present and line of sight from the construction area to surrounding suitable breeding habitat.

If active nests are found, a 0.25-mile buffer or other distance determined appropriate through consultation with CDFW will be maintained between construction activities and the active nest(s) until it has been determined that young have fledged. In addition, a qualified biologist (experienced with raptor behavior) will be present onsite daily during construction activities occurring during the breeding season to watch for any signs of stress. If nesting birds are observed to exhibit agitated behavior indicating that they are experiencing stress, construction activities will cease until the qualified biologist, in consultation with CDFW, determines that young have fledged.

Effect WILD-6: Potential Mortality or Disturbance of Nesting Special-Status and Non–Special Status Birds and Removal of Suitable Breeding Habitat.

Special-status birds that may nest in the riparian forest in and adjacent to the affected area include Swainson's hawk, white-tailed kite, bald eagle, western yellow-billed cuckoo, purple martin, and yellow warbler. Bank swallow may nest adjacent to the affected area in the banks of the Feather River. Northern harrier may nest in ruderal areas in the affected area. Loggerhead shrike may nest in shrubs and trees in more open portions of the affected area. Tricolored blackbirds may nest in blackberry brambles or field crops. Numerous nonspecial-status birds also may nest in these areas. Because construction is anticipated to occur between April 15 and November 30, effects on nesting birds may occur. Vegetation removal and other construction activities during the breeding season (generally February 1 through August 31) could result in the mortality or disturbance of nesting birds in and adjacent to the construction area. The removal of riparian forest, ruderal areas, and field crops would reduce the amount of available nesting habitat for special-status and nonspecial-status birds.

Removal of nest trees during the breeding season or anticipated disturbance that may result in nest abandonment and subsequent loss of eggs or young of Swainson's hawk, bald eagle, western yellow-billed cuckoo, or bank swallow would require an incidental take permit from CDFW.

Construction activities and removal of trees could result in the loss or disturbance of breeding pairs of Swainson's hawk during the nesting season. Removal of nests or suitable nesting habitat and construction disturbance during the breeding season could result in the incidental loss of fertile eggs or nestlings or otherwise lead to nest abandonment. Removal of active nest trees or anticipated disturbance that may result in nest abandonment would require an incidental take permit from DFG. Loss of Swainson's hawk eggs or nests, any activities resulting in nest abandonment, and loss of nesting and foraging habitat would be considered significant effects. Implementation of Mitigation Measure VEG-MM-1, Compensate for the Loss of Woody Riparian Habitat, would compensate for the loss of potential nesting habitat for Swainson's hawk. Implementation of the following mitigation measures would reduce these effects to a less-than-significant level.

Because white-tailed kite is fully protected, removal of trees with active nests and activities that may result in loss of white-tailed kites are prohibited. Removal of nests or suitable nesting habitat (trees,

shrubs, ruderal areas, field crops) and construction disturbance during the breeding season could result in the incidental loss of fertile eggs or nestlings or otherwise lead to nest abandonment. Such losses could affect the local population of special-status and nonspecial-status species and would be considered a significant effect. Implementation of Mitigation Measure WILD-MM-8 and the mitigation measure below, would reduce this effect to a less-than-significant level.

Mitigation Measure WILD-MM-10: Conduct Nesting Surveys for Special-Status and Nonspecial-Status Birds and Implement Protective Measures during Construction

Nesting surveys will be conducted before the start of construction. Surveys will include a search of all suitable nesting habitat (trees, shrubs, ruderal areas, field crops) in the construction area. In addition, a 500-foot area around the project area will be surveyed for nesting raptors, and a 50-foot buffer area will be surveyed for other nesting birds. If no active nests are detected during these surveys, no additional measures are required.

If active nests are found in the survey area, no-disturbance buffers will be established around the nest sites to avoid disturbance or destruction of the nest site until the end of the breeding season (approximately September 1) or until a qualified wildlife biologist determines that the young have fledged and moved out of the project area (this date varies by species). The extent of the buffers will be determined by the biologists in coordination with USFWS and CDFW and will depend on the level of noise or construction disturbance, line-of-sight between the nest and the disturbance, ambient levels of noise and other disturbances, and other topographical or artificial barriers.

Effect WILD-7: Potential Loss or Disturbance of Western Burrowing Owl and Loss of Nesting and Foraging Habitat

Construction is anticipated to occur during the breeding season of western burrowing owl (March through August). Burrowing owls also could be present year-round. Construction activities and removal of nesting habitat (burrows in ruderal areas and on the edges of agricultural areas) could result in the loss or disturbance of western burrowing owl. Removal of occupied burrows and construction disturbance during the breeding season could result in the incidental loss of fertile eggs or nestlings or otherwise lead to nest abandonment. Permanent or temporary loss of foraging or burrow habitat for this species also would result from construction activities. Nesting burrowing owls are protected under the Migratory Bird Treaty Act (MBTA) and California Fish and Game Code Sections 3503 and 3503.5. Loss of active breeding or wintering burrows or disturbance of breeding burrows resulting in mortality of young and displacement of adults would be considered a significant effect. Implementation of Mitigation Measure WILD-MM-8 and the mitigation measures below would reduce this effect to a less-than-significant level.

Mitigation Measure WILD-MM-11: Conduct Surveys for Western Burrowing Owl Prior to Construction and Implement Protective Measures if Found

CDFW recommends burrowing owl surveys whenever burrowing owl habitat is present on or within 500 feet of a project site. Breeding season and nonbreeding season surveys will be conducted in accordance with recommendations of the CDFW and USFWS.

If burrowing owls are found during any of the surveys, compensatory mitigation best practices as described below will be used. Because ample lead time is necessary for putting compensation

in place, these efforts should begin as soon as possible after presence of burrowing owls is determined.

Regardless of results from the surveys described above, initial take avoidance (preconstruction) surveys will be conducted no less than 14 days prior to and 24 hours before initiating ground disturbing activities. Burrowing owls may re-colonize a site after only a few days. As such, subsequent take avoidance surveys will be conducted if a few days pass between project activities. If no burrowing owls are found, no further mitigation is required. If burrowing owls are found, USACE will use avoidance, minimization measures, monitoring, and reporting of such measures as recommended by the CDFW and USFWS.

Mitigation Measure WILD-MM-12: Compensate for the Loss of Occupied Burrowing Owl Habitat

If burrowing owls have been documented to occupy burrows at the project site in the last 3 years, current scientific literature supports the conclusion that the site should be considered occupied and mitigation is required. Mitigation would then be determined in consultation with the USFWS and the CDFW.

Effect WILD-8: Potential Injury, Mortality or Disturbance of Tree-Roosting Bats and Removal of Roosting Habitat

Construction is anticipated to occur during the maternity season of bats (April 1 through September 15) and beginning of the hibernation period (November 1). The proposed project would result in the loss of trees, which provide suitable roosting habitat (cavities, crevices, furrowed bark, and foliage) for special-status bats (western red bat and pallid bat) and bats for which conservation actions are warranted (hoary bat and silver-haired bat) (Western Bat Working Group 2007). Tree removal/trimming and noise or other construction activities could result in the injury, mortality, or disturbance of roosting bats, if present in cavities, crevices, furrowed bark, or foliage of trees. Because no work on bridges or other structures in the affected area is expected, effects on bats that may roost on these structures (pallid bat or maternity colonies of nonspecial-status bats) are not anticipated. Mortality of tree-roosting bats during the maternity season or hibernation period that results from tree removal/trimming or other disturbances could affect the local populations of these species and would be considered a significant effect. Implementation of Mitigation Measure WILD-MM-8 and the following mitigation measure would lessen effects on western red bat, pallid bat, and other bat species.

Mitigation Measure WILD-MM-13: Conduct Preconstruction Surveys for Roosting Bats and Implement Avoidance and Protective Measures

If tree removal/trimming cannot be conducted between September 15 and October 30, qualified biologists will examine trees to be removed or trimmed for suitable bat roosting habitat before removal/trimming. High-quality habitat features (large tree cavities, basal hollows, loose or peeling bark, larger snags, palm trees with intact thatch, etc.) will be identified and the area around these features searched for bats and bat sign (guano, culled insect parts, staining, etc.). Riparian woodland, orchards, and stands of mature broadleaf trees should be considered potential habitat for solitary foliage–roosting bat species. If suitable habitat and/or bat sign is detected, biologists will conduct evening visual emergence surveys of the source habitat feature, from a half hour before sunset to 1–2 hours after sunset for a minimum of two nights within the

season that construction will be taking place. Night vision goggles and/or full-spectrum acoustic detectors should be used during emergence surveys to assist in species identification. All emergence surveys will be conducted during favorable weather conditions (calm nights with temperatures conducive to bat activity and no precipitation predicted). Additional passive monitoring using full spectrum bat detectors may be needed if identification of bat species is required. Survey methods would be discussed with CDFW prior to the start of surveys.

Avoidance and minimization measures may be necessary if sensitive bats species are detected during surveys and/or acoustic monitoring and will be determined in coordination with CDFW and the USFWS.

Effect WILD-9: Potential Injury, Mortality or Disturbance of Ringtail and Removal of Habitat

Levee construction is anticipated to occur during the ringtail breeding and maternity period (February through August). The proposed project would result in the loss of trees, some of which may provide suitable shelter and denning habitat (hollow trees, logs, snags) for ringtails. The project may also disturb burrows that provide suitable denning habitat. Newborn/young ringtails are especially vulnerable during May through August, when they are unable to leave the maternal den. Removal of suitable shelter or denning habitat, noise, or other construction activities could result in the injury, mortality, or disturbance of ringtails. Mortality of ringtail, a fully protected species, could affect the local population along the Feather River and would be considered a significant effect. Because ringtail is a fully state-protected species, take of this species is prohibited. Implementation of the following mitigation measure would avoid effects on ringtail.

Mitigation Measure WILD-MM-14: Identify Suitable Shelter and Denning Habitat for Ringtail and Implement Avoidance and Protective Measures

Prior to the start of construction wildlife biologists will survey the area to be impacted for suitable burrows and examine trees to be removed for suitable hollow areas that may provide shelter or denning habitat for ringtail. All hollow trees, snags, downed logs, and appropriately sized burrows that will be removed will be thoroughly examined. If necessary, a ringtail specialist will be contracted to confirm the suitability of habitat and determine if suitable habitat is occupied through the use of remote cameras or other non-invasive methods for determining occupancy. Riparian woodlands and areas adjacent to riparian woodlands should be considered suitable habitat and be searched for appropriate shelter/denning habitat. Survey methods should be discussed with CDFW and/or a ringtail specialist prior to the start of surveys.

Effect WILD-10: Disturbance to or Loss of Common Wildlife Species and Their Habitats

The project area contains both natural and human-influenced habitats that support numerous common wildlife species. These species include a wide variety of terrestrial and aquatic invertebrates, birds and raptors, amphibians, reptiles, and mammals, some of which are listed in Table 4-30. These nonspecial-status species also could be directly and indirectly affected by project construction.

The effects on wildlife include short-term and long-term effects. Short-term effects are generally the result of physical disturbance during construction (i.e., clearing of vegetation, noise, pollution, and soil compaction), while long-term effects are generally the result of habitat modification. The effects described below are considered significant for both SB-8 and SB-7 but with the implementation of

Mitigation Measures WILD-MM-8, WILD-MM-9 and WILD-MM-10 would be reduced to a less-than-significant level.

The clearing of vegetation would cause impacts to wildlife, but these impacts are expected to be offset in the long-term by the implementation of Mitigation Measure VEG-MM-1, Compensate for the Loss of Woody Riparian Trees. Under SB-8, habitat losses would occur linearly along 41 miles of levee where vegetation extends into the vegetation-free zone or is otherwise impacted by construction. Under SB-7, about 27 miles of levee improvements are proposed. The location of the river relative to the levee varies significantly, averaging approximately 1,400 feet and ranging from approximately 50 to 5,600 feet from the Feather River during typical summer base flows. Under SB-8 and the FRWLP Alternatives, the USFWS has calculated that about 11 discontinuous miles of levee improvements would be constructed within 300 feet of the river's edge (USFWS Final FWCA Report, Appendix D). Under SB-7, about 7 discontinuous miles of levee are within 300 feet. According to the USFWS, removing vegetation from areas where stands' width is already narrow causes a greater loss of habitat and, therefore, a larger effect on wildlife species. According to the USFWS, narrowing of riparian habitat could isolate some species that require larger stands of habitat.

Construction-related activities would directly and/or indirectly affect most animals that reside within the areas of impact. Heavy machinery may adversely affect smaller, low-mobility species, particularly amphibians, reptiles, and small mammals. Construction activities may adversely affect the young (i.e., nestlings and fledglings) of some birds and potentially destroy some nests. To the maximum extent feasible and in compliance with the MBTA, vegetation (trees, shrubs, ruderal areas) removal/trimming will be scheduled during the nonbreeding season of birds (September 1–January 31) as described in Mitigation Measure WILD-MM-8. If vegetation removal cannot be removed in accordance with this timeframe, preconstruction surveys for nesting birds and additional protective measures will be implemented (see Mitigation Measure WILD-MM-9, and WILD-MM-10).

Mobile species, such as birds and larger mammals, may avoid initial clearing and construction activities and move into adjacent areas outside the affected areas. Heavy machinery may also cause soil compaction, which may adversely affect fossorial animals (i.e., those that live underground). Construction activities may temporarily deprive some animals of cover, and, therefore, potentially subject them to increased natural predation. The increased noise and activity levels during construction could potentially disturb the daily activities (e.g., breeding, foraging, etc.) of species inhabiting the areas adjacent to the affected areas. Dust and gaseous emissions should minimally affect wildlife. Although construction activities may disrupt the normal behavior of many wildlife species, little permanent damage to these populations should result. Such impacts would be temporary and without long-term implications.

Following construction, periodic levee maintenance activities may disturb wildlife species due to noise and physical disturbance. However, because the existing levee would remain in place, with only minor exterior differences (e.g., presence of seepage berms, canal/levee realignment), the effects on wildlife from O&M activities would not be appreciably different from existing or future without project conditions.

Effect WILD-11: Potential Disruption of Wildlife Movement Corridors

Terrestrial wildlife species may use the Feather River or the levee as a movement corridor. Additionally, smaller, more localized movement corridors may be present in the 41-mile project

area of Alternative SB-8 or the 23-mile length of Alternative SB-7. During construction of levee improvements, movement through the project site would be temporarily impeded by the placement of physical barriers (fencing) used to protect resources within or near the construction footprint. Additionally, animals may avoid movement through the project area or along the Feather River because of the extensive amount of noise and human activity associated with construction. Upon completion of levee improvements, the affected area would have a different footprint but generally would be available as a movement corridor. Mitigation Measure VEG-MM-1 would compensate for the "narrowing" of riparian stands and habitat fragmentation by improving connectivity along the riparian corridor. No permanent barriers would be installed as part of the proposed project. This effect is considered less than significant, and no mitigation is required.

Summary of Potential Mitigation Measures

A summary of the timing of potential mitigation measures is provided in Table 4-37.

Table 4-37. Timing of Potential Mitigation Measures

Species	Requirement	Timing
Valley elderberry longhorn beetle	1) Transplant elderberry shrubs	November 1–February 15
	2) Install orange barrier fencing around shrubs to be protected.	Prior to the start of any construction activities
	3) Compensate for impacts by purchasing mitigation credits or planting elderberries and associated natives onsite.	Mitigation credits must be purchased prior to groundbreaking. Timing of onsite mitigation would be determined in coordination with USFWS.
Western pond turtle	Preconstruction survey	One week before and within 24 hours of beginning work during the cooler part of the day (8 a.m. and 12 p.m. during spring and summer)
Giant garter snake	1) Construction activity in giant garter snake aquatic and upland habitat within 200 feet of aquatic habitat	Between May 1 and October 1
	2) Install exclusion fencing and orange barrier fencing along the edge of the construction area that is within 200 feet of suitable habitat	Install on or after May 1
	3) Preconstruction survey	Within 24 hours of the start of construction in or within 200 feet of suitable habitat
Nesting birds	1) Vegetation removal/trimming	September 1–January 31
	2) Preconstruction Surveys (3)	February 1–June 1
Swainson's hawk	Preconstruction surveys	February through July
Burrowing owl	Breeding and wintering surveys (8)	Four surveys between February 15 and April 15 and four surveys spread evenly between September 1 and January 31
	Preconstruction surveys (2)	Preconstruction surveys no less than 14 days before and 24 hours before ground disturbance
Bats	1) Tree removal	September 15–October 30
	2) Disturbance of maternity colony	No disturbance until September 15
	3) Monitor tree removal	October 30–August 31

4.9 Fish and Aquatic Resources

4.9.1 Introduction

The following section describes the regulatory and environmental setting for fish and aquatic resources. The effects resulting from No Action Alternative, SB-7, and SB-8 are discussed along with mitigation measures required to reduce significant effects.

4.9.2 Affected Environment

The regulatory setting and environmental setting remain unchanged from those described in the FRWLP Final EIS and that information is hereby incorporated by reference in this integrated report. The FRWLP Final EIS addressed the Federal and state laws, and local policies and regulations relevant to fish and aquatic resources.

4.9.3 Determination of Effects

The purpose of this assessment is to determine whether the proposed project's effects on fish and aquatic resources are significant. Federal legislation requires that all Federal agencies consult with NMFS regarding all actions or proposed actions permitted, funded, or undertaken that may adversely affect "essential fish habitat." Essential fish habitat is defined as "waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The legislation states that migratory routes to and from anadromous fish spawning grounds are considered essential fish habitat. The phrase "adversely affect" refers to the creation of any impact that reduces the quality or quantity of essential fish habitat. Federal activities that occur outside of an essential fish habitat but that may, nonetheless, have an impact on essential fish habitat waters and substrate must also be considered in the consultation process. Federal agencies undertaking water projects are required to fully consider recommendations made by USFWS, NMFS, and State fish and wildlife resource agencies in project reports and to include measures to reduce impacts on fish and wildlife in project plans. Criteria defining significant effects under CEQA are provided in Mandatory Findings of Significance in Section 15065(a)(1) of the State CEQA Guidelines. The project may have a significant effect on the environment if it has the potential to substantially degrade the quality of the environment; substantially reduce the habitat of a fish or wildlife species; cause a fish or wildlife population to drop below self-sustaining levels; threaten to eliminate a plant or animal community; substantially reduce the number or restrict the range of an endangered, rare, or threatened species.

Consistent with this guidance, effects on fish and aquatic habitat are broadly defined as significant for this analysis if the project would contribute to any of the following effects in the study area.

- Degradation in the quantity or suitability of aquatic habitat of sufficient magnitude and/or duration to reduce the population levels of species of primary management concern.
- Loss of existing riparian habitat, especially that occurring below OHWM.
- Increase in predation of substantial magnitude and/or frequency to reduce the population levels of fish species in the Feather River.
- Interference with the movement of any resident or migratory fish species.
- Substantial long- or short-term loss of habitat quality or quantity.
- Substantial adverse effects on rare or endangered species, candidate species, other special-status species, or habitat of the species.

To further characterize effects on specific habitat parameters, qualitative thresholds (Table 4-38) were used to assess how individual construction effect mechanisms may contribute to the overall project effect.

Table 4-38. Construction-Related Impact Indicators

Impact Mechanism	Indicator Value
Shaded riverine aquatic habitat quantity and quality	Loss of existing shaded riverine aquatic habitat value, acreage, and riverside length resulting in habitat modification or degradation in the form of a reduction in physical habitat availability or habitat constituent element suitability for a species to substantially affect this species, relative to the basis of comparison.
Erosion, sedimentation, and turbidity	Increase in erosion, sedimentation, and turbidity resulting in habitat modification or degradation in the form of a reduction in physical habitat availability or habitat constituent element suitability for a species to substantially affect this species, relative to the basis of comparison.
Potential hazardous materials and chemical spills	Potential hazardous materials and chemical spills resulting in habitat modification or degradation in the form of a reduction in physical habitat availability or habitat constituent element suitability for a species to substantially affect this species, relative to the basis of comparison.
Hydrostatic pressure waves, noise, and vibration	Hydrostatic pressure waves, noise, and vibration resulting in habitat modification or degradation in the form of a reduction in physical habitat availability or habitat constituent element suitability for a species to substantially affect this species, relative to the basis of comparison.
Predation risk	Increase in predation of a species to substantially affect this species, relative to the basis of comparison.

4.9.3.1 Assessment Methods

In order to determine the proposed project's effects on fish species, fish biologists reviewed existing resource information related to the study area to evaluate whether sensitive habitats and special-status fish species are known from or could occur in the study area.

Construction activities near or in water can cause a range of short- and long-term effects on fish and aquatic resources. Short-term effects are those associated with construction-related activities that typically are limited to the immediate project area and duration of construction. The assessment methods for evaluating potential short-term, construction-related effects in the project area considered construction timing; physical habitat disturbance; potential for physical injury, hazardous spills, turbidity, sedimentation, and erosion resulting from short-term changes in habitat conditions; and the lifestage periodicity and habitat use by species of primary management concern. Long-term effects are those that result in adverse changes to habitat variables that reduce the suitability of fish habitat over a long time period.

Overall, potential effects on fish and aquatic resources were qualitatively assessed by identifying key effect mechanisms associated with construction activities, including the proximity to the Feather River, and evaluating the risk of those effects to harm fish or aquatic resources. Effects assessment methods rely on an understanding of potential effect mechanisms, general construction activities and timing, and a detailed understanding of species habitat use and life history characteristics. The potential effect mechanisms associated with construction activities that could occur under the project alternatives are described below.

4.9.3.1.1 Erosion, Sedimentation, and Turbidity

Ground-disturbing activities, such as grading, excavation, and vegetation removal, can result in large areas of exposed soils that are susceptible to erosion. Increased erosion could increase

sedimentation and siltation, resulting in increased turbidity in the Feather River, adjacent to the project area.

Construction-related increases in sedimentation and siltation above background condition potentially could affect listed anadromous fish and their habitat by reducing egg and alevin (juveniles still relying on the yolk sac for energy) survival, interfering with feeding activities, causing breakdown of social organization, and reducing primary and secondary productivity. The magnitude of potential effects on fish would depend on the timing and extent of sediment loading and flow in the stream before, during, and immediately following construction. Therefore, the effects assessment considers each of the flow and sediment factors to qualitatively evaluate whether the project alternatives would change conditions in the Feather River as a result of increased erosion, sedimentation, and turbidity.

4.9.3.1.2 Hazardous Materials and Chemical Spills

Use and storage of hazardous materials and chemicals (e.g., diesel fuel, lubricants, uncured concrete) near waterways potentially could impair water quality if chemicals or other construction materials are spilled or enter waterways. In general, construction-related chemical spills could affect fish by increasing physiological stress, reducing biodiversity, altering primary and secondary production, and possibly causing direct mortality (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998). Therefore, the effects assessment qualitatively evaluates the potential for hazardous materials and chemical spills to alter aquatic habitat conditions in the Feather River.

4.9.3.1.3 Habitat Modification

Long-term effects of levee repair and bank protection projects on aquatic habitat include loss or degradation of Shaded Riverine Aquatic (SRA) cover, including physical alteration of bank slope, substrate, and instream and overhead cover. Therefore, the potential for significant effects on fisheries resources was based on an assessment of the degree to which the project would affect these key habitat attributes in nearshore and seasonal inundation areas of the Feather River. Analyzing seasonal inundation areas involves understanding the relationships between the characteristics that define the floodplain, such as topography, vegetative cover, water surface elevation, depth, duration, and frequency of hydrologic events. Analysis of effects on woody vegetation relative to OHWM is the primary method for determining effects on critical habitat.

4.9.3.1.4 Hydrostatic Pressure Waves, Noise, and Vibration

No proposed in-water construction activities would occur under any of the action alternatives evaluated in this EIR/SEIS. Therefore, the potential for hydrostatic pressure waves, noise, and vibration to affect fish is relatively small. However, installation of sheet piles along proposed levee segments would involve equipment and activities that could produce subsurface pressure waves that could reach the Feather River and potentially affect fish and aquatic resources. These waves could result in underwater noise and vibration, thereby temporarily altering in-river conditions.

Of particular concern is the noise associated with pile driving that can cause sharp and dramatic hydrostatic pressure waves and vibration that can adversely affect all life stages of fish over relatively long distances (Washington et al. 1992). Hydrostatic pressure waves potentially could rupture the swim bladders and other internal organs of all life stages of fish in the immediate construction area (Bonneville Power Administration 2002; Jones & Stokes Associates 2001;

Washington et al. 1992). Additionally, noise and vibration generated by pile driving activities potentially could have sublethal effects on individual fish by inciting movement into lower quality habitats (Bonneville Power Administration 2002).

There is evidence that lethal effects can occur from pile driving, but accurately analyzing and addressing these effects, as well as sublethal effects (e.g., injury, temporary hearing threshold shifts, stress, behavioral disturbance), is complicated by several factors. Sound levels and particle motion produced from pile driving can vary depending on pile type, pile size, substrate composition, and type of equipment used. Also, the effects of underwater noise vary among species as a function of species morphology and species physiology. Further, Oriard (1985) and Jones & Stokes Associates (2001) noted that the effects of energy resulting from blasting in rock adjacent to waterways differs depending on the composition and slope of the bank and specifically is reduced relative to in-water blasting. Presumably, pile driving activities on land result in similar reductions in energy transfer to waterways, and thus would result in lesser effects than in-river pile driving activities. Therefore, the effects assessment qualitatively evaluates whether the project alternatives would be anticipated to change conditions in the Feather River as a result of hydrostatic pressure waves and increased noise and vibration caused by construction along the levee footprint.

4.9.3.1.5 Predation Risk

Proposed construction activities may increase river turbidity, reduce habitat suitability, and cause disorientation, which in turn could affect normal fish behavior. Deviation from normal behavior, associated with increased turbidity, reportedly increases the risk of predation (DeVore et al. 1980; Birtwell et al. 1984). However, it also has been reported that increased turbidity potentially could decrease predation on fish. In a study conducted in the Fraser River, it was found that juvenile Pacific salmon were less likely to encounter and be consumed by fish predators in turbid waters relative to clear waters (Gregory and Levings 1998). The effects assessment qualitatively evaluates whether the project alternatives would alter habitat conditions in the Feather River that potentially could increase the risk of predation.

Table 4-38 displays construction-related impact indicators.

4.9.4 Effects and Mitigation Measures

This section describes the environmental consequences relating to fish under the No Action Alternative and Alternatives SB-8 and SB-7. It describes the methods used to determine the effects of the action and lists the thresholds used to conclude whether an effect would be significant. The effects that would result from implementation of the action, findings with or without mitigation, and applicable mitigation measures are presented in a table under each alternative.

Effects and mitigation measure requirements concerning fish and aquatic resources are summarized in Table 4-39.

Table 4-39. Summary of Effects on Fish and Aquatic Resources

Effect	Finding	Mitigation Measure	Finding with Mitigation
Alternatives SB-7 and SB-8			
Effect FISH-1: Loss or Degradation of Riparian and SRA Cover (including Critical Habitat)	Less than significant	None required	Less than significant
Effect FISH-2: Construction-Related Erosion Resulting in Substantially Increased Sedimentation and Turbidity	Less than significant	None required	Less than significant
Effect FISH-3: Adverse Effects on Fish Health and Survival Associated with Potential Discharge of Contaminants during Construction Activities	Less than significant	None required	Less than significant
Effect FISH-4: Adverse Effects Caused by Construction Equipment Noise and Vibration	Less than Significant	None required	Less than Significant

4.9.4.1 No Action Alternative

The No Action Alternative represents the continuation of the existing deficiencies along the portion of the Feather River in the study area. Current levee operations and maintenance activities would continue, and there would be no change in the geomorphic and flood risk–management regimes relative to existing conditions.

Under the No Action Alternative, no construction-related release of contaminants would occur. Further, there would be no noise and disturbance effects or construction-related loss of habitat for special-status fish species. Because no levee improvements would be made under the No Action Alternative, the risk that the Feather River West Levee could fail because of under-seepage, slope stability, or geometry issues would continue. Failure of the Feather River West Levee, depending on the magnitude of the event, could cause catastrophic flooding.

A catastrophic levee failure could result in the displacement of fish into flooded areas and the potential for stranding and mortality. In addition, adverse water quality effects could result from the release of hazardous materials during a flood event, which could lead to stress and direct mortality of fish and could adversely affect migration, spawning, and rearing habitat of fish species in the Feather River and adjacent water bodies. Emergency clean-up and earth-moving activities also could result in an increase in sediment and turbidity and the release of hazardous materials into the Feather River and adjacent waterways that could adversely affect migration, spawning, or rearing habitat or result in direct mortality of special-status fish species. Depending on the magnitude of the flood, emergency clean-up activities could last for days, weeks, or even months. If a flood occurred in late winter, clean-up activities could last into the spring, a critical time for migration, movement, and rearing of spring-run Chinook salmon, steelhead, and green sturgeon. Given the unpredictable nature of emergency clean-up activities, is it likely that implementation of BMPs and measures to reduce effects on fish would not be possible. Restoration of this critical habitat could take decades. All of these effects would be considered significant; however, given the uncertainty of the occurrence or magnitude of such an event, potential effects on fish cannot be quantified based on available information.

O&M activities such as removal of vegetation and levee repair on the land side and waterside of the levees could occur at varying levels depending on which No Action scenario is implemented (See

Section 4.7.4.1). Effects from these activities are anticipated to be less than significant since all work is above the OHWM. Estimates of the total acres of riparian vegetation losses are presented in Section 4.7, *Vegetation and Wetlands.*

Effect FISH-1: Loss or Degradation of Riparian and SRA Cover (including Critical Habitat)

Loss of riparian and SRA cover resulting from removal of riparian vegetation and IWM along the shoreline of a river can adversely affect aquatic organisms and their habitat. Riparian vegetation serves important functions in stream ecosystems by providing shade, sediment storage, nutrient inputs, channel and streambank stability, habitat diversity, and cover and shelter for fish (Murphy and Meehan 1991). Shoreline areas are particularly important to juvenile salmonids and other native fishes that depend on such habitat for shelter from fast currents, protection from predators, and favorable feeding and growth conditions relative to open-water habitat. Riparian vegetation also acts to moderate stream temperatures. The effect of riparian vegetation on stream temperatures is greatest on small streams and decreases with increasing stream size. Because of the large size of the Feather River relative to its existing shoreline canopy, the effect of riparian vegetation in moderating water temperatures is minor compared with the effects of reservoir operations, discharge, and meteorological conditions (National Marine Fisheries Service 2006).

Moderate- to high-quality SRA cover is present in some areas where dense riparian vegetation and IWM occurs below the OHWM. Full application of the Vegetation ETL would not affect SRA cover or critical habitat below the OHWM. The removal of trees would be considered a loss of riparian habitat and the effect would be considered significant and unavoidable at least in the short term, but would be mitigated to a less-than-significant level over the long term with compensatory mitigation as described in Section 4.7.4.2, *Vegetation and Wetlands.* Under a variance or modified application of the Vegetation ETL, the effect would be considered less than significant because there would not be a substantial temporal loss and because the existing riparian and SRA cover below the OHWM within the project area would remain intact.

4.9.4.2 Alternative SB-8

Effect FISH-1: Loss or Degradation of Riparian and SRA Cover (including Critical Habitat)

SB-8 construction activities are assumed to result in removal of all riparian vegetation within the construction footprint. No construction activities are proposed in-river or below the OHWM; all activities that would result in physical disturbance and removal of vegetation on the waterside slope of the levee would be limited to areas above the OHWM. Therefore, no physical modification of critical habitat for ESA-listed fish species would be expected. Most of the affected areas are set well back from the river, averaging approximately 1,400 feet and ranging from approximately 50 to 5,600 feet from the Feather River during typical summer base flows. The NMFS has concurred in a letter dated September 26, 2013 with USACE's determination that SB-8 "is not likely to adversely affect" listed fish species (Appendix D). Although not directly modifying critical habitat, the removal of vegetation from these areas may indirectly affect critical habitat through temporal reductions in large wood recruitment, nutrient contributions, and other riparian functions. NMFS determined that the proposed action would adversely affect essential fish habitat (EFH) designated under the Magnusson-Stevens Conservation and Management Act. NMFS in their September 26, 2013 concurrence letter (Appendix D) provided conservation recommendations pursuant to the Act. USACE adopted the conservation recommendations of the NMFS to avoid or minimize adverse effects to EFH.

To compensate for permanent and temporary loss of woody riparian vegetation, compensatory mitigation is proposed (VEG-MM-1) to ensure no net loss of habitat functions and values as described in the mitigation and monitoring plan (MMP) (Appendix D). For the purposes of NEPA and CEQA, the effect on fisheries resources would be less than significant.

Effect FISH-2: Construction-Related Erosion Resulting in Sedimentation and Turbidity

Temporary disturbance of fish and degradation of habitat may occur during construction activities for SB-8. Construction activities occurring along the levee footprint could cause increased sedimentation and turbidity during spawning periods that would result in significant and adverse effects on special-status species. However, with the project environmental commitment to implement a SWPPP, described in Section 4.3.4.2, and standard erosion and sediment control BMPs, these effects are expected to be less than significant.

Effect FISH-3: Adverse Effects on Fish Health and Survival Associated with Potential Discharge of Contaminants during Construction Activities

Accidental spills or leakage of contaminants such as bentonite, gasoline, lubricants, and other petroleum-based products could kill or injure fish in the project area. Adverse effects related to contaminant spills and leaks are potentially significant but would be adequately mitigated by implementing a spill prevention, control, and countermeasure plan and a SWPPP, as described in Section 4.3.4.2, as part of the environmental commitments for the project. Therefore, potential effects associated with contaminant spills are expected to be less than significant.

Effect FISH-4: Adverse Effects Caused by Construction Equipment Noise and Vibration

Construction activities near the Feather River may result in noise and vibrations that could potentially adversely affect fish is described in the FRWLP Final EIS. Temporary disturbance to fish may occur during construction activities including driving of sheet piles through the crown of the levee. Sheet piles would be used only as a site-specific treatment (rather than applied on a reach-wide basis) such as at roadway or railroad crossings, and would be restricted to the levee crown above the OHWM where sound waves would be expected to attenuate quickly before reaching the Feather River. Consequently, pile driving activities would have negligible noise and vibration effects on fish in the Feather River. Therefore, the level of underwater noise from the upland sheet pile driving under SB-8 is anticipated to result in a less-than-significant effect on fish.

4.9.4.3 Alternative SB-7

Effect FISH-1: Loss or Degradation of Riparian and SRA Cover (including Critical Habitat)

SB-7 construction activities are assumed to result in removal of all riparian vegetation within the construction footprint. An estimate of the total acreage of riparian vegetation to be removed is presented in Section 4.7, *Vegetation and Wetlands*, Table 4-26. No construction activities are proposed in-river or below the OHWM; all activities that would result in physical disturbance and removal of vegetation on the waterside slope of the levee would be limited to areas above OHWM. Therefore, no physical modification of critical habitat for ESA-listed fish species would be expected. Most of the affected areas are set well back from the river, averaging approximately 1,400 feet and ranging from approximately 50 to 5,600 feet from the Feather River during typical summer base flows. Although not directly modifying critical habitat, the removal of vegetation from these areas

may indirectly affect critical habitat through temporal reductions in large wood recruitment, nutrient contributions, and other riparian functions.

To compensate for permanent and temporary loss of woody riparian vegetation, compensatory mitigation is proposed (VEG-MM-1) to ensure no net loss of habitat functions and values as described in the MMP (Appendix D). For the purposes of NEPA and CEQA, the effect on fisheries resources would be less than significant with implementation of mitigation.

Effect FISH-2: Construction-Related Erosion Resulting in Sedimentation and Turbidity

Temporary disturbance of fish and degradation of habitat may occur during construction activities. Construction activities occurring along the levee footprint could cause increased sedimentation and turbidity during spawning periods, resulting in significant adverse effects on special-status species (salmonids and green sturgeon). However, with implementation of the environmental commitment to implement a SWPPP, and standard erosion and sediment control BMPs as part of the project, these effects are expected to be less than significant.

Effect FISH-3: Adverse Effects on Fish Health and Survival Associated with Potential Discharge of Contaminants during Construction Activities

Accidental spills or leakage of contaminants such as bentonite, gasoline, lubricants, and other petroleum-based products could kill or injure fish in the project area. Effects on fish may potentially exist during construction activities on the waterside slope of the levee. Adverse effects related to contaminant spills and leaks would be potentially significant but would be adequately mitigated by implementing a spill prevention, control, and countermeasure plan and a SWPPP. Therefore, potential effects associated with contaminant spills are expected to be less than significant.

Effect FISH-4: Adverse Effects Caused by Construction Equipment Noise and Vibration

Temporary disturbance of fish resulting from construction generated noise and vibration may occur as described for SB-8, but effects would be limited to a shorter length of levee (about 27 miles instead of about 41 miles). Because construction would occur only on land adjacent to the Feather River and not in the watercourse itself, potential effects associated with noise and vibration would be less than significant.

4.10 Visual Resources

4.10.1 Introduction

This section evaluates potential impacts of the alternatives on visual resources. Section 3.13, *Visual Resources*, of the FRWLP Final EIS addressed the visual resources of the project area; described the visual character and quality; evaluated the significance and quality of views of the area; and analyzed the potential impacts the FRWLP would have on visual resources, and that information is incorporated by reference.

4.10.2 Affected Environment

4.10.2.1 Regulatory Setting

The *Regulatory Setting* section in the FRWLP Final EIS has remained unchanged and that information is incorporated by reference. The FRWLP Final EIS did not identify any Federal or state policies related to visual resources that apply to the implementation Feather River West Levee improvements.

4.10.2.2 Environmental Setting

The following is brief summary of the visual character of the region and project area based on information contained in the FRWLP Final EIS.

4.10.2.2.1 Visual Character of the Region

The study area is located in the region of California's Sacramento Valley (valley). Yuba City is the largest city in the project area and is connected by State Route 99 to the smaller cities of Gridley and Live Oak. The city of Biggs in Butte County is located a short distance off State Route 99.

Agricultural land, planted predominantly with row crops and orchards, stretches for miles in the region. A patchwork of fields surrounds the suburban outskirts of cities and communities, separating developed areas. When haze is at a minimum, these fields offer expansive views that extend over agricultural fields and recent development in the foreground to the middleground and background. The Sutter Buttes can be seen vividly rising up from the flat valley floor in the background, based on the viewer's location in the landscape. Views of the Coast Range to the west are common. Background views to the Sierra Nevada foothills to the east are rarer because of atmospheric haze.

While much of the valley is still in agricultural production, agricultural land has been and continues to be converted to suburban land uses. This trend is evident around the outskirts of Yuba City, Gridley, and Live Oak. Smaller, agrarian communities have not experienced a great deal of new development or growth over the past decade. Development in the region is typified by a growing core of residential, commercial, and some industrial land uses, with agricultural fields surrounding the city outskirts.

4.10.2.2.2 Visual Character and Quality of the Project Vicinity

The project area can be divided into two categories based on, and defined by, similar existing visual characteristics, visual qualities, and associated viewer groups: rural reaches and urban reaches.

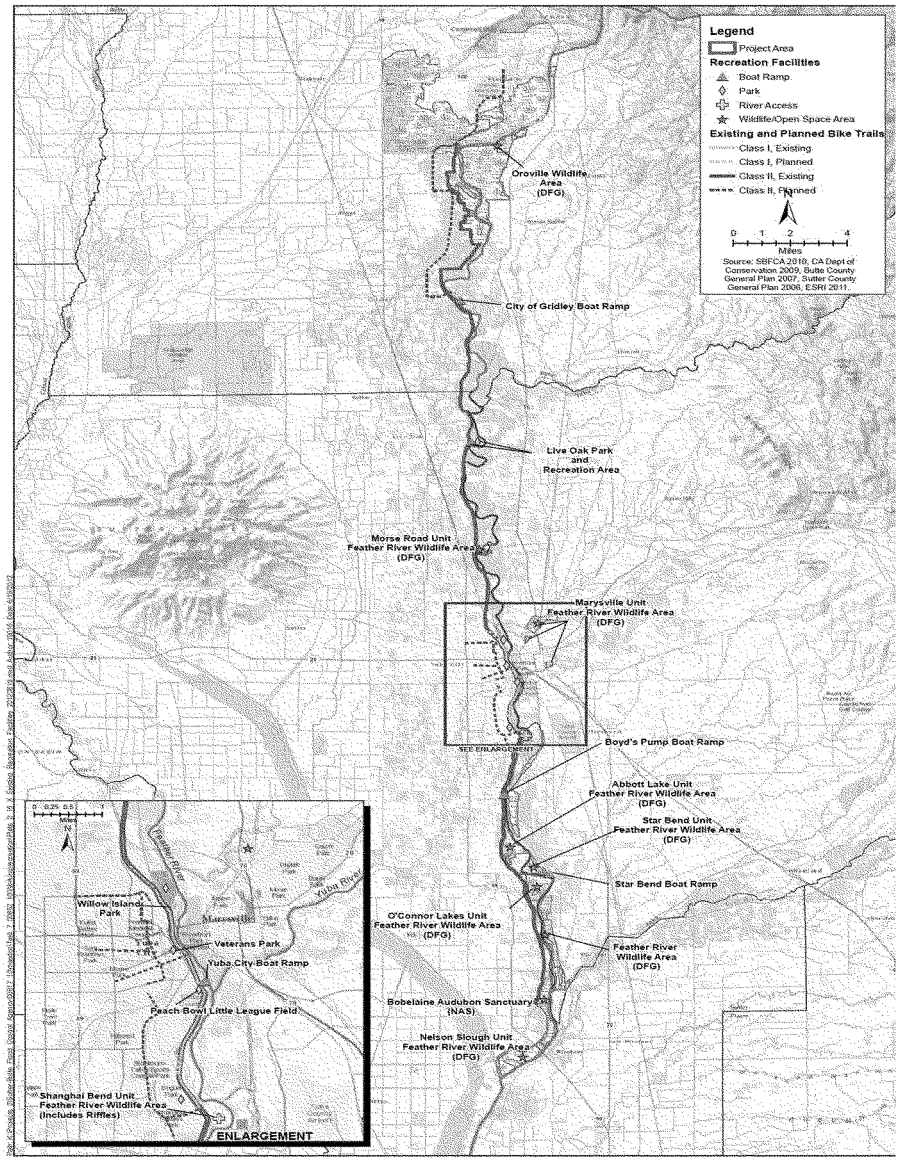
Rural Reaches

Rural reaches include portions of the project area where the adjacent land use is primarily large blocks of land used for agriculture. These agricultural fields are routinely leveled, disked, and planted in row crops or orchards. Consistency in the visual character is found by the common element of agriculture in the foreground and middleground.

Rural reaches comprise Reaches 2 through 11 (up to station 820+00) and Reaches 18 (beginning at station 1150+00) to 41. While the character of these rural reaches is primarily agricultural, they do contain public recreation opportunities, as shown in Plate 4-8, including the Feather River Wildlife

Areas (Nelson Slough Unit, O'Connor Lakes Unit, Abbot Lake Unit, and Morse Road Unit), Bobelaine Audubon Sanctuary, Boyd's Boat Ramp, Live Oak Park and Recreation Area, City of Gridley Boat Ramp, and the Oroville Wildlife Area. These public areas provide visual and recreational opportunities to appreciate the river and its surrounding environment. Aside from those public areas, the rural reaches are defined by agricultural uses that stretch for miles.

Plate 4-8. Existing Recreation Facilities near the Project Area



The rural reaches of the project area have been evaluated for scenic character and quality. As described in the FRWLP Final EIS, visual quality ratings were assigned for vividness, intactness, and unity on a scale of 0 to 7, with 7 being the highest quality. The overall visual quality of the rural reaches was determined to be moderate (3.5–4.3). Vividness (V=3.5–4), intactness (I=3.5–4.5), and unity (U=3.5–4.5) were determined to be moderate to moderately high because the vast amount of agricultural fields and orchards coupled with the mature vegetation along the river corridor provide a more unique and pleasing visual experience.

Urban Reaches

Urban reaches are those areas in the project area where the adjacent land uses have a higher density of residential, commercial, and industrial uses. The only urban reaches in the project area are in Yuba City, which includes Reach 11 (starting at station 820+00) through Reach 18 (ending at station 1150+00).

Adjacent development in the project area for these reaches is composed of residential subdivisions; commercial and industrial uses; park, recreation, and open space land uses; and the Sutter County Airport. Along these reaches are significant roadways, such as State Route 20 (Colusa Avenue), the Twin Cities Memorial Bridge, Shanghai Bend Road, 2nd Street, and Live Oak Boulevard.

The overall visual quality of the urban reaches is moderately low to moderate (3.2–3.8). Vividness (V=2.5–3.5), intactness (I=3.5–4), and unity (U=3.5–4) are moderately low to moderate (FRWLP Final EIS, page 3.13-6). This is because the contrasting built elements of Yuba City that combine with the Feather River corridor lack a coherent and harmonious visual pattern. The urbanization associated with Yuba City does not provide visual order; rather, it encroaches into the Feather River corridor.

4.10.2.2.3 Viewer Groups and Viewer Responses

The primary viewer groups in the project area are people living or conducting business near levees; travelers using highways and smaller local roads; and recreational users (including boaters and beachgoers along the Feather River; anglers using canals, creeks, and rivers; trail users; equestrians; bicyclists; and joggers). Residents are considered to have high sensitivity to changes in the viewshed because of their potential exposure to such views, proximity to the project area, and sense of ownership. Viewer sensitivity is considered high among recreational users in the project area because they are more likely to value the natural environment, appreciate the visual experience, have an enhanced sense of ownership, and be more sensitive to changes in views. Recreational uses consist of boating and fishing; hunting in the bypasses; birding; and walking, running, jogging, and bicycling along trails, levee crowns, and local roads.

4.10.3 Determination of Effects

Effects on visual resources may be considered significant if an alternative would result in any of the following conditions.

- Cause a substantial, demonstrable negative aesthetic effect on a scenic vista or view open to the public.
- Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway.

- Substantially degrade the existing visual character or quality of the site and its surroundings.
- Create a new source of substantial light or glare that would adversely affect day or nighttime public views.

According to professional standards, a project may be considered to have an adverse (i.e., significant) effect if it would substantially:

- Conflict with local guidelines or goals related to visual quality.
- Alter the existing natural viewsheds, including changes in natural terrain.
- Alter the existing visual quality of the region or eliminate visual resources.
- Increase light and glare in the project vicinity.
- Result in backscatter light into the nighttime sky.
- Result in a reduction of sunlight or introduction of shadows in community areas.
- Obstruct or permanently reduce visually important features.
- Result in long-term (persisting for 2 years or more) adverse visual changes or contrasts to the existing landscape as viewed from areas with high visual sensitivity.

There are no roadways in or near the project area that are designated in Federal or state plans as scenic highways; therefore, there would be no effects on a state scenic highway.

4.10.4 Effects and Mitigation Measures

This section describes the environmental consequences relating to visual resources. Effects and mitigation measure requirements concerning visual resources are summarized in Table 4-40.

Table 4-40. Summary of Effects for Visual Resources

Effect	Finding	Mitigation Measures	Finding with Mitigation
Alternatives SB-7 and SB-8			
Effect VIS-1: Result in Temporary Visual Effects from Construction	Significant	None available	Significant and unavoidable
Effect VIS-2: Adversely Affect a Scenic Vista	Significant	None available	Significant and unavoidable
Effect VIS-3: Substantially Degrade the Existing Visual Character or Quality of the Site and Its Surroundings	Significant	None available	Significant and unavoidable
Effect VIS-4: Create a New Source of Substantial Light or Glare That Would Adversely Affect Day and Nighttime Public Views	Less than significant	None required	Less than significant

4.10.4.1 Effects Not Addressed Further in this Document

Effect VIS-4: Create a New Source of Substantial Light or Glare That Would Adversely Affect Day and Nighttime Public Views

The FRWLP Final EIS addressed new sources of substantial light or glare that would adversely affect day or nighttime views in the project area. Alternatives SB-7 and SB-8 would not create permanent new sources of light and glare, or result in changes to these conclusions; therefore, this issue is not discussed further.

4.10.4.2 No Action Alternative

The No Action Alternative represents the continuation of the existing deficiencies along the portion of the Feather River in the study area. Current levee operations and maintenance activities would continue, but there would be no change in the geomorphic and flood risk–management regimes relative to existing conditions. No levee improvements would be made to decrease flood risk. No construction-related effects relating to visual resources such as vegetation removal, displacement of agricultural land or development, or construction of a new levee, cutoff wall, and landside seepage and stability berms would occur.

It assumed under the future without-project conditions, that the existing vegetation that is in noncompliance with the standard project operations and maintenance manual would be removed. SFBCA has provided the Corps of Letter of Intent to apply for a SWIF to bring the levee into compliance. The extent of vegetation removal under the SWIF would be confined to the levee prism, which would involve less vegetation removal than under full application of the Vegetation ETL. Full application of the Vegetation ETL would require prohibition and removal of woody vegetation within the levee prism and within 15 feet of the landside or waterside levee toes. The degree of visual change in character and diminishment in visual quality from loss of the trees could be potentially significant and unavoidable if the losses are not adequately mitigated.

Without implementation of the SBPFS alternatives, visual resources are expected to remain similar to existing conditions, aside from vegetation removal pursuant to the O&M manual. The visual character could change in the event of a levee failure. Catastrophic flooding has the potential to destroy vegetation, infrastructure, and development. Such an event would cause a change in the existing visual character and potentially could lay waste to miles of land. Scenic vistas would be significantly altered for an extended period of time, or irreparably damaged, because views across this landscape would be so changed. The necessary cleanup after such an event would introduce considerable heavy equipment and associated vehicles, including bulldozers, excavators, water trucks, and haul trucks, into the viewshed. It is assumed that these effects would be significant; however, given the uncertainty of the occurrence or magnitude of such an event, the effects cannot be quantified based on available information.

4.10.4.3 Alternative SB-8

The effects of SB-8 on visual resources would be similar to Alternative 3 described in the FRWLP Final EIS, except as discussed below.

Effect VIS-1: Result in Temporary Visual Effects from Construction.

Alternative SB-8 would have substantially greater impacts on vegetation than under the proposed FRWLP. All vegetation, except for erosion-controlling grasses, within the immediate construction footprint and within 15 feet of the waterside and landside levee toe would be removed during construction, in addition to the vegetation that would be removed for construction access and staging. The removal of mature landscape and native trees would substantially change the aesthetic qualities of the area. In reaches where only a narrow band of vegetation exists, complete removal of vegetation could result in a drastic visual change. Complete removal would contrast sharply from the existing visual landscape from one that is vegetated to one without vegetation. Visual effects would be significant because of the proximity to highly sensitive residential viewers, roadway users, and recreationists. Trees and other vegetation cannot be replanted to reduce the severity of this short- and long-term effect. The magnitude of this effect is considered significant and unavoidable.

Effect VIS-2: Adversely Affect a Scenic Vista

The river and numerous roadways throughout and near the project area offer scenic vistas of contrasting landscape features. Development associated with Yuba City and the expansive agricultural fields are softened by the riparian corridors that line the river. Vistas from the river would be affected by vegetation removal; however, removal of vegetation could create new vistas. Both Alternatives SB-8 and SB-7 would adversely affect vistas in the urban reaches to an equal extent; however, the total disturbance area would be considerably greater for Alternative SB-8. Vegetation to be cleared from the VFZ would have a substantial effect on the visual character and result in a substantial reduction in the overall visual quality, including scenic vistas. Therefore, these effects are considered significant and unavoidable with no mitigation available due to the nature of the effects.

Effect VIS-3: Substantially Degrade the Existing Visual Character or Quality of the Site and Its Surroundings

As discussed under Effect VIS-1 and VIS-2, the magnitude of the loss of vegetation to be cleared from the VFZ coupled with the loss of agricultural land, would have a substantial effect on the visual character and result in a substantial reduction in the overall visual quality. Both Alternatives SB-7 and SB-8 would adversely affect vistas in the urban reaches of Yuba City to an equal extent. Accordingly, these effects are considered significant and unavoidable with no mitigation available due to the nature of the effects.

4.10.4.4 Alternative SB-7

Effect VIS-1: Result in Temporary Visual Effects from Construction

This effect would be comparable in type to the effect under Alternative SB-8, but at a lesser magnitude because there would be no construction above Sunset Weir. However, alternative SB-7 would similarly adversely affect visual quality in the urban reaches of Yuba City. Accordingly, these effects are considered significant and unavoidable with no mitigation available due to the nature of the effects.

Effect VIS-2: Adversely Affect a Scenic Vista

This effect would be comparable in type to the effect under Alternative SB-8, but at a lesser magnitude. However, Alternative SB-7 would similarly adversely affect visual quality in the urban reaches of Yuba City. Accordingly, these effects are considered significant and unavoidable with no mitigation available due to the nature of the effects.

Effect VIS-3: Substantially Degrade the Existing Visual Character or Quality of the Site and Its Surroundings

The magnitude of the loss of vegetation to be cleared from the VFZ coupled with the loss of agricultural land would be less under SB-7 than under SB-8, but there would still be a substantial effect on the visual character and vistas in the urban reaches of Yuba City. Accordingly, these effects are considered significant and unavoidable with no mitigation available due to the nature of the effects.

4.11 Recreation

4.11.1 Introduction

This section evaluates potential impacts of the alternatives on recreation. Section 3.14, *Recreation*, of the FRWLP Final EIS described recreation facilities and opportunities in the study and project areas. The FRWLP Final EIS analyzed the potential impacts the FRWLP would have on recreation, and that information is incorporated by reference.

4.11.2 Affected Environment

4.11.2.1 Environmental Setting

The following is brief summary of the visual character of the project area excerpted from the FRWLP Final EIS.

The Feather River and its adjacent levees are a popular recreation venue for local residents and visitors. While recreation opportunities vary among locations along the river, recreationists are attracted to water-based recreation as well as land-based recreation on the levees and facilities surrounding the river. Water-based recreation activities include boating, fishing, kayaking, canoeing, floating, tubing, water skiing, and swimming. Land-based activities include bicycling, walking, hiking, hunting, bird-watching, wildlife viewing, enjoying nature trails, photography, and picnicking. Access to the right (west) bank of the Feather River is provided by state wildlife areas, local parks, and a wildlife sanctuary. Many parts of the shoreline, especially north of Yuba City, are inaccessible to recreationists.

4.11.2.2 Formal Recreation Facilities

Of the 41 project reaches that comprise the project area, flood management measures are proposed in 34 of the reaches. Recreation facilities and resources are located in, or adjacent to, 22 of the project reaches. The following formal recreation facilities and resources in, adjacent to, or within view of the project area are described below from north to south (Plate 4-8).

4.11.2.2.1 Oroville Wildlife Area

The Oroville Wildlife Area (OWA) is managed by the California Department of Fish and Wildlife. The OWA is 11,869 acres in size and is primarily riparian woodland along the Feather River and Thermalito Afterbay (California Department of Fish and Game 2012). There are approximately 10.5 miles of levee on the west side of the Feather River within the OWA. About 5.5 miles of this levee are within the project area, Reaches 33 through 41.

4.11.2.2.2 City of Gridley Boat Ramp

The City of Gridley Boat Ramp is managed by the City of Gridley. The City of Gridley Boat Ramp is located within view of the FRWLP Reach 30 on the east side of the Feather River outside of the project area. The boat ramp is next to the city's water treatment plant and provides opportunities for boating and day use (City of Gridley 2010:18).

4.11.2.2.3 Live Oak Park and Recreation Area

The Live Oak Park and Recreation Area is managed by Sutter County. The campground, RV park, and boat ramp at the facility allow for camping and boating in addition to swimming, picnicking, and day use (City of Live Oak 2010:2). The Live Oak Park and Recreation Area is located within Reach 23.

4.11.2.2.4 Feather River Wildlife Area

The Feather River Wildlife Area (FRWA) is composed of eight separate wildlife area management units. Five wildlife area units are located on the west side of the Feather River and are within the project area. These five areas from north to south are: Morse Road Unit, Shanghai Bend Unit, Abbott Lake Unit, O'Connor Lakes Unit, and Nelson Slough Unit. These five unites total 1,724 acres (California's Protected Areas Database 2012). Three units are located on the east side of the Feather River and are visible from and have views to the project area. These three areas from north to south are: Marysville Unit, Star Bend Unit, and Lake of the Woods Unit. Morse Road Unit is a 62-acre management unit located within project Reach 19. Marysville Unit is located across from project Reaches 16 and 17. Shanghai Bend Unit is a 98-acre management unit located within project Reaches 11 through 13. Abbott Lake Unit is a 409-acre management unit located within project Reaches 7 and 8. Star Bend Unit is located across from project Reaches 6 and 7. O'Connor Lake Unit is a 467-acre management unit located within project Reaches 5 and 6. Lake of the Woods Unit is located across from project Reaches 3 through 5. Nelson Bend Unit is a 688-acre management unit located within project Reach 2 (California's Protected Areas Database 2012).

4.11.2.2.5 Park and Recreation Facilities within Yuba City

There are six park and recreation facilities in Yuba City within the project area. From north to south these are: Feather River Parkway Bike Trail, Willow Island Park, Veterans Park, Yuba City Boat Ramp, Peach Bowl Little League Fields, and Yuba Sutter Dog Park (City of Yuba City 2004:6-4). The most notable are the Feather River Parkway Bike Trail and Willow Island Park.

Feather River Parkway Bike Trail is 5 miles long between Northgate Drive and Shanghai Bend Road located within Reaches 12 through 17. The trail is heavily used (McIntire pers. comm.). The trail will connect to Yuba City's Class I and Class II bike trail network at Northgate Drive, B Street, and Shanghai Bend Road in the future (Feather River Air Quality Management District 1995: 16).

Willow Island Park is 172 acres in size and is located within project Reaches 16 and 17. Construction is under way. The first phase of Willow Island Park includes pedestrian and bicycle trails, a picnic area, and a parking lot, with more amenities planned for future phases. Willow Island Park is expected to be a heavily used park once completed (McIntire pers. comm.).

4.11.2.2.6 Boyd's Pump Boat Ramp

The Boyd's Pump Boat Ramp, just south of Yuba City, is a public boat launching facility on the Feather River managed by Sutter County. The facility has a parking area and boat ramp that provides an opportunity for motorized and nonmotorized boat launching. This facility is located within Reach 9.

4.11.2.2.7 Bobelaine Audubon Sanctuary

The Bobelaine Audubon Sanctuary is a 430-acre wildlife sanctuary owned by the National Audubon Society and managed by volunteers of the Sacramento Audubon Society. Bobelaine is a rare remnant of the riparian forests that once projected 2 to 5 miles on either side of the rivers in the Great Central Valley of California. The sanctuary is registered as a "State Ecological Reserve" and is protected by the California Department of Fish and Wildlife and the National Audubon Society. It is also listed as part of an "Important Bird Area" by the National Audubon Society. Hiking, walking, and wildlife viewing are all allowed recreational uses within the preserve (Sacramento Audubon Society 2012). Bobelaine Audubon Sanctuary is located within Reaches 2 and 3.

4.11.2.3 Regulatory Setting

The *Regulatory Setting* portion of FRWLP Final EIS, Section 3.14, lists the following Federal and state policies related to recreation.

- Federal:
  - 2004 Engineering Manual 1110-1-400 (EM) prepared by USACE.
  - Recreation Facility Design Guidelines prepared by U.S. Department of the Interior.
- State:
  - *Feather River Wildlife Area Management Plan* (California Department of Fish and Game 1991).

4.11.3 Determination of Effects

Effects on recreation may be considered significant if implementation of an alternative would result in any of the following conditions.

- Increase the use of existing neighborhood and regional parks or other recreation facilities such that substantial physical deterioration of the facility would occur or be accelerated.
- Include recreation facilities or require the construction or expansion of recreation facilities that might have an adverse physical effect on the environment.
- Substantially restrict or reduce the availability or quality of existing recreation opportunities in the project vicinity.

- Implement operational or construction-related activities related to the placement of project facilities that would cause a substantial long-term disruption of any institutionally recognized recreation activities.
- Result in increased risk to recreationists in or adjacent to the project vicinity.

The proposed alternatives do not include the construction of recreation facilities.

4.11.4 Effects and Mitigation Measures

As described in the FRWLP Final EIS, there is a substantial variety of type and intensity of recreation occurring at sites along the Feather River within the project area. Effects and mitigation measure requirements concerning recreation are summarized in Table 4-41.

Table 4-41. Summary of Effects for Recreation

Effect	Finding	Mitigation Measures	With Mitigation
Alternatives SB-7 and SB-8			
Effect REC-1: Temporary Changes in Recreation Opportunities during Construction	Less than significant	None required	Less than significant
Effect REC-2: Long-Term or Permanent Loss of Recreation Opportunities in the Levee Corridor	Less than significant	None required	Less than significant

4.11.4.1 No Action Alternative

Under No Action, construction activities associated with the proposed program would not occur. While pre-scheduled levee maintenance activities and any required emergency repairs would continue to be conducted, the levees, riverbanks, and associated recreation uses would remain unchanged from their current (baseline) conditions. Levees would be subject to ongoing risk of levee failure. Failure of the levee and subsequent flooding would result in potentially significant effects on recreation resources and public safety.

4.11.4.2 Alternative SB-8

The effects of SB-8 on recreation resources would be similar to effects under the FRWLP preferred alternative. Recreation activities would be disrupted during construction along the levee crown and adjacent construction and staging areas likely would be closed to public access at most of the project sites during construction. In places where construction occurs close to recreation areas, the areas themselves may not be closed but the proximity to construction equipment and activity may degrade recreation experiences.

In addition to the adverse effects during construction, levee improvements proposed for Alternative SB-8 would follow USACE policies regarding vegetation on levees, which does not allow woody vegetation on the slopes of the levee or within 15 feet of the waterside and landside levee toes. This would require the removal of a substantial amount of mature trees and vegetation in addition to those losses that would otherwise occur under the FRWLP.

Many recreation activities are enhanced by or depend on the presence of mature woody vegetation. Recreationists, such as anglers, pedestrians, cyclists, boaters, and swimmers, use woody vegetation

for shade, while wildlife and nature viewers enjoy the various wildlife and aesthetic values that this vegetation supports and for the visual characteristics it contributes to the landscape. Permanent loss of woody vegetation on and within 15 feet of levees could reduce the quality of existing recreation activities.

At construction sites where feasible, implementation of Mitigation Measure VEG-4 MM-1: Compensate for the Loss of Woody Riparian Habitat (described in Section 4.7, *Vegetation and Wetlands*), would reduce but may not fully compensate for effects. At construction sites where this mitigation measure is not feasible to implement onsite because of the Vegetation ETL, the effect would remain adverse and unavoidable, but less than significant because recreation opportunities degraded by vegetation removal, such as hiking, hunting, and wildlife viewing are not unique but are allowed and supported by the several nearby recreation facilities. No loss of developed recreation facilities or infrastructure would be displaced by the project. The riparian habitat compensation proposed under Measure VEG-4 MM-1 at the Star Bend Conservation Area and TRLIA restoration site would enhance recreation opportunities in these areas.

4.11.4.3 Alternative SB-7

Effects associated with Alternative SB-7 would be comparable in type to those described above for Alternative SB-8, but at a lesser magnitude due to the reduced footprint of the alternative. At construction sites where feasible, implementation of Mitigation Measure VEG4 MM-1: Compensate for the Loss of Woody Riparian Habitat (described in Section 4.7, *Vegetation and Wetlands*), would reduce but may not fully compensate for effects. At construction sites where this mitigation measure is not feasible, the effect would remain adverse and unavoidable, but less than significant as described above for Alternative SB-8.

4.12 Cultural Resources

4.12.1 Introduction

This section evaluates potential impacts of the alternatives on cultural resources. Section 3.17, *Cultural Resources*, of the FRWLP Final EIS described the regulatory and environmental setting and the potential impacts of the FRWLP. That information is incorporated by reference.

4.12.2 Affected Environment

The identification of cultural resources to this point has consisted of a record and literature search at the Northeast Information Center, a built environment survey conducted by ICF International (ICF), and a pedestrian survey for prehistoric resources, also conducted by ICF. The results of these surveys have not yet been formally reported. In order to satisfy the requirements of CEQA, ICF plans to conduct archaeological test excavations on all archaeological sites encountered in the course of the pedestrian survey to determine their significance and to evaluate project impacts on those sites.

Consultation with Native American tribes is a key aspect of USACE consideration of cultural resources. The tribes whom USACE has contacted are listed in the FRWLP Final EIS. USACE has been in continued consultation with the two tribes that have responded to outreach efforts so far: the United Auburn Indian Community (UAIC) and Enterprise Rancheria. Consultation with the UAIC has resulted in the identification of a new, presently unnamed prehistoric site that may exist within the

project area. USACE will continue to include all these tribes in all decisions regarding cultural resources.

USACE has identified tentative areas of potential effects (APE) for each of the project alternatives. These areas are largely the same as the final APE that has been formally determined and documented by USACE and the California State Historic Preservation Officer (SHPO) for the FRWLP project. Differences that exist between these areas are described in more detail in Section 4.12.4, *Effects and Mitigation Measures*, below.

USACE negotiated a programmatic agreement (PA) with SHPO that outlines the specific processes that USACE will follow to identify and treat cultural resources (Appendix D). The PA took effect after it was signed by USACE and SHPO on June 8, 2012, and was subsequently transmitted to the Advisory Council on Historic Preservation. USACE's adherence to the processes outlined in the PA constitutes full compliance with Section 106 of the National Historic Preservation Act (NHPA) of 1966, 16 USC Section 470f (Section 106).

In accordance with the terms of the PA, before construction begins, the following will occur.

- USACE and SHPO will formally agree upon a final APE for the project. The APE comprises the entirety of the area where cultural resources could potentially be affected by the project.
- USACE, in consultation with SHPO, will fully inventory the APE for cultural resources. This inventory will include both the pedestrian survey efforts conducted to date by ICF, as well as subsurface prospection efforts.
- In consultation with SHPO, USACE will evaluate all cultural resources in the APE for their eligibility for listing in the National Register of Historic Places (NRHP). Work necessary for these evaluations may include detailed recordation, background research, and test excavation.
- In consultation with the SHPO, the public, interested Native American Tribes, or other identified stakeholders, USACE will provide adequate mitigation to resolve any unavoidable adverse effects on NRHP eligible cultural resources (historic properties).

4.12.3 Determination of Effects

Effects on cultural resources are considered significant for the purposes of this EIR/SEIS if the project alternative would result in any of the following, under the respective laws that govern the undertaking.

- Under NEPA, effects are significant if they would alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the NRHP in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association (36 CFR Section 800.5(a)[1]). These are the criteria of adverse effect under NHPA. USACE uses the NHPA threshold of adverse effect to determine significant effects under NEPA. Therefore, significant effects under NEPA only include effects on resources that are NRHP-eligible or NRHP-listed; effects on resources considered significant under state law are not significant effects under NEPA if those resources do not qualify for listing in the NRHP.
- Under CEQA, an effect is significant if it involves demolition or materially altering the qualities that justify the resource for eligibility or inclusion on the California Register of Historic Resources (State CEQA Guidelines Section 15064.5[b][2][A],[C]).

- Under CEQA, a project also would have a significant impact if it would demolish or materially alter the qualities that justify the inclusion of the resource on a local register (State CEQA Guidelines Section 15064.5[b][2][B]) or its identification as a historical resource survey meeting the requirements of Public Resources Code Section 5024.1(g).
- CEQA also covers effects on unique archaeological sites. Effects on unique archaeological sites are significant if the project would demolish or materially impair the characteristics that allow a site to qualify as a unique archaeological resource (Public Resources Code Section 21083.2[g]).
- CEQA protects interred human remains. Under CEQA, an effect is significant if the project would disturb human remains, including remains interred outside of established cemeteries (State CEQA Guidelines, Appendix G checklist).

4.12.4 Effects and Mitigation Measures

Effects and mitigation measure requirements concerning cultural resources are summarized in Table 4-42. Effects on NRHP eligible properties and archaeological sites would be resolved through the processes outlined in the PA. Though the resolution of adverse effects under Section 106 would reduce most effects to a less-than-significant level under NEPA and Section 106, those effects could remain significant for the purposes of CEQA.

Table 4-42. Summary of Effects for Cultural Resources

Effect	Finding	Mitigation Measures	Finding with Mitigation
Alternatives SB-7 and SB-8			
Effect CR-1: Effects on Identified Archaeological Sites Resulting from Construction of Levee Improvements and Ancillary Facilities	Significant	CR-MM-1: Perform Field Studies, Evaluate Identified Resources and Determine Effects, and Develop Treatment to Resolve Significant Effects	Significant and unavoidable
Effect CR-2: Potential to Disturb Unidentified Archaeological Sites	Significant	CR-MM-2: Implement a Cultural Resources Discovery Plan, Provide Related Training to Construction Workers, and Conduct Construction Monitoring	Significant and unavoidable
Effect CR-3: Potential to Disturb Human Remains	Significant	CR-MM-3: Monitor Culturally Sensitive Areas during Construction and Follow State and Federal Laws Governing Human Remains if Such Resources Are Discovered	Significant and unavoidable
Effect CR-4: Direct and Indirect Effects on Built Environment Resources Resulting from Construction Activities	Significant	CR-MM-4: Conduct Inventory of Built Environment Resources, Evaluate Identified Properties, Assess Effects, and Prepare Treatment to Resolve and Mitigate Significant Effects	Significant and unavoidable

The effects and mitigation measures outlined below are described in more detail in the FRWLP Final EIS.

4.12.4.1 No Action Alternative

This alternative would result in no change from the existing conditions. The No Action Alternative would result in no impacts beyond the naturally occurring degradation incurred by taphonomy, decomposition, and erosion.

4.12.4.2 Alternative SB-8

Effect CR-1: Effects on Identified Archaeological Sites Resulting from Construction of Levee Improvements and Ancillary Facilities

A range of archaeological resources has been identified that may be affected by this alternative (See Effects Discussion below). Identified prehistoric resources contain midden (habitation debris), human burials, hearths (charred remains from cooking), and lithic debris (remains from manufacture of stone tools). Deposits with these constituents often have data potential for archaeological research, which strives to describe human adaptations and their changes over time and to construct meaningful explanations for these changes. Because material in these sites may be useful for this purpose, it is likely that many of these sites have significance within the meaning of the NRHP. Furthermore, because many of these resources are expansive (each in excess of 30 meters across), they are each likely to contain some portion of the deposit with sufficient integrity to yield meaningful data. Additional research value may be associated with specific deposits that cannot be identified in advance. Therefore, these sites are likely to be eligible for inclusion in the NRHP because they may yield information pertinent to prehistoric archaeological research (30 CFR Part 60.4[d]). These sites thus are likely to qualify as historic properties. Identified resources may be significant under other NRHP eligibility criteria. Individual sites and their potential register eligibility are described in the FRWLP FEIS in Appendix I, Section I.4, Identified Resources Affected by the Action Alternatives. Potential resource-specific treatments are identified in Table I-4 of that same document.

Identified historic-era archaeological sites are associated with the themes of mining, transportation, and settlement. These themes are significant because they are associated with the historic-era economy and development of the region. For these reasons, it is likely that many of these sites have significance within the meaning of the NRHP. In addition, because these sites contain physical remnants of the activities associated with these themes, they may be able to elucidate significant details regarding the settlement of the region and expansion of Euro-American populations into the Sacramento Valley. For this reason, these sites may have data potential within the meaning of the NRHP. While these sites have not been revisited to assess their integrity, these resources are expansive and it is likely that some portion of the deposits remain with sufficient integrity to yield useful data. For these same reasons, these sites are likely to have significance and integrity for the NRHP as defined in 30 CFR Section 60.4, because these sites may yield information in historic research regarding the theme of settlement and resource extraction in California, a theme that is significant at the local, state, and national levels (30 CFR Section 60.4(a)). The NRHP may include resources that are significant at the state, local, and national levels (U.S. Department of the Interior 1999:i). These sites thus are likely to qualify as historic properties.

In addition, USACE would conduct both pedestrian and subsurface inventory efforts in order to identify other buried and obscured sites in advance of construction. Sites that may be identified through these efforts have the potential to qualify as historic properties.

Construction of levee improvements and ancillary activities such as borrow operations have the potential to directly disturb identified resources (including sites that may be located through subsurface inventory) through ground-disturbing excavation or by placement of large, durable new features, such as seepage berms or stability berms, over these resources. Because direct disturbance through excavation would disrupt the associations that contain meaningful information, this work could result in significant effects under Section 106 (36 CFR Section 800.5(a)(1)). Mitigation Measure CR-MM-1 is available to reduce these effects. In addition, this mitigation addresses management steps necessary under Section 106 to resolve significant effects by attempting to avoid or minimize those effects or to recover consequential information where avoidance is not feasible. Because feasible management steps cannot guarantee that all effects would be avoided (even where such effects would be resolved under Section 106), these effects would remain significant and unavoidable.

Mitigation Measure CR-MM-1: Perform Field Studies, Evaluate Identified Resources and Determine Effects, and Develop Treatment to Resolve Significant Effects

USACE will complete the following mitigation and management steps to satisfy Section 106. The record and literature search and pedestrian surveys conducted for the FRWLP project provide sufficient baseline information to anticipate potentially significant effects under NEPA. However project designs are not presently specific enough to make a formal determination of adverse effect under NHPA. Pursuant to the PA and this mitigation measure, the USACE would make such a determination when the necessary information is available.

- USACE will ensure that an inventory and evaluation report for cultural resources is completed within all areas where effects on archaeological resources may occur.
- The work will be led or supervised by cultural resources specialists who meet the Secretary of the Interior's professional qualification standards provided in 36 CFR Part 61.
- Inventory methods will include pedestrian surveys and probabilistic subsurface sampling through appropriate subsurface excavation methods.
- Identified resources and newly identified resources will be mapped and described on California Department of Parks and Recreation (DPR) 523 forms. Mapping will be performed by recording data points with GPS hardware through which data can be imported and managed digitally. Mapping of previously identified resources will be limited to updates of existing records where necessary to describe the current boundaries of the resource.
- For all identified resources, USACE will perform an evaluation to determine if they qualify as historic properties per the criteria provided in 36 CFR Part 60.4.
- The recorded resources and the resource evaluations will be summarized in an inventory and evaluation report (unless testing is required to complete the evaluation, as described below).
- USACE will make a finding of effect; a significant effect will occur if the project would alter, directly or indirectly, the qualities that make a resource eligible for listing in the NRHP (36 CFR Part 800.5[a][1]).
- Where necessary, USACE will conduct test excavation to support the evaluation and finding of effect. Test excavation is typically performed to retrieve a suitable sample of material to determine the constituents and integrity of the resource. Test excavation will be conducted

in consultation with SHPO and other relevant parties. Test excavation will follow a testing plan developed in consultation with SHPO, either for the specific resource or as part of the treatment methods developed pursuant to the PA.

- For all resources subject to significant effects, USACE will implement treatment in consultation with SHPO and other relevant parties including Native American stakeholders and the public.

Construction will also be monitored, and discoveries of human remains will be treated as prescribed under Mitigation Measures CR-MM-2 and CR-MM-3, below.

Effect CR-2: Potential to Disturb Unidentified Archaeological Sites

The footprint of Alternative SB-8 is sensitive for buried and obscured archaeological sites that cannot always be identified in advance of construction. Because much of the right-of-way occurs within natural floodplains, archaeological sites in the right-of-way are subject to the geological processes associated with river systems and flooding. During prehistory, sites were formed over many millennia. When habitation ceased or flood events occurred, interrupting human occupation, these sites may have been obscured by the deposition of sediment. In addition, because of the intensity of farming activity in the historic era, surface manifestations for prehistoric sites may have been obscured by cultivation, leaving portions of the site below grade with no visible indication above ground. Geological processes may obscure historic-era sites as well. In addition, USACE does not currently have rights-of-entry to complete inventory in the entire project area; previously unidentified sites may occur in these locations. An inventory will occur in these locations pursuant to Mitigation Measure CR-MM-1.

Because these sites may contain important data useful in research, and may have integrity to convey this data, these sites may qualify as historic properties. Disturbance of these resources through direct excavation would result in significant effects under Section 106 by disrupting scientifically meaningful associations.

While probabilistic subsurface excavation is a standard tool that is available to identify such sites, the scale of the project area and the size of such sites in relation to the acreage affected by the project create conditions where identification of all buried and unknown sites may not be possible. For these reasons, these sites may remain undetected prior to construction. It is particularly worth noting that the construction of deep slurry cutoff walls may disturb deeply buried early Holocene or Pleistocene sites that exist far below grade where there is no feasible means to identify such resources prior to disturbance. Buried sites may contain human remains in addition to archaeological debris. While mitigation is available to minimize these effects under Mitigation Measure CR-MM-2, this mitigation would not ensure that these effects would be avoided. For this reason, this effect is significant and unavoidable.

Mitigation Measure CR-MM-2: Implement a Cultural Resources Discovery Plan, Provide Related Training to Construction Workers, and Conduct Construction Monitoring

Prior to ground-disturbing construction, USACE will include a cultural resources discovery plan in the contract conditions of the construction contractor, incorporating the following actions to be taken in the event of the inadvertent discovery of cultural resources:

- An archaeological monitor will be present to observe construction at geographic locations that are sensitive for unidentified cultural resources. Such locations will consist of

construction areas near identified cultural resource(s) sites (within a 200-foot radius around the known boundaries of identified resources) and where ground-disturbing construction will occur within 1,500 feet of major water features.

- In the event of an archaeological resource discovery, work will cease in the immediate vicinity of the find, based on the direction of the archaeological monitor or the apparent distribution of cultural resources if no monitor is present. A qualified archaeologist will assess the significance of the find and make recommendations for further evaluation and treatment as necessary.
- Discovered resources will be mapped and described on California Department of Parks and Recreation (DPR) 523 forms. Mapping will be performed by recording data points digitally with GPS hardware.
- In consultation with SHPO, USACE will evaluate identified resources to determine if they are historic properties. Test excavations will be performed where necessary to support evaluation. Evaluation and treatment will follow the standards and order of priority described above for Mitigation Measure CR-MM-1, with the exception of timing. Discoveries may occur after the EIR/SEIS is completed and, thus, need not be described in that document.
- In consultation with SHPO, USACE will make a finding of effect for eligible resources, and for all adversely affected resources, resolve adverse effects as required under the PA (Appendix J).
- If human remains are discovered as part of the deposit, SBFCA, USACE, and the contractors will coordinate with the county coroner and the Native American Heritage Commission (NAHC) to make the determinations and perform the management steps prescribed in California Health and Safety Code Section 7050.5 and Public Resources Code Section 5097.98.
- If Native American human remains are discovered on Federal land, work in the immediate vicinity will cease, and SBFCA and USACE will contact the relevant representative of the Federal agency where the remains were discovered, as prescribed in the Native American Graves Protection and Repatriation Act (NAGPRA), 25 USC Section 3002(d). After notification from the relevant agency representative and treatment of the remains as required under NAGPRA, work may continue. Disposition of the remains will follow the ownership priority described in NAGPRA (25 USC Section 3002[a]).

SBFCA and USACE will develop a list of cultural resources staff who can respond to cultural resources discoveries and SBFCA and USACE will also develop training materials for construction workers regarding management direction following discoveries. The staff list and training materials will be provided to the supervisory field staff. SBFCA and USACE, or their archaeological consultant, will conduct training for construction workers that provides an overview of cultural resources identification and this mitigation measure.

Effect CR-3: Potential to Disturb Native American Human Remains

The project area is located in an area of moderate to high sensitivity for archaeological cultural remains, including Native American burials. Some of the identified archeological resources contain burials, and the remaining right-of-way is sensitive for additional archaeological sites. Ground-disturbing work necessary to construct proposed levee improvements may inadvertently damage

and disturb these resources before they can be discovered. In particular, slurry cutoff walls may disturb these resources at depths where the resource cannot be identified, even during monitoring.

Slurry cutoff wall construction occurs through use of a bentonite mixture that obscures artifacts and cultural material, making identification infeasible or at least unlikely during monitoring of these features in particular. Mitigation Measure CR-MM-3 would reduce the severity of this effect, but it cannot guarantee the effect would be avoided. For these reasons, this effect remains significant and unavoidable.

Mitigation Measure CR-MM-3: Monitor Culturally Sensitive Areas during Construction and Follow State and Federal Laws Governing Human Remains if Such Resources Are Discovered

USACE will retain a qualified archaeologist to monitor areas of sensitivity for previously unidentified archaeological resources and Native American human remains, as required under Mitigation Measure CR-MM-2. The following actions will be taken:

If Native American human remains are discovered as part of the deposit or in isolation, work will cease in the immediate vicinity and within the radius necessary to avoid further disturbance. USACE, and the contractors will coordinate with the county coroner and NAHC to make the determinations and perform the management steps prescribed in California Health and Safety Code Section 7050.5 and PRC Section 5097.98. This coordination requires the following steps.

- The county coroner will be notified so that he/she may determine if an investigation regarding the cause of death is required. If the coroner determines that the remains are of prehistoric Native American origin, the coroner will notify the NAHC.
- Upon notification, the NAHC will identify the most likely descendant (MLD), and the MLD will be given the opportunity to reinter the remains with appropriate dignity. If the NAHC fails to identify the MLD or if the parties cannot reach agreement as to how to reinter the remains as described in PRC Section 5097.98(e), the landowner will reinter the remains at a location not subject to further disturbance. USACE will ensure the protections prescribed in PRC Section 5097.98(e) are performed, such as the use of conservation easements and recording of the location with the relevant county.
- If Native American human remains are discovered on Federal land, work in the immediate vicinity will cease, and USACE will contact the relevant representative of the Federal agency where the remains were discovered, as prescribed in 25 USC Section 3002(d) (NAGPRA). After notification from the relevant agency representative and treatment of the remains as required under NAGPRA, work may continue. Disposition of the remains will follow the ownership priority described in NAGPRA (25 USC Section 3002[a]).
- SBFCA and USACE will include an overview of the potential for encountering human remains and an overview of this mitigation measure in the training performed under Mitigation Measure CR-MM-2.

Effect CR-4: Direct and Indirect Effects on Built Environment Resources Resulting from Construction Activities

Identified built environment resources consist of structures associated with the historical themes of transportation, water conveyance, and commercial development. Known built environment resources that may be impacted are discussed below in Section 4.12.4.2.1, *Effects Discussion*.

Because these resources are associated with the historical settlement and development of the region, they may have significance within the meaning of the NRHP. If these resources retain their setting and character-defining elements, they may have integrity under the NRHP. For these reasons, these resources may qualify as historic properties under NRHP (36 CFR Part 60.4[a]). It should be noted that the settlement, development, and reclamation of the Sacramento Valley is significant at both the local and state levels.

Demolition of these structures may be required for the construction of new levee improvements such as seepage berms, stability berms, or wider levee prisms. In addition, even if demolition does not occur, these new features may not be consistent with the setting. Construction may also generate substantial vibration (e.g., soil compaction is typically required for seepage berm construction). Vibration may damage structures. For these reasons, construction may impair the ability of these resources to convey their significance, resulting in a significant effect under NEPA and Section 106. The basis for the conclusion that individual resources are register-eligible is provided in the FRWLP FEIS in Appendix I, Section I.4, *Identified Resources Affected by the Action Alternatives*. Potentially affected built environment resources and potential resource-specific treatments are identified in Appendix I, Table I-5 of that document.

Although mitigation is available to reduce this effect, mitigation cannot guarantee these effects would be avoided entirely. Because mitigation cannot guarantee avoidance of these effects, this effect remains significant.

An inventory for the right-of-way required for the project alternatives has not been completed because not all rights-of-entry have been secured. The presence of identified built environment resources and a review of aerial photographs indicate that the right-of-way is sensitive for additional unidentified built environment resources. Such resources may consist of individual structures and residences or landscape-scale features such as rural historic landscapes (U.S. Department of the Interior 1999). In addition, built environment features such as community gathering halls or traditional activity areas may consist of traditional cultural properties (Parker and King 1998). The right-of-way for the proposed alternatives is sensitive for these types of resources because of the intensity of activity in the historic (and prehistoric) era and because the rural setting makes it more likely that these resources may have remained intact. These resources may qualify as historic properties under NRHP for their integrity, if they remain intact, and their association with important historic-era themes identified in this setting.

The construction of new levee improvements such as seepage berms, stability berms, or wider levee prisms may require demolition of built environment resources that would be identified through inventory and evaluation efforts. Even if demolition does not occur, these new features may not be consistent with the setting. For these reasons, construction may impair the ability of these resources to convey their significance. While mitigation is available to reduce these effects under Mitigation Measure CR-MM-4, this mitigation cannot guarantee all effects would be avoided. For these reasons, this effect remains significant and unavoidable.

Mitigation Measure CR-MM-4: Conduct Inventory of Built Environment Resources, Evaluate Identified Properties, Assess Effects, and Prepare Treatment to Resolve and Mitigate Significant Effects

USACE will ensure that an inventory and evaluation report is completed for all areas where effects on built environment resources may occur.

- The scope of the inventory will include the entire area where effects may occur. Such effects consist of direct disturbance, damage through vibration, and/or changes to the setting.
- The work will be led or supervised by architectural historians who meet the Secretary of the Interior's professional qualification standards provided in 36 CFR Part 61.
- Inventory methods and evaluation will include pedestrian surveys, photographic documentation, and historical research using primary and secondary sources, interviews, and oral histories.
- Identified resources will be mapped and described on forms provided by DPR. Mapping will be performed by recording data points digitally with GPS hardware.
- USACE, in consultation with SHPO, will evaluate these resources to determine if they are historic properties (36 CFR Part 60.4).
- The recorded resources and the resource evaluations will be summarized in an inventory report.
- USACE in consultation with SHPO will make a finding of effect to determine if the project will result in significant effects on NRHP-eligible resources. A finding of adverse (i.e., significant) effect will be made if the project would alter, directly or indirectly, the qualities that make a resource eligible for listing on the NRHP (36 CFR 800.5[a][1]).
- For all resources subject to significant effects (or adverse effects under NHPA), USACE will develop and implement treatment. Where avoidance or relocation is not feasible, standard treatment such as documentation through the Historic American Building Survey, Historic American Landscape Survey, or Historic American Engineering Record will be completed. Other documentation such as district documentation, interpretive displays, or walking tours may also be considered and implemented as appropriate.

4.12.4.2.1 Effects Discussion

Impacts on certain resources can be anticipated based on information collected during the record search and the pedestrian survey conducted by ICF staff for the FRWLP project. These specific resources are described below, but the list is not exhaustive. Subsurface prospection will likely result in the identification of more resources than are presently known.

The APE for Alternative SB-8 would include the entire FRWLP APE but would extend 2,250 feet further south. Additionally, to provide an operations and maintenance road along the levee, USACE proposes to move the levee and/or the Sutter Butte Canal in various locations where the two features are too close together to accommodate the access road. This would result in additional impacts on the levee and the canal, both of which may be NRHP eligible, and on prehistoric archaeological sites including CA-BUT-496, and CA-BUT-52.

Most of the 2,250-foot segment where SB-8 would extend south beyond the limit of the FRWLP APE was inspected by USACE archaeologists, who did not encounter evidence of cultural resources visible on the surface. However, a berm located on private property abuts the dam in this area and may be a prehistoric mound site. USACE personnel were not able to gain access to this landscape feature, but the size and shape of it are consistent with the dimensions of known prehistoric mounds. Additionally, a prehistoric village and burial site, CA-SUT-57, is located close by. Pursuant to the PA, USACE would conduct a more detailed inventory of this area prior to construction, including subsurface prospection.

Most of the cultural resources impacts that would result from the construction of SB-8 are anticipated by the FRWLP Final EIS. These include impacts on the levee itself, the Sutter Butte Canal, historic buildings and neighborhoods in Yuba City, other built environment resources identified in the FRWLP Final EIS, and several known prehistoric archaeological sites (CA-SUT-5, CA-SUT-10, CA-SUT-20, CA-SUT-77, CA-BUT-52, CA-BUT-53, CA-BUT-496, CA-BUT-1123, and the unnamed site identified by UAIC). These sites and properties are described in more detail in the FRWLP Final EIS.

Borrow areas and utility relocations associated with SB-8 have not yet been surveyed or fully defined. These areas would be inventoried and any resources encountered would be treated pursuant to the PA.

In the course of further inventory work, including subsurface prospection, it is likely that USACE would encounter additional cultural resources. Prior to the initiation of construction, these resources would be evaluated and treated as described in the PA in consultation with SHPO, the public, and interested Native American Tribes or other identified stakeholders. USACE, in consultation with SHPO and the Tribes, would formally make a determination of adverse effects under NHPA once all the required information is at hand.

4.12.4.3 Alternative SB-7

4.12.4.3.1 Effects Discussion

The general effects and mitigation measures for Alternative SB-7 are the same as those described above for Alternative SB-8, though Alternative SB-7 is geographically less expansive than Alternative SB-8 and would impact fewer cultural resources. Based on the information at hand, it is possible to anticipate that construction of Alternative SB-7 would affect known cultural resources including the levee itself, the historic buildings and neighborhoods in Yuba City, other built environment resources identified in the FRWLP Final EIS, and several prehistoric archaeological sites (CA-SUT-5, CA-SUT-10, CA-SUT-20, CA-SUT-77, and the unnamed site identified by UAIC). All of these impacts are anticipated by the FRWLP Final EIS.

Proposed borrow areas have not yet been surveyed. The records and literature search indicates that one of the proposed borrow locations at Star Bend would impact a fourth prehistoric archaeological site, CA-BUT-17. Inventories of the remaining borrow sites and other sites that may be defined in the future could result in the identification of more impacts.

Any unknown cultural resources found in the course of further inventory work would be evaluated for NRHP eligibility, and effects on those resources would be resolved as necessary, following the processes outlined in the PA. USACE, in consultation with SHPO and the Tribes, would formally make a determination of adverse effects under the NHPA once all the required information is at hand.

4.13 Cumulative and Growth-Inducing Impacts

4.13.1 Growth-Inducing Effects

4.13.1.1 Introduction

Chapter 4 of the FRWLP Final EIS discussed cumulative and growth-inducing impacts. The regulatory background information and the methods used to analyze growth-inducing effects remains the same for analysis of Alternatives SB-8 and SB-7. The conclusions about growth-inducing effects remain applicable to Alternative SB-8. However, Alternative SB-7, which would reduce flood risk primarily in the urban area of Yuba City, would expose a smaller area to potential growth-inducing impacts. The discussion in the FRWLP Final EIS is included below, along with updates that consider Alternative SB-7.

CEQ regulations require an EIS to consider the potential indirect effects of a proposed action (40 CFR Section 1502.16(a) and (b)). The indirect effects of an action include those that occur later in time or farther away in distance but are still reasonably foreseeable. They may include "growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate" (40 CFR Section 1508.8[b]).

In addition, Section 21100(b)(5) of CEQA requires an EIR to discuss how a proposed project, if implemented, may induce growth and the impacts of that induced growth (see also State CEQA Guidelines Section 15126). CEQA requires an EIR to discuss specifically "the ways in which the proposed project could foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment" (State CEQA Guidelines Section 15126.2[d]).

4.13.1.2 Growth Projections

Population is not static, and the population of California has been growing significantly. According to the California Department of Finance, "California's population is projected to reach almost 60 million people by 2050, adding over 25 million since the 2000 decennial census" (California Department of Finance 2007). The California Department of Finance provides population data estimates and projections for cities and counties throughout California. Population information for Butte and Sutter Counties is provided below.

4.13.1.2.1 Butte County

Between April 2000 and January 2010, the overall population of Butte County increased by 9.2%, growing from 203,171 to 221,768 people. Within that same timeframe, the incorporated city of Gridley saw an increase of 19.3%, with the estimated population rising from 5,408 to 6,454, and the city of Biggs saw a 0.9% decrease in population, going from 1,793 to 1,787. For comparison, the state's population rose 14.1% during the same period, from 33,873,086 to 38,648,090 (California Department of Finance 2010). Although the county population has been increasing steadily, the population of the unincorporated portion of the county has been declining as people move to urban areas and cities annex areas to accommodate this growth (Butte County 2010: 32). Butte County had a population density of approximately 134 persons per square mile in 2010, compared with the state average of 239 persons per square mile (U.S. Census Bureau 2010).

The population of Butte County is expected to reach 281,442 by 2020 (California Department of Finance 2007). The city of Gridley population is expected to reach 8,774 by 2020, assuming a growth rate of 2.86% per year (Redamonti pers. comm.). The city of Biggs is expected to reach a population of 2,136, based on a 1.5% growth rate per year (City of Biggs 1998:1–5).

By 2050, the total population of Butte County is expected to reach 441,596 (California Department of Finance 2007). Based on the Department of Finance's unofficial 2070 population estimates for Butte and Sutter Counties prepared for the Sutter Basin Project, Butte County is expected to reach a total population of 512,095. These projections are based on very preliminary analyses of migration and fertility trends, which could change. Also, it is important to note that 60-year projections are subject to an enormous amount of potential external changes that could render these values inaccurate (Schwarm pers. comm.). Despite the preliminary nature of these projections, the population in the affected area is expected to continue to increase, and it can be assumed that employment, income, and the demand for housing also would increase.

4.13.1.2.2 Sutter County

Between April 2000 and January 2010, the overall population of Sutter County increased by 25.6%, growing from 78,930 to 99,154. Within that same timeframe, the incorporated cities of Live Oak and Yuba City saw increases of 41.1% and 77.8%, respectively, with their estimated populations rising from 6,229 to 8,791 and 36,758 to 65,372. In contrast, the state's population rose more slowly (14.1%) during that time, as noted above (California Department of Finance 2010).

Nearly two-thirds of the county's residents live in the cities of Live Oak and Yuba City (California Department of Finance 2010). Sutter County is primarily rural, with extensive agricultural areas and a low population density (Sutter County 2010:1–7). The county had a population density of approximately 157 persons per square mile in 2010, compared with the state average of 239 persons per square mile (U.S. Census Bureau 2010).

The population of Sutter County is expected to reach 141,159 by 2020 (California Department of Finance 2007), and Yuba City's population is expected to reach 79,000, based on an average annual growth rate of 2.5% per year (City of Yuba City 2004:2-3). According to the county's general plan (Sutter County 2010:4-2):

> For nearly 40 years, and, in particular, since 1990, most of the growth in Sutter County has taken place in its two cities, Yuba City and Live Oak. Yuba City annexations and new development in the incorporated cities has increased the share of the county's incorporated population from 40% in 1970 to 75% in 2007. As a result, fewer people resided in unincorporated areas of the county in 2007 than in 1970. This trend is assumed to continue during the time horizon of the 2006–2013 housing element.

By 2050, Sutter County is expected to more than triple in size (+255%). In 2050, the total population of Sutter County is expected to reach 282,894 (California Department of Finance 2007). Based on the California Department of Finance's unofficial 2070 population estimates for Butte and Sutter Counties for the Sutter Basin Project, Sutter County is expected to reach a total population of 341,216. As is described for Butte County above, based on these projections, the population in the affected area would continue to increase, and it can be assumed that employment, income, and the demand for housing also would increase.

4.13.1.2.3 Current and Planned Development

To accommodate current populations and growth, development has been planned in Butte and Sutter Counties in accordance with California law. The key land use planning documents are the following general plans:

- Butte County General Plan 2030 (Butte County 2010).
- City of Biggs General Plan 1997–2015 (City of Biggs 1998).
- City of Gridley General Plan (City of Gridley 2010).
- Sutter County 2030 General Plan (Sutter County 2010).
- City of Yuba City General Plan (City of Yuba City 2004).
- City of Live Oak General Plan (City of Live Oak 2010).

To account for growth relative to flood risk management, the local governments in the affected area have in place the following flood risk–management programs. This list is not a comprehensive inventory, but rather is meant to demonstrate the responsibility communities are showing for flood risk management and to provide a representation of the types of programs currently being implemented.

Butte County

- Butte County Flood Mitigation Plan.
- Public education and awareness programs.
- Land use planning and development restrictions in floodplains.
- Emergency Preparedness and Evacuation Plan.
- FEMA Community Rating System (CRS) Program.

City of Biggs

- Development restrictions in flood-prone areas.
- Emergency response plan and emergency evacuations routes.

Sutter County

- Sutter County Floodplain Management Ordinance, which includes the following flood-risk management measures.
    - Standards of construction to prevent flood damage.
    - Development restrictions in floodways.
- FEMA CRS Program.
- Emergency Operations Plan.
- Emergency Action Plan.
- Public Outreach Strategy Team.

City of Yuba City

- Flood Damage Prevention Ordinance, which includes the following flood-risk management measures.
  - Standards of construction to prevent flood damage.
  - Development restrictions in floodways.
- FEMA Community Rating System Program: Class 7.
- Emergency Evacuation Plan.
- Floodplain development permit requirement.
- Public Outreach Program.

City of Live Oak

- Development restrictions in flood-prone areas.
- Emergency Response Plan and emergency evacuations routes.

4.13.2 Effects and Mitigation Measures

An action that removes an obstacle to growth is considered to be growth-inducing. Consequently, where flood risk may be seen as an obstacle to growth in an area, levee improvements that would reduce that risk may be considered to remove an obstacle to growth and, thereby, be indirectly growth-inducing.

Growth inducement may lead to environmental effects, such as increased demand for utilities and public services, increased traffic and noise, degradation of air or water quality, degradation or loss of plant or animal habitats, and conversion of agricultural and open space land to urban uses. Growth within a floodplain area increases the risk to people or property of flooding.

However, if the induced growth is consistent with or provided for by the adopted land use plans and growth management plans and policies for the affected area (e.g., city and county general plans, specific plans, transportation management plans), those plans may ensure that these effects are either less than significant or mitigated to a less-than-significant level. In some instances, significant and unavoidable effects would occur as a result of implementation of land use plans. All effects associated with this planned growth are the responsibility of the city or county in which the growth takes place. Local land use plans provide for land use development patterns and growth policies that encourage orderly urban development supported by adequate urban public services, such as water supply, roadway infrastructure, sewer services, and solid waste services.

4.13.2.1 No Action Alternative

Under the No Action Alternative, USACE and SBFCA would not implement levee improvements. The levees protecting the study area would continue to deteriorate and require improvements to meet both FEMA's and the State's minimum acceptable levels of performance. Under the No Action Alternative, population growth trends may change as result of FEMA and State restrictions on development. In addition, the associated risk to human health and safety, property and the adverse economic effect that serious flooding could cause would continue, and the risk of a catastrophic flood would remain high. Although no improvements would be implemented, regular operations and

maintenance of the levee system would continue as prescribed and as presently executed by the local maintaining entities.

Despite the likelihood of Federal or State-led implementation of repairs, for the purposes of evaluating effects under the No Action Alternative, the feasibility study assumes that the improvements would not be made. This assumption provides the most conservative approach for disclosure and comparison of potential effects. Therefore, the No Action Alternative assumes no levee repair or strengthening would be implemented, the purpose and objectives would not be met, and flood risk would continue.

4.13.2.2 Alternatives SB-8 and SB-7

Alternatives SB-7 and SB-8 would incrementally reduce flood risk for the levee reaches proposed for improvement. SB-8 would expose a larger area than SB-7 to potential growth-inducing impacts. The levees proposed for improvement represent only a portion of the total levee system protecting Butte and Sutter Counties. The remaining unimproved levees in the system also would determine FEMA mapping and build-out decisions. As described in the FRWLP Final EIS, the levee reach proposed for improvement under SB-8 and the FRWLP preferred alternative would potentially remove approximately 6,300 acres from the current officially mapped FEMA floodplain. As acknowledged in Section 4.2.2.5.3 of this document, FEMA is updating and modernizing existing FIRMs for most of the United States, including California. Accordingly, and given known levee deficiencies, FIRM data may not be entirely indicative of the present status of designated floodplains. Therefore, areas yet to be updated by FEMA may also be potentially removed from the FEMA floodplain.

The project would facilitate build-out for areas planned for growth in adopted municipal general plans. Such build-out growth is part of the planned development of Butte and Sutter Counties. The counties and incorporated cities have general plans under which growth and increases in population could lead to effects on air and water quality, water supply, traffic, and noise conditions, and increases in the demand for such public services as schools, fire protection, police, sewer, solid waste disposal, and electric and gas utilities. The expansion of such services could result in significant effects. The effects of this growth have been analyzed in the CEQA documents associated with these plans (Butte County General Plan, City of Biggs General Plan, City of Gridley General Plan, Sutter County 2030 General Plan, City of Yuba City General, City of Live Oak General Plan). Mitigation measures that would reduce or eliminate these effects are included in the CEQA documents that were prepared for these local actions.

In addition to areas currently approved for build-out growth, the potential exists for additional new development to be induced as a result of improved levels of flood risk performance in areas not currently planned for urbanization. It should be further noted that while Alternatives SB-7 and SB-8 would remove a potential obstacle to growth by reducing the area subject to FEMA floodplain designation, they would not directly facilitate growth (e.g., develop new water supply, utilities, or other infrastructure). Ultimately, the effects associated with growth in Butte and Sutter Counties are the responsibility of cities and counties in which they occur, in combination with specific project proponents.

4.13.3 Cumulative Effects

4.13.3.1 Introduction

The FRWLP Final EIS identified other past, present, and reasonably foreseeable projects that could interact with SBPFS actions to create cumulative effects. Cumulative effects were identified and mitigation was recommended for significant cumulative effects. This information is hereby incorporated by reference. Cumulative effects are addressed in this integrated EIR/SEIS only in the environmental resource areas of vegetation, wildlife, and visual resources. All other cumulative effects are adequately addressed in the FRWLP Final EIS. The modifications proposed under SB-8 and SB-7 to the FRWLP preferred alternative would not result in any new cumulative or substantially more severe cumulative significant direct and indirect effects, including short- and long-term effects, than were analyzed in the FRWLP Final EIS.

4.13.3.2 Vegetation and Wetlands

Construction, the implementation of USACE's Vegetation ETL, and levee maintenance activities to maintain a vegetation-free zone would result in substantially greater direct loss of riparian vegetation and other habitats under both Alternatives SB-8 and SB-7 than would occur under the FRWLP. Levee repairs on other reaches of the Feather River and future implementation of the Vegetation ETL policy throughout the SRFCP also may result in losses of vegetation and wetlands, and permanent loss could contribute to a significant cumulative impact. Consideration of a variance under the Vegetation ETL and habitat compensation would lessen the loss of riparian habitat. As stated in the FRWLP Final EIS, it is expected that each project would be required to mitigate for such loss due to regulatory requirements, thereby reducing any cumulative effect to a less-than-significant level; however, temporal losses could be significant until the vegetation has reestablished and matured sufficiently to offset the loss in habitat values.

4.13.3.3 Wildlife

As described above, Alternatives SB-8 and SB-7 would result in the direct loss of habitat and, thus, associated special-status species as a result of construction and as a result of implementation of USACE's Vegetation ETL. Effects on wildlife from operation and maintenance (e.g. disturbance to wildlife from noise and physical disturbance) would be similar to the effects of existing levee maintenance and therefore not result in significant cumulative effects. As described in the FRWLP Final EIS, the loss of these habitats would contribute to the cumulative effects on wildlife, along with projects that remove these types of habitats in the project region. The Feather River corridor provides important nesting, roosting, foraging, cover, and movement habitat for numerous wildlife species, including several listed and rare species. Additional levee improvement projects along the Feather River levee system would result in losses of riparian habitat as a result of construction or implementation of the Vegetation ETL. Coordination with USFWS, NMFS, CDFW and appropriate local agencies would be required for such projects to ensure appropriate compensation for effects on riparian habitat. Because special-status species are protected under state and Federal laws, other projects also would be required to minimize injury and mortality and compensate for loss of their habitats. It is expected that each project would be required to mitigate for such loss, thereby reducing any cumulative effect to a less-than-significant level; however, temporal losses could be significant until the vegetation has reestablished and matured sufficiently to offset the loss in habitat values.

4.13.3.4 Visual Resources

The SBPFS would potentially result in significant and unavoidable visual effects in reaches with sensitive viewers for both SB-7 and SB-8. The effects are primarily associated with vegetation removal. The SBPFS would have greater impact on existing visual values than the FRWLP because of the greater amount of vegetation removal under the SBPFS. As other projects to achieve flood risk reduction in the region are implemented, these effects would be additive and could be cumulatively significant and unavoidable despite mitigation measures to compensate for loss of riparian vegetation.

4.13.4 Other Required Disclosures

4.13.4.1 Relationship between Local Short-Term Uses of the Environment and Maintenance and Enhancement of Long-Term Productivity

NEPA requires that an EIS consider the relationship between short-term uses of the environment and the impacts that such uses may have on the maintenance and enhancement of long-term productivity of the affected environment (40 CFR Section 1501.16). This section compares the short- and long-term environmental effects of the proposed project.

Short-term impacts caused by the project would be similar for any of the construction alternatives. These impacts would occur during and immediately after construction and would generally result in adverse effects. However, the long-term impacts that would occur over the life of the project would result in overall beneficial effects.

Implementation of either Alternative SB-7 or SB-8 would result in beneficial long-term impacts. The alternatives would address levee deficiencies that currently threaten property and public safety. Flooding in the event of a levee failure would result in extensive flooding and potential loss of life.

4.13.4.2 Significant Irreversible and Irretrievable Environmental Commitment of Resources

Construction of the levee improvements would result in an irretrievable and irreversible commitment of natural resources through the direct consumption of fossil fuels and use of materials. With completion of the project, that commitment of resources would end. The primary long-term, irreversible commitment of resources resulting from the project would be the conversion of farmland.

4.13.4.3 Unavoidable Significant Impacts

Unavoidable significant impacts are impacts that remain following the implementation of mitigation measures, or impacts for which there are no mitigation measures. This section lists the unavoidable significant impacts that could occur as a result of implementing the analyzed build alternatives, Alternatives SB-8 and SB-7. Nearly all potentially significant impacts could be reduced to less-than-significant levels by mitigation measures specified in this EIR/SEIS.

The effects that are significant and unavoidable or potentially significant and unavoidable are listed below.

- Air Quality

- Effect AQ-2: Exceedance of Applicable Thresholds for Construction Emissions

- Noise
  - Effect NOI-1: Exposure of Sensitive Receptors to Temporary Construction-Related Noise
  - Effect NOI-2: Exposure of Sensitive Receptors to Temporary Construction-Related Vibration
- Vegetation
  - Effect VEG-1: Disturbance or Removal of Riparian Trees
  - Effect VEG-4: Potential Loss of Special-Status Plant Populations Caused by Habitat Loss Resulting from Project Construction
- Visual Resources
  - Effect VIS-1: Result in Temporary Visual Effects from Construction
  - Effect VIS-2: Adversely Affect a Scenic Vista
  - Effect VIS-3: Substantially Degrade the Existing Visual Character or Quality of the Site and its Surroundings
- Cultural Resources
  - Effect CR-1: Effects on Identified Archaeological Sites Resulting from Construction of Levee Improvements and Ancillary Features
  - Effect CR-2: Potential to Disturb Unidentified Archaeological Sites
  - Effect CR-3: Potential to Disturb Human Remains
  - Effect CR-4: Direct and Indirect Effects on Identified Historic Architectural/Built Environment Resources Resulting from Construction Activities

Chapter 5
Consultation and Coordination

This chapter contains a summary of the consultation and coordination activities that have occurred in support of the Sutter Basin Pilot Feasibility Study (SBPFS).

5.1 Public Involvement

5.1.1 Public Scoping

On May 20, 2010, USACE published a notice of intent (NOI) in the Federal Register (Vol. 76, No. 98) to prepare an EIS and SBFCA published a notice of preparation for an EIR with the State Clearinghouse. The NOI was published as a combined NOI covering both the feasibility study EIS and the Feather River West Levee Project (FRWLP) EIS.

In June 2011, four scoping meetings were held jointly for the FRWLP and the SBPFS. Because the two projects would affect the same general area, have similar purposes, are related to each other, have the same lead agencies, and are being studied in close coordination, a joint scoping process was conducted to explain the relationship between the two efforts and obtain public input in a manner that was convenient, efficient, and integrated. The meetings were held to educate the public about each of the two efforts and to garner input on the proposed scope of each, in accordance with NEPA and CEQA.

The meetings were held at two different times over the course of two days. On June 27, 2011, meetings were conducted from 3:30 to 5:30 p.m. and from 6:30 to 8:30 p.m. Both were at the Yuba City Veterans Memorial Community Center. On June 28, 2011, meetings were conducted from 3:30 to 5:30 p.m. and from 6:30 to 8:30 p.m. Both were at the Gridley Veterans Memorial Hall.

The meeting locations were chosen because they are central to the region. The meeting times were chosen to accommodate both the workday schedules of public agency representatives and the general public, including residents and business owners.

The meetings were open-house style workshops in which attendees could read and view the information about the two projects and interact with project staff, including representatives of SBFCA, USACE, the California Department of Water Resources (DWR), and engineering and environmental consultants.

The views expressed in the scoping meeting are summarized as follows:

- Keep landowners apprised of associated activities occurring on their lands.
- Keep the Sutter Basin Feasibility Study on schedule so the state will be able to release early implementation program funding for the FRWLP.
- Coordinate with the Lower Feather River Corridor Management Project so that duplicative efforts pertaining to environmental studies are avoided.
- Put in a levee setback in the Nelson Slough area.
- Consider a perimeter levee around Yuba City or a J-levee on the south and west sides.

For more detail on comments received, information available at the meetings, and a summary of key issues that were raised, see Appendix D which contains a scoping report.

5.1.2 Public Review of Draft Report

The draft Integrated Feasibility Report and EIR/SEIS was circulated on June 14, 2013. An "All Interested Parties" notice was also sent out to a mailing list. A Notice of Availability was published in the Federal Register on June 14, 2013, and a public meeting was held by USACE and SBFCA on July 22, 2013 to receive comments on the report from agency representatives and other interested parties. The report was also made available for viewing and download from the USACE Sacramento District website. Meeting attendees included five members of the public.

USACE received six comment letters during the 45-day public review period, which ended on July 29, 2013 and two comments were submitted during the July 22, 2013 public meeting. Table 5-1 lists all parties who submitted comments. Appendix F contains the comments received and responses to the comments. Comments received on the Draft Report during the 45-day comment period were considered during preparation of this Final Report. Comments included issues such as induced flooding, availability of construction funding, consideration of a System Wide Improvement Framework to address vegetation and other levee deficiencies, evaluation of alternatives for compliance with Clean Water Act 404(b)(1) Guidelines, and mitigation monitoring.

Table 5-1. List of Commenters

Letter #	Commenter	Date of Comment
Federal Agencies (F)		
F1	Federal Emergency Management Agency	June 11, 2013
F2	U.S. Environmental Protection Agency	July 25, 2013
F3	U.S. Department of Interior, Office of Environmental Policy and Compliance	July 29, 2013
State Agencies (S)		
S1	Governor's Office of Planning and Research	July 30, 2013
Local Agencies (L)		
L1	Sacramento Area Flood Control Agency	July 25, 2013
Individuals (I)		
I1	Patrick Porgans	July 29 and 30, 2013
Public Meeting (PM)		
PM-1	Lawrence Mentz	July 22, 2013
PM-2	Patrick Porgans	July 22, 2013

5.1.3 Issues of Concern and Controversy

The following issues were identified as a result of public scoping, during the conduct of the feasibility study, and during preparation of the FRWLP EIS and EIR. While these issues were also addressed in the FRWLP EIS, these issues are of continuing concern to the public.

5.1.4 Construction-Related Effects

Because the levee system in the study area is in close proximity to residential areas and other developed land uses, flood improvements proposed under the SBPFS are likely to result in construction-related effects. These effects include those under the topics of public safety, noise, traffic, and air quality and are specifically described in Chapter 4, *Affected Environment and Environmental Consequences.*

5.1.5 Property Acquisition

A specific subset of construction-related effects involves potential conflicts with private property underlying or near proposed improvements. In some cases there may be temporary property use in the form of construction easements to build the project and permanent acquisition for operations and maintenance of the project. These effects are described in Chapter 4, *Affected Environment and Environmental Consequences.*

5.1.6 USACE Vegetation ETL Levee Safety Policy

Implementation of USACE national policy concerning restrictions on vegetation on and near flood control structures is controversial. Much of the remaining natural riparian habitats in the Central Valley are located along flood control levees. Levee inspections conducted by the USACE have identified vegetation that would need to be removed; otherwise a variance would need to be obtained for compliance with this policy. Effects on vegetation, recreation, and visual resources from project implementation are addressed in Chapter 4, *Affected Environment and Environmental Consequences.*

5.1.7 Climate Change and Sea-Level Rise

Global climate change and resultant sea-level rise are phenomena receiving international attention. These issues are further analyzed in the effects discussions in Chapter 4 under *Air Quality and Climate Change.*

5.1.8 River Access for Recreation

The Feather River is popular for recreation activities such as fishing, boating, walking, and wildlife viewing. There is demand to increase opportunities for public access to the river corridor.

5.2 Agency Consultation and Coordination

Beyond formal public scoping, USACE and SBFCA have been in communication with Federal, state, and local agencies in the course of project planning, design development, and preparation of this integrated report. These communications have taken the form of in-person meetings, telephone conversations, and written correspondence. The communications have addressed consistency with

other planning studies and projects in the region, pursuit of agency approvals, information to be considered in the document, and opportunities for partnership.

Since June 2012, numerous meetings have been held between staff from USACE Sacramento District, USFWS, and SBFCA to discuss various issues, including scope of service, the USFWS Coordination Act Report, Endangered Species Act Section 7 consultation, potential mitigation, and compliance strategy. USACE has also sent numerous electronic mail messages to the USFWS transmitting important information, including the USFWS Scope of Work, Civil Works project funding reports, and analysis of acreage impacts. An onsite field tour of the entire project area was conducted in July 2012 that was attended by USFWS staff and representatives of USACE, SBFCA, California Department of Water Resources, California Department of Fish and Wildlife, and Central Valley Flood Protection Board. The USFWS has provided USACE a final Fish and Wildlife Coordination Act Report that contains the USFWS analysis and recommendations concerning fish and wildlife impacts and mitigation (Appendix D). USFWS has also issued a biological opinion and incidental take statement covering the effects of the project on listed species within its jurisdiction under the Endangered Species Act. The National Marine Fisheries Service provided a letter concurring with USACE's "not likely to adversely affect" determination and recommendations to avoid and minimize effects to essential fish habitat (Appendix D).

5.3 Other Communication

Beyond agency coordination, USACE and SBFCA are in communication with Native Americans, environmental non-governmental organizations, and other interested stakeholders. Correspondence was received from United Auburn Indian Community, Mooretown Rancheria, and Enterprise Rancheria in response to a written inquiry from USACE based on Native American Heritage Commission coordination.

Chapter 6
Compliance with Environmental Laws and Regulations

6.1 Federal Requirements

This final integrated pilot feasibility report and EIR/SEIS was prepared in accordance with the regulatory requirements found in statutes, regulations, executive orders, and various policy and guidance documents. This chapter contains a summary of the status of the proposed action in relation to each statutory and regulatory requirement. This section also discusses specific permitting activities and agency coordination for each statutory and regulatory requirement. Many of the requirements of the Federal government are codified under the United States Code (USC) as described below. Where a more common name for a law or regulation is typically used, the statute or regulation is listed by that name with a reference to the corresponding USC section.

6.1.1 National Environmental Policy Act

This final integrated pilot feasibility report and EIR/SEIS was prepared in accordance with the National Environmental Policy Act (NEPA) (42 USC Section 4321, et seq.), Council on Environmental Quality regulations (40 Code of Federal Regulations [CFR] Sections 1500–1508), and USACE NEPA implementing regulations (230 CFR Section 230.9). This report begins to fulfill requirements of NEPA. The draft report was circulated during a 45-day public comment. Appendix F contains the comments received and the responses to those comments. This final report incorporates public comments. Following circulation of the final report for 30 days, USACE will execute a Record of Decision in accordance with NEPA.

6.1.2 Federal Endangered Species Act

Section 7 of the Endangered Species Act (ESA) (16 USC Section 1536) requires Federal agencies, in consultation with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS), to ensure that their actions do not jeopardize the continued existence of endangered or threatened species, or result in the destruction or adverse modification of habitat of such species determined to be critical. Implementation of the Recommended Plan (RP) would result in direct and indirect effects on the valley elderberry longhorn beetle and the giant garter snake, both of which are listed as threatened under ESA. Therefore, a biological assessment was submitted to USFWS requesting initiation of formal consultation for adverse effects on these species. On September 19, 2013, the USFWS issued an amended biological opinion covering the additional effects of the project (Appendix D). A biological assessment was also submitted to NMFS requesting concurrence of the USACE determination that the RP may affect, but is not likely to adversely affect, listed fish species. In a letter dated September 26, 2013, the NMFS issued a letter concurring with USACE's determination (Appendix D). With receipt of an USFWS biological opinion and a NMFS letter of concurrence, USACE has complied with requirements under Section 7 of the ESA.

6.1.3 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (16 USC Section 661, et seq.) provides for consultation with USFWS and the California Department of Fish and Wildlife (CDFW) whenever the waters or channel of a body of water are modified by a department or agency of the United States. Under this act, the Federal department or agency shall consult with USFWS and the state agency with a view to the

conservation of wildlife resources. The act's purposes are to recognize the vital contribution of our wildlife resources to the nation, and their increasing public interest and significance, and to provide that wildlife conservation receive equal consideration and be coordinated with other features of water-resource development programs through planning, development, maintenance, and coordination of wildlife conservation and rehabilitation. A final Coordination Act Report (CAR) prepared by USFWS in coordination with CDFW was received from USFWS in April 2013 and can be found in Appendix D. The final CAR describes the existing environmental resources within the study area and the potential effects of the project on these resources, in addition to evaluating the proposed mitigation and monitoring plans. Recommendations developed by the USFWS contained in the final CAR have been considered in formulation of the RP. Table 6-1 more specifically demonstrates how each recommendation, opportunity, or problem identified in the CAR has been considered in plan formulation and mitigation plan development.

6.1.4 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) (16 USC Section 470f) requires Federal agencies to take into account the effects of Federal undertakings on historic properties. Section 106 of the NHPA describes the process for identifying and evaluating historic properties; for assessing the effects of Federal actions on historic properties; and for consulting to avoid, reduce, or minimize significant effects. The term *historic properties* refers to cultural resources that meet specific criteria for eligibility for listing on the National Register of Historic Places (NRHP). This process does not require historic properties to be preserved but does ensure that the decisions of Federal agencies concerning the treatment of historic properties result from meaningful consideration of cultural and historic values and the options available to protect the properties.

Under these requirements, the selected project's area of potential effects is inventoried and evaluated to identify historical, archeological, or traditional cultural properties that have been placed on the NRHP and those that the agency and the State Historic Preservation Officer (SHPO) agree are eligible for listing on the NRHP. If the project is determined to have an adverse effect on such properties, the agency must consult with SHPO and the Advisory Council on Historic Preservation (ACHP) to develop alternatives or mitigation measures to resolve adverse effects. Compliance with these and other provisions of the NHPA is required as a process separate from, but concurrent with, NEPA.

USACE and the SHPO have executed a programmatic agreement (PA) to provide guidelines for compliance with the Section 106 process when the effects on historic properties are unknown. The PA was executed on June 8, 2012 and has been transmitted to the Advisory Council on Historic Preservation.

Ongoing coordination and communication will be maintained by USACE with both the signatories and concurring parties to the PA, and other key stakeholders, as planned follow-on efforts are undertaken and the proposed project proceeds. By carrying out the terms of the PA, USACE will have fulfilled its responsibilities under Section 106 of the NHPA and ACHP regulations.

Table 6-1. Consideration of USFWS Recommendations

Recommendations	Response
1. Mitigate the loss of any natural habitat types (riparian forest, riparian scrub-shrub, oak woodland, wetland, pond, canal, stream) at a ratio of at least 2:1.	Concur. The proposed mitigation and monitoring plan (Appendix D) proposes 2:1 compensation for impacts on natural habitats.
2. Should the feasibility study move forward, USACE should work with DWR and SBFCA to develop a variance to allow vegetation within the USACE vegetation-free zone to remain in place.	Concur. As part of the recommended RP, USACE proposes to investigate during the design phase the applicability of a variance to lessen loss of riparian vegetation.
3. Work with USFWS on development of the mitigation area.	Concur. USACE and SBFCA will coordinate implementation of mitigation features.
4. Lands disturbed by construction activities, including the staging areas, should be reseeded with native grasses and forbs. Reseeding should be conducted just prior to the rainy season to enhance germination and plant establishment.	Concur. Site restoration following construction will include the seeding of native grasses in areas of disturbance prior to the rainy season to enhance germination and establishment.
5. Conduct pre-construction surveys for breeding birds, including state-listed Swainson's hawk and burrowing owl.	Concur. Preconstruction surveys would be conducted as recommended.
6. Develop and implement a vegetation monitoring program as part of the project. Monitoring the riparian restoration effort should focus on (a) recording tree survival rates, (b) the quantification of improved habitat values for wildlife (primarily bird species) by measuring percentage of tree and shrub cover, average height of overstory trees, canopy layering, and total woody riparian vegetation, and (c) developing recommendations for alternative methods of riparian restoration should initial efforts fail. A vegetation monitoring report should be submitted annually for the first 5 years after planting activities, and on the 10th, 15th, and 20th years after planting. The monitoring reports should also identify any shortcomings in the restoration effort and include remedial actions on how to improve restoration efforts. All phases of the revegetation and monitoring programs should be coordinated with, and approved by, USFWS, CDFW, and NMFS.	Concur. The proposed mitigation and monitoring plan (MMP) includes monitoring as part of the project (Appendix D). The details of the monitoring plan (periodicity, standards, and remedial actions) and the contents of the monitoring reports will be coordinated with USFWS, CDFW and NMFS to obtain their approval.
7. Comply with Conservation Measures and Terms and Conditions in the Biological Opinion.	Concur. Requirements of the Biological Opinion and Incidental Take Statement issued by USFWS will be met.
8. Complete the appropriate consultation with CDFW regarding impacts on state-listed species, and with NMFS, as required under Section 7 of the Endangered Species Act, for potential impacts on anadromous fish under NMFS jurisdiction.	Concur. USACE has completed consultation with NMFS on listed fish species. The results of consultation are included in this Final EIR/SEIS (Appendix D).
9. SB-7 and SB-8 (depending on the alternative selected) should mitigate for the loss of upland habitat due to erosion protection. Effects resulting from this action should be discussed both under the Fish and Wildlife Coordination Act as well as under the Federal and state endangered species acts.	Concur. The effects of levee landside slope erosion protection on upland habitats used by giant garter snake and the western borrowing owl were included in the Biological Opinion issued by the USFWS.
10. Initiate Section 7 consultation with USFWS on the effects of O&M activities on listed species.	Concur. Per the USFWS biological opinion, O&M activities will be consulted on when an O&M manual is prepared by USACE.

6.1.5 Farmland Protection Policy Act

The Farmland Protection Policy Act (FPPA) (7 USC Section 4201, et seq.) is implemented by the Natural Resources Conservation Service (NRCS). The purpose of this act is to minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses, and to ensure that Federal programs are administered in a manner that, to the extent practicable, will be compatible with state and local government, and private programs and policies to protect farmland. NRCS is authorized to review Federal projects to determine whether a project is regulated under the act and establish the farmland conversion impact rating for the project. As described in the FRWLP Final EIS, USACE provided NRCS with project information on Form NRCS-CPA-106 ("Farmland Conversion Impact Rating for Corridor Type Projects") to determine a Farmland Conversion Impact Rating for the FRWLP Preferred Alternative, Alternative 3. Projects are scored on a scale of 260 points, and under the FPPA, projects receiving a total score of less than 160 need not be given further consideration for protection and no alternative sites need to be evaluated (FPPA Rule 401.24, Section 658.4). The completed forms accompany the FRWLP Final EIS. The total score for the Butte County portion of Alternative 3 is 124 points, and the total score for the Sutter County portion of Alternative 3 is 118 points. Because the score was less than 160 points, no further consideration for protection and additional alternatives must be evaluated. This conclusion is applicable to the Sutter Basin Pilot Feasibility Study because the same general project area is being assessed and the amount of farmland permanently impacted by Alternative SB-8 would be less than under the FRWLP (Section 4.6, *Agriculture, Land Use, and Socioeconomics*).

6.1.6 Clean Water Act

Construction of the RP would require compliance with Sections 404, 401, and 402 of the Clean Water Act (CWA) (33 USC Sections 1344, 1341, and 1342). Some placement of fill within jurisdictional wetlands and waters of the United States is required for the project, which is detailed in Section 4.7, *Vegetation and Wetlands*. USACE has responsibility for issuing permits pursuant to Section 404. However, by regulation, a USACE Section 404 permit is not required for USACE Civil Works projects (33 CFR Sections 323.3(b) and 322.3(c)). The RP must be evaluated pursuant to Section 404(b)(1) of the Clean Water Act in accordance with the guidelines promulgated by the Environmental Protection Agency (EPA) (40 CFR Section 230) for evaluation of the discharge of dredged or fill material into waters of the United States. The proposed discharge must represent the least environmentally damaging practicable alternative and would include all appropriate and practicable measures necessary to minimize adverse effects on the aquatic environment. The work would not result in the unacceptable degradation of the aquatic environment. A Section 404 (b)(1) evaluation has been prepared for the RP and is included in Appendix D.

Unavoidable effects on approximately 5.79 acres of waters of the United States would result from RP implementation. Relocation of the Sutter Butte Canal has been minimized to the extent feasible to avoid effects on CWA Section 404 jurisdictional waters. Onsite replacement of 4.07 acres would occur in conjunction with relocation of the canal. Remaining acreage impacts would be mitigated at a mitigation bank.

A Section 401 State Water Quality Certification for activities associated with implementation of the RP would be required. Prior to construction, USACE would submit a 401 certification application to the Central Valley Regional Water Quality Control Board (Central Valley RWQCB). Pursuant to Section 402 of the CWA, the project would also require a National Pollutant Discharge Elimination

System permit, through the development of a Stormwater Pollution Prevention Plan, because the RP would disturb more than 1 acre of ground.

6.1.7 Clean Air Act

The Clean Air Act (CAA) (42 USC Section 7401, et seq.) mandates the establishment of national ambient air quality standards and regulations to reduce air pollutants. These air pollutants are also known as criteria pollutants. RP construction falls under the jurisdiction of the Butte County Air Quality Management District (BCAQMD) and the Feather River Air Quality Management District (FRAQMD). The districts determine whether project emission levels significantly affect air quality, based on Federal standards established by EPA and the California Air Resources Board (CARB). The districts would first issue a *permit to construct*, followed by a *permit to operate*, which would be evaluated to determine whether all facilities have been constructed in accordance with the permit to construct. Construction of the RP would result in the temporary increase in criteria pollutant emissions that is unavoidable and significant. Mitigation measures will be implemented in accordance with requirements determined by BCAQMD and FRAQMD. In addition, the proposed project is subject to the General Conformity Rule (42 USC Section 7596(c) (Section 176(c)) and its implementing regulation (40 CFR Section 93). The air quality analysis has concluded that a general conformity determination is not required because de minimis thresholds for nonattainment pollutants would not be exceeded (see Section 4.5.4.2). Implementation of the RP would not trigger a formal conformity determination under Section 176(c) of the CAA. Therefore, analyses in this integrated report indicate that the RP would comply with the CAA.

6.1.8 Executive Order 11988, Floodplain Management

This Executive Order (EO) requires USACE to provide leadership and take action to (1) avoid development in the base (1-in-100 annual event) floodplain, unless such development is the only practicable alternative; (2) reduce the hazards and risk associated with floods; (3) minimize the effect of floods on human safety, health, and welfare; and (4) restore and preserve the natural and beneficial values of the base floodplain. To comply with EO 11988, the policy of USACE is to formulate projects which, to the extent possible, avoid or minimize significant effects associated with use of the without-project floodplain, and avoid inducing development in the existing floodplain unless there is no practicable alternative. Compliance with the executive order is addressed in Chapter 7, *Recommended Plan*.

6.1.9 Executive Order 11990, Protection of Wetlands

This order directs USACE to provide leadership and take action to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands in implementing Civil Works projects. Wetlands have been avoided to the extent possible through design and siting of the RP. Unavoidable effects on approximately 9.59 acres of wetlands would result from implementing the RP. Wetland effects would be mitigated. Relocation of the Sutter Butte Canal has been minimized to the extent feasible to avoid effects on CWA Section 404 jurisdictional waters.

6.1.10 Executive Order 12898, Environmental Justice

The order requires all Federal agencies to identify and address, as appropriate, disproportionately high and significant human health or environmental effects of their programs, policies, and activities

on minority and low-income populations. Anticipated effects resulting from the RP were reviewed to determine whether low-income or minority neighborhoods would be disproportionately affected by the RP. No effects associated with environmental justice or social equity are anticipated as a result of the RP.

6.1.11 Executive Order 13514, Environmental, Energy, and Economic Performance

EO 13514 requires Federal agencies to set a 2020 greenhouse gas emissions reduction target; increase energy efficiency, reduce fleet petroleum consumption, conserve water, and reduce waste; support sustainable communities; and leverage Federal purchasing power to promote environmentally responsible products and technologies. USACE is requiring use of construction equipment that produces lower emissions and electricity-powered batch plants.

6.1.12 Executive Order 13112, Invasive Species

This order directs Federal agencies not to authorize, fund, or carry out actions that they believe are likely to cause or promote the introduction or spread of invasive species. To avoid introduction or spread of invasive species, USACE would ensure that appropriate control measures are implemented during project construction that would comply with applicable state and county invasive species control regulations.

6.1.13 Wild and Scenic Rivers Act

The RP complies with this act (16 USC Section 1271, et seq.) because no river segments designated as wild and scenic exist in the project area.

6.1.14 Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) (16 USC Section 703, et seq.) states that it is unlawful to kill, capture, collect, possess, buy, sell, trade, or transport any migratory bird, nest, young, feather, or egg in part or in whole without a Federal permit issued in accordance within the MBTA's policies and regulations. Several special-status bird species are known to forage in the project area and vicinity, and there is a possibility that one or more could establish a nest in or near the project area. The nest would be protected under the MBTA. To avoid possible disturbance to nesting birds, tree and brush removal should preferably take place during the non-nesting season. In the event that migratory birds are encountered onsite during project construction, every effort would be made to avoid take of protected birds, active nests, eggs, and young. Most effects resulting from the RP are anticipated to be short-term direct disturbances to migratory birds, which would likely temporarily avoid the construction area.

6.1.15 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Act (16 USC Section 1801, et seq.) establishes a management system for national marine and estuarine fishery resources. This legislation requires that all Federal agencies consult with NMFS regarding all actions or proposed actions that may adversely affect Essential Fish Habitat (EFH). Under the Magnuson-Stevens Act, effects on habitat managed under the Pacific Salmon Fishery Management Plan must also be considered. Consultation conducted with the NMFS determined that the proposed action would adversely affect EFH for Federally managed fisheries.

Pursuant to the Magnuson-Stevens Act, the NMFS, in their Section 7 ESA concurrence letter, provided conservation recommendations to avoid or further minimize adverse effects to EFH. The NMFS recommended that USACE strongly consider in the future design phase revising the proposed alignment of levees near the Sutter Butte Canal to avoid or further minimize waterside construction and that other options be considered in-lieu of strict adherence to the Vegetation ETL, including a variance, to allow existing waterside vegetation to remain. The NMFS EFH recommendations have been adopted by USACE.

6.1.16 Noise Control Act of 1972

Section 4(b) of the Noise Control Act (42 USC Section 4903(b)) directs Federal agencies to comply with applicable Federal, state, and local noise requirements with respect to the control and abatement of environmental noise. Construction equipment and vehicles would create localized, temporary noise effects. However, once construction is completed, background noise levels would return to usual levels. While most construction activities would occur in nonurban setting, analyses reveal that construction-generated noise would exceed regulatory noise thresholds and would result in significant effects on sensitive receptors that are not amenable to mitigation to a level of insignificance. Prior to construction, nearby local residents would be notified of the construction schedule. Staging areas would be sited to minimize effects on surrounding areas.

6.2 State Requirements

Many of the requirements of the State of California are codified under the Public Resources Code (PRC) as described below. Where a more common name for a law or regulation is typically used, the statute or regulation is listed by that name with a reference to the corresponding code section.

6.2.1 California Environmental Quality Act

CEQA (PRC Section 21000, et. seq.) requires disclosure of environmental effects, alternatives, potential mitigation, and environmental compliance of the proposed project. To comply with CEQA, SBFCA will finalize this EIR/SEIS and file a Notice of Determination.

6.2.2 California Fish and Game Code

Under Sections 1600–1616 of the California Fish and Game Code, CDFW regulates activities that would substantially divert, obstruct, or change the natural flow of a river, stream, or lake; substantially change the bed, channel, or bank of a river, stream, or lake; or use material from a streambed that falls under CDFW jurisdiction. Federal projects are not subject to California Fish and Game Code.

6.2.3 California Endangered Species Act

CDFW administers the California Endangered Species Act (CESA), which requires non-federal lead agencies to prepare documentation if a project may significantly affect one or more state-listed endangered species. Federal agencies are not subject to CESA. However, SBFCA is coordinating with CDFW in compliance with CESA.

6.2.4 Porter-Cologne Water Quality Control Act

Porter-Cologne (Water Code Section 13000, et seq.) designates RWQCBs as the primary state agencies with regulatory authority over California water quality and appropriative surface water rights allocations. Under Porter-Cologne and the CWA, the State is required to adopt water quality standards and waste discharge requirements to be implemented by the State Water Resources Control Board and the nine RWQCBs. The study area is within the Central Valley RWQCB's jurisdiction. Pursuant to Porter-Cologne, the Central Valley RWQCB establishes water quality standards and reviews individual projects for compliance with the standards. USACE will submit a CWA Section 401 State Water Quality Certification application as described under Section 6.1.6, *Clean Water Act.*

6.2.5 California Streets and Highways Code

The California Department of Transportation (Caltrans) is responsible for ensuring the safety and integrity of the state's highway system. Under California Streets and Highways Code Section 660, any encroachment on a state route must be approved by Caltrans. USACE would coordinate with Caltrans for any construction permitting.

6.2.6 California Clean Air Act

As discussed above under Section 6.1.7, BCAQMD and FRAQMD determine whether project emission sources and emission levels would significantly affect air quality based on Federal standards established by EPA and state standards set by CARB. The RP would be in compliance with all provisions of Federal and state Clean Air Acts.

6.2.7 California Land Conservation Act (Williamson Act) and Farmland Security Zone Act

The California Land Conservation Act of 1965, commonly referred to as the Williamson Act (Government Code Section 51200, et seq.), is a state policy administered at the local government level. The Williamson Act is intended to preserve agricultural and open space lands through contracts with private landowners. By entering into a Williamson Act contract, the landowner foregoes the possibility of converting agricultural land to nonagricultural use for a rolling period of 10 years in return for lower property taxes. No lands under Williamson Act protection would be affected in Sutter County and no further action is required. SBFCA will be responsible for addressing any Williamson Act issues in Butte County and is in the process of determining any Williamson Act triggers.

The Williamson Act was amended in 1998 to establish Farmland Security Zones. In return for a 20-year contract commitment, property owners are granted greater tax reductions. Neither Sutter County nor Butte County currently participates in the Farmland Security Zone program.

6.2.8 Administration and Control of Swamp, Overflowed, Tide, or Submerged Lands

Under PRC Section 6301, the State Lands Commission has exclusive jurisdiction over all ungranted tidelands and submerged lands owned by the State and the beds of navigable rivers, sloughs, and lakes. State ownership extends to lands lying below the ordinary high-water mark of tidal

waterways and below the low-water mark of nontidal waterways (Civil Code Section 830). The area between the ordinary high and low water on nontidal waterways is subject to a *public trust easement.* Projects such as bridges, transmission lines, and pipelines fall into this category. A proposed project cannot use these state lands unless a lease is first obtained from the State Lands Commission. The Commission also issues separate permits for dredging. For the RP, no state lands have been identified that require State Lands Commission review and approval.

6.3 Local Plans and Policies

Evaluating the level of compliance with locally adopted plans can be complicated due to the following: (1) the intentionally broad and unspecific goals articulated in local general plans; (2) the potential of a Federal project to influence the location, density, and rate of development in ways that differ from existing local plans and policies; and (3) the currency of local plans. The RP is located within the jurisdiction of the general plans of Sutter and Butte Counties and the Cities of Yuba City, Live Oak, and Gridley. As the non-federal sponsor representing Sutter and Butte Counties, SBFCA would ensure, to the extent practicable, that the RP complies with the provisions of all relevant local plans.

This chapter describes the Recommended Plan (RP), as well as the procedures and cost sharing required to implement the plan. A schedule and a list of further studies are also included.

7.1 Recommended Plan Identification

The plan identified as the RP is the Locally Preferred Plan (LPP), Alternative SB-8. This plan is justified and has a benefit to cost ratio of 2.6 to 1.0. Further, the LPP will comply with criteria of the California Government Code requirements for a 200-year level of protection for urban and urbanizing areas by 2025. This results in the northern urban areas achieving the State requirements, but not the southern portion of the basin Refer to Appendix C1b. Hydraulic Design and Analysis.

The Assistant Secretary of the Army for Civil Works (ASA[CW]), by Memorandum dated May 7, 2013, has approved an exception to National Economic Development (NED) policy for the Federal government to recommend a LPP over the NED Plan as the RP at NED level of Federal participation cost share. The estimated total project cost of the RP is $688,930,000; the estimated Federal cost share is $255,270,000, and the estimated non-federal cost share is $433,660,000, as shown in Table 7-2. The RP is described briefly below, including the specific cost share requirements associated with the approved policy exception. For more detailed information, refer to Chapter 3, *Plan Formation*, and to the appendices and supporting documentation.

7.1.1 Features and Accomplishments

The RP is a fix-in-place design to the existing Feather River West Levees divided into 41 levee reaches beginning near Thermalito Afterbay (Station 2368+00) and extending south to near Laurel Avenue (Station 180+00). The primary method of strengthening the existing levee would be the construction of soil-bentonite cutoff walls of various depths. The specific design features for the RP are listed in Table 7-1 and shown in Plate 7-1.

Table 7-1. Design Features of Recommended Plan

	Feature Description	Quantity
Alternative SB-8 Reach 2A-North to 41 180+00 to 2638+00 2013–2019	No Rehabilitation Required	28,220 LF
	Cutoff Wall Only	158,780 LF
	Jet Grouting Cutoff Wall Only	960 LF
	Seepage Berm Only	5,350 LF
	Cutoff Wall with Full Levee Degrade	600 LF
	Cutoff Wall with Existing Relief Wells	2,500 LF
	Cutoff Wall with Seepage Berm	7,670 LF
	Cutoff Wall with Levee Relocation	11,600 LF
	Cutoff Wall with Sutter Butte Canal Relocation	1,540 LF
	Cutoff Wall with Landside Toe Fill	1,870 LF
	Erosion Protection	7,660 LF
	Utility Improvements	142
	Utility Relocations	109
	Land Acquisition	2,196 acres
	Number of Effected Parcels	468
	Number of Potential Structural Demolition	34
	Closure Structure (stop log)	1

LF = linear feet.

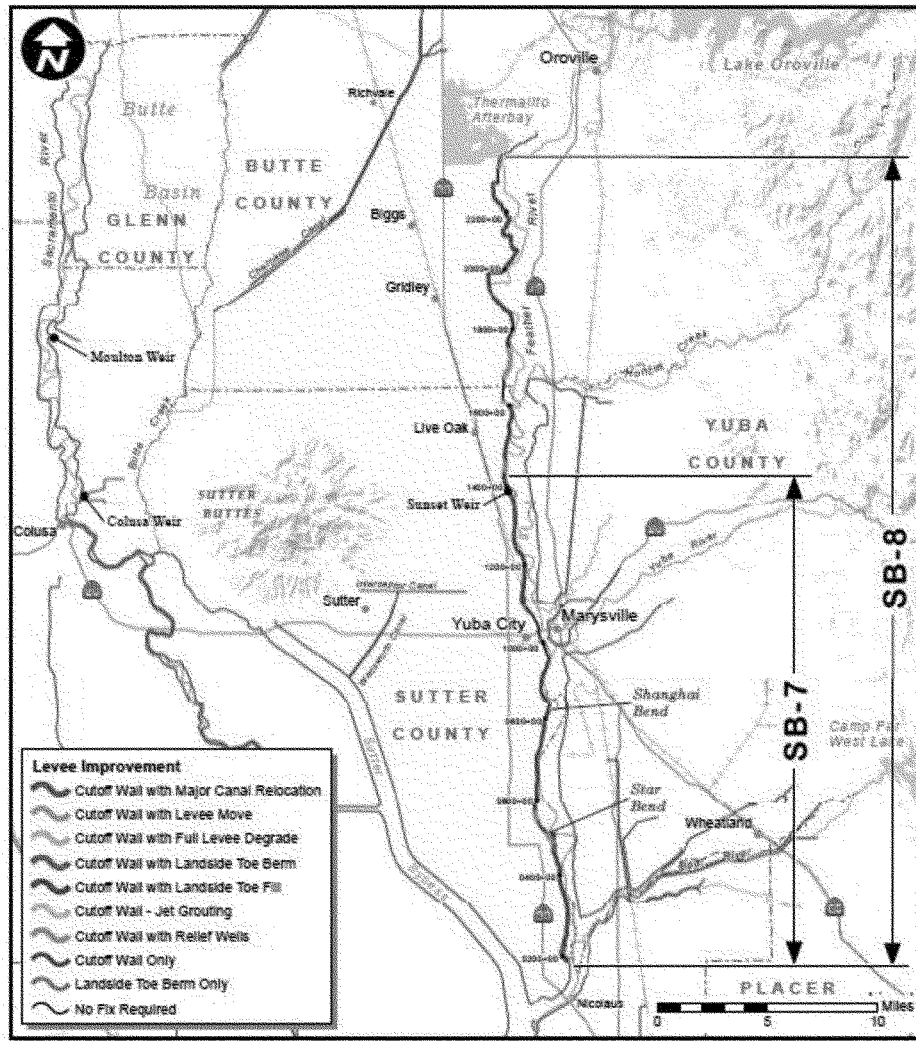


Plate 7-1. RP (SB-8) Levee Improvement and Proposed Design Feature

Table 7-2. Summary of Cost Sharing Responsibilities for the RP ($1,000)[a, b]

MCACES Account[c]	Account	Federal	Non-Federal	Total[d]
	NED Plan			
1	Land and Damages	$0	$42,390	$42,390
2	Relocations	$0	$28,542	$28,542
6	Fish and Wildlife	$4,797	$1,241	$6,038
11	Levees and Floodwalls	$190,596	$49,326	$239,922
18	Cultural Resources	$493	$127	$620
30	Preconstruction, Engineering, and Design	$43,086	$8,633	$51,719
31	Construction Management	$16,664	$4,312	$20,976
	Add Data Recovery	$1,633	$0	$1,633
	Percentage	65%	35%	100%
	Total First Cost (NED)	$255,270	$136,570	$391,840
	Recommended Plan: LPP Increment from NED to LPP			
1	Land and Damages	$0	$11,156	$11,156
2	Relocations	$0	$58,917	$58,917
6	Fish and Wildlife	$0	$1557	$1,557
11	Levees and Floodwalls	$0	$172,933	$172,933
18	Cultural Resources / Data Recovery	$0	$1,853	$1,853
30	Preconstruction, Engineering, and Design	$0	$35,831	$35,831
31	Construction Management	$0	$14,843	$14,843
	Total Incremental Increase	$0	$297,090	$297,090
	Total First Cost (LPP)	**$255,270**	**$433,660**	**$688,930**

Notes:

[a] Based on October 2013 price levels.

[b] Planning, Engineering, and Design costs incurred after completion of the Feasibility Report will be cost shared between the Government and the project sponsors in accordance with a Design Agreement. Upon initiation of project construction, all costs incurred under the Design Agreement will be included as part of the total project costs and subject to the project cost sharing requirements in accordance with the Project Partnership Agreement which will be executed prior to award of the first construction contract.

[c] Micro Computer-Aided Cost Engineering System (MCACES) is the software program and assorted format used by USACE in developing cost estimates. Costs are divided into various categories identified as "accounts." Detailed costs estimates are presented in Appendix C, part 4, Cost Engineering.

[d] Relocations estimate includes construction cost, design cost, and construction management cost associated with required relocations.

Required borrow materials for project construction are available within the Sutter Basin or close to the basin, and suitable borrow areas have been generally identified for the RP. Excavated materials from levee degradation are expected to be reusable. Haul routes are expected to consist primarily of existing public roads.

The RP includes additional risk reduction through levee superiority to allow for a more controlled failure of the levee due to prolonged overtopping. Two levee reach locations have been identified where levee overtopping could potentially first occur for large flood events. Because the RP is based upon an existing levee profile, the design top of levee was reviewed relative to the modeled mean water

surface profiles to determine the likely initial overtopping locations, which are located between Station 547+00 to 604+60, south of Yuba City, and between Station 1528+00 to 1601+00, north of Yuba City. Both locations are located in nonurbanized areas and the initial overtopping is estimated to occur between the mean 0.5% (1/200) Annual Chance Exceedance (ACE) and 0.2% (1/500) ACE flood events. At each location the landward side of the levee would be covered with anchored High Performance Turf Reinforced Mat (HPTRM). This design element would increase the erosion resistance of the levee slope and allow for a more controlled failure of the levee in the event of prolonged overtopping.

A number of known prehistoric and historic resources exist in the project area and more may be encountered in the course of further inventory work. Pursuant to a programmatic agreement between the USACE and the California State Historic Preservation Officer (SHPO), the USACE, in consultation with SHPO and interested Native American Tribes, would determine the specific area of potential effects for the project, inventory that area thoroughly for significant cultural resources, and resolve adverse effects to all significant resources identified. This work would entail subsurface prospection, test excavation, data recovery excavations, other alternative mitigations, and extensive open consultation.

Nonstructural measures to be implemented in conjunction with the RP are preparation of an emergency evacuation plan, identification of flood fight pre-staging areas, updates to the floodplain management plan, and flood risk–awareness communication.

Project performance statistics for the without- and with-project condition are shown on Tables 7-3 and 7-4, respectively. Figure 7-1 shows the residual 1% (1/100 year) ACE composite floodplain for the with-project condition. As shown, The RP provides significant flood risk management reduction to the urban areas of Yuba City, Live Oak, Gridley and Biggs, as well as to the rural agricultural areas east and north of Yuba City. The RP does not include measures to strengthen the existing levees along the Feather River south of Laurel Avenue or along the Sutter Bypass between Sutter Buttes and the Feather River. Plate 4-14 in Chapter 4, *Affected Environment and Environmental Consequences*, shows the residual 1% (1/100 year) ACE composite floodplain for the without-project condition.

A sensitivity analysis was performed on the effects of climate change on the economic analysis and is documented in the Hydrology Appendix. The hydrologic and economic analysis for estimating the impact of climate change in the selection of draft alternatives for the Sutter Basin Pilot Feasibility Study (SBPFS) indicates that the identification of the NED Alternative (SB-7) is not sensitive to the climate change scenarios. Further, the rationale for selection of the LPP (SB-8) would not be affected by climate change scenarios. The RP would significantly reduce residual flood risk to public and life safety over the NED Plan, as discussed in Chapter 3, *Plan Formation*.

Table 7-3. Project Performance by Economic Impact Area: Without-Project Condition

		Annual Exceedance Probability		Long-Term Risk			Assurance by Event			
Economic Impact	Breach Location	Median	Expected	10-yr Period	30-yr Period	50-yr Period	10%	2%	1%	0.20%
Biggs	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Gridley	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Live Oak	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Yuba City	F9.0R	0.04	0.04	33%	70%	86%	85%	67%	60%	22%
Rural Butte	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Rural Sutter	S4.0L	0.45	0.52	99%	100%	100%	33%	30%	22%	6%

Table 7-4. Project Performance by Economic Impact Area: With-Project Condition

Economic Impact	Breach Location	Annual Exceedance Probability		Long-Term Risk			Assurance by Event			
		Median	Expected	10-yr Period	30-yr Period	50-yr Period	10%	2%	1%	0.20%
Biggs	F9.0R	0.02	0.02	2%	7%	11%	99%	99%	97%	64%
Gridley	F9.0R	0.02	0.02	2%	7%	11%	99%	99%	97%	64%
Live Oak	F9.0R	0.02	0.02	2%	7%	11%	99%	99%	97%	64%
Yuba City	F9.0R	0.02	0.03	3%	8%	13%	99%	99%	99%	55%
Rural Butte	F9.0R	0.02	0.02	2%	7%	11%	99%	99%	97%	64%
Rural Sutter	S4.0L	0.45	0.52	99%	99%	99%	33%	30%	22%	6%

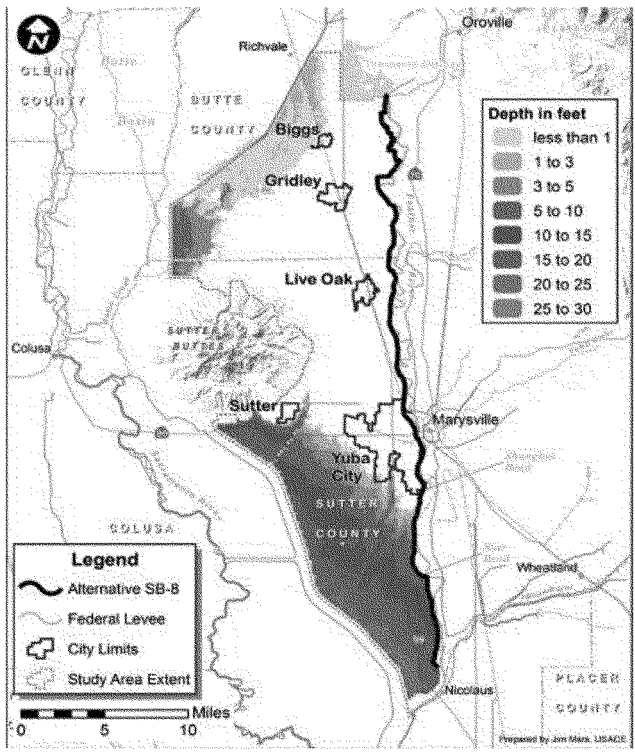


Figure 7-1. Recommended Plan: Residual 1% ACE Composite Floodplain under Alternative SB-8

7.1.2 Compliance with Engineering Technical Letter 1110-2-571

The RP is in full compliance with the Vegetation ETL, and maximum potential effects have been disclosed in this report. Environmental effects resulting from the RP construction have been identified in Chapter 4, *Affected Environment and Environmental Consequences*. Some direct effects on some riparian habitat and elderberry shrubs cannot be avoided, requiring the development of a mitigation and monitoring plan in consultation with appropriate resource agencies. During the preconstruction engineering and design (PED) phase, all options then available for compliance with the Vegetation ETL, including but not limited to the application and issuance of a variance to permit woody vegetation on the lower two-thirds of the waterside slope of the levee, will be considered.

Maintenance deficiencies for the Sutter Basin levees were identified in USACE's 2010 Periodic Inspection Report (PIR). A number of identified deficiencies have been addressed or repaired by the local levee maintaining agencies. Unwanted woody vegetation growth is one of the most significant remaining deficiencies. By letter dated March 28, 2013, the Central Valley Flood Protection Board indicated that the local levee maintaining agencies within the Sutter Basin, led by SBFCA, intend to develop and implement a System-Wide Improvement Framework (SWIF) plan to address deficiencies in order for the levee systems to regain eligibility for rehabilitation assistance under Public Law 84-99. A 2-year period was requested to develop the SWIF.

Based upon the letter of intent to develop a SWIF plan to achieve compliance with existing Operations and Maintenance (O&M) requirements, including vegetation removal, the SBPFS has assumed that there will be no deferred maintenance; i.e., the without-project condition will be fully compliant with existing O&M requirements. During construction, any unacceptable inspections items and deficiencies that have not been addressed in accordance with the SWIF, would be included in the government construction contract as a non-federal expense.

7.1.3 Hydraulic Mitigation

The only potential hydraulic effects would be project-induced increases in flood risk in adjacent or downstream areas. No identifiable hydraulic effects would be caused by the RP. Therefore, no hydraulic mitigation is required.

The RP includes the proposed realignment of 11,600 linear feet of existing levee where it lies directly adjacent to the Sutter Butte Canal. The modification would move the levee about 20 feet waterward to provide a 10-foot maintenance road between the canal and the project levee. To evaluate whether moving the levee waterward would affect water surface elevations and increase the potential risk of flooding, changes to flow, depth, duration, and velocity were estimated using a hydraulic model. The hydraulic model results were also used to perform a transfer of risk analysis using Risk and Uncertainty based methods.

The hydraulic model results indicated no measureable change in flow, depth, duration, and velocity within the Feather River (stage change less than 0.005 feet). The 20-foot realignment would be located where the levee toe is higher than the 0.5% (1/200) ACE water surface elevation. Therefore, any change in water surface elevation would only occur for flood events more rare than 0.5% (1/200) ACE. In addition, this study area reach of river is more than 5,000 feet wide, and the 20-foot realignment of the levee would be a small change in the overall hydraulic cross section of the river.

Transfer of flood risk was evaluated by comparing with-project and without-project levee performance values at index points throughout the study area. For purposes of evaluating system impacts, the risk

analysis is limited to hydrologic and hydraulic parameters and their uncertainties. This approach is consistent with Section 3.b (2) of the memorandum *Clarification Guidance on the Policy and Procedural Guidance for the Approval of Modifications and Alterations of Corps of Engineers Projects* (U.S. Army Corps of Engineers 2008). The analysis is described in detail in Appendix C1b, *Hydraulic Design and Analysis.*

Analysis of the RP (Alternative SB-8) found no transfer of flood risk. As described above, the hydraulic model created for Alternative SB-8 computed the same water surface elevations as Alternative SB-1 (No Action Alternative). Because the water surface elevations are the input to the Risk and Uncertainty model, and they did not change, there would be no change in the project performance and no transfer of flood risk.

7.1.4 Local Advanced Work

The RP includes the construction of a slurry wall to strengthen 3,400 feet of existing levee from station 478+68 to station 512+00 in the vicinity of Star Bend. In 2010, SBFCA constructed a setback levee in the same location to address historic under-seepage problems while providing for habitat enhancement opportunities. One of the non-federal project sponsors, SBFCA, requested credit consideration under Section 104 of the Water Resources Development Act (WRDA) of 1986 for this work to be applied toward the required non-federal cost share of any future Federal Sutter Basin project. By memorandum dated June 10, 2009, ASA(CW) approved the request for credit consideration.

In accordance with Engineer Regulation 1165-2-29: *Water Resources Policies and Authorities—General Credit for Flood Control* (1987), Section 104 crediting is limited to that part of the local work directly related to a flood risk management purpose. The local project is compatible with the RP as an acceptable substitute strategy. The locally constructed setback levee provides FRM improvements that are identical to those that would be provided by the RP's proposed work and will eliminate the need to construct the fix-in-place slurry wall section in the vicinity of Star Bend, as part of the RP. Section 104 credit will be the actual local cost associated with constructing the FRM features of the setback levee or the savings to the government by not having to construct the fix-in-place slurry wall, whichever is less, and will be evaluated in a crediting report to be prepared prior to execution of the Project Partnership Agreement (PPA).

Further local advance work includes SBFCA initiating construction of the local Feather River West Levee Project (FRWLP) that provides flood risk management benefits to the people and property within the Sutter Basin in advance of a Federal Sutter Basin project. The sponsor's intent is to seek Section 221 credit under WRDA 1986 to be applied toward the non-federal cost share of a Sutter Basin project. A Section 221 Memorandum of Understanding (MOU) was executed in advance of local construction as required by Engineer Regulation 1165-2-208: *Water Resources Policies and Authorities; In-Kind Contribution Provisions of Section 221 of the Flood Control Act of 1970* (as Amended 2012). Section 221 provides that credit may be afforded only if ASA(CW) determines that a material or service provided as in-kind contribution by a non-federal sponsor is integral to the project. To be integral to the project, the material or service must be part of the work that the Federal Government would otherwise have undertaken for construction of what is ultimately determined to be the Federal project. During the PED phase an Integral Determination Report will be prepared prior to execution of the PPA. Section 104 and Section 221 credit will be afforded only in accordance with the provisions of the PPA.

7.1.5 Operation and Maintenance, Repair, Replacement, and Rehabilitation

Existing project levees have continuing OMRR&R obligations, manuals, and agreements. The local sponsors have coordinated with the responsible OMRR&R districts and agencies of the RP levees. Annual operation and maintenance, repair, replacement, and rehabilitation (OMRR&R) cost is estimated to be $454,000, an increase of $22,000 over existing costs from existing OMRR&R commitments of the existing levees. Some primary OMRR&R responsibilities and factors evaluated are enumerated below.

- Slurry wall will not change long term maintenance or replacement costs.
- Wet penetration encroachments will be improved or replaced along the entire levee reaches.
- Dry encroachments such as power poles and vegetation will be reduced.
- Relief wells north of Shanghai Bend will be converted to observation wells.
- Right-of-way will be increased, so maintenance costs will increase to cover a larger vegetation management footprint. However, these costs will be offset by reduction in the need for periodic levee toe re-grading formerly caused by adjacent farming operations.
- Life cycle vegetation management maintenance costs will increase.

Once project construction is complete, the project levees would again be turned over to the non-federal sponsors (SBFCA and the Central Valley Flood Protection Board (CVFPB)), with an amended OMRR&R manual and a revised agreement. The non-federal sponsors would then be responsible for the continued OMRR&R of the levees with any amendments in accordance with the amended OMRR&R manuals and new signed agreements.

The annual cost for OMRR&R of the RP is estimated to be about $454,000. Additional detail on the OMRR&R can be found in the Civil Design Appendix C.

7.1.6 Real Estate

Acquisition of an estimated 402 acres in permanent levee easements, maintenance road easements, and temporary work area easements, 1,772 acres of potential borrow sites, and 71 acres of potential mitigation sites would be required for RP implementation, as discussed in the Real Estate Appendix. The non-federal sponsor would acquire these lands as part of the project. The project is estimated to require permanent and temporary easements on approximately 468 parcels. Approximately two to four parcels would need to be acquired in fee for onsite mitigation. The majority of the disposal material would be recycled at the potential borrow sites. Approximately 18,000 cubic yards of structural debris could be disposed of at the local landfills. The RP may require relocations of a total of 34 residential, 5 businesses, and 10 agricultural buildings. The majority of the relocations are located in Yuba City and the remaining relocations are located north of Yuba City. These relocations would comply with the Uniform Relocation Assistance and Real Property Acquisition Policies Act. The Uniform Act provides for fair and equitable treatment of persons whose property will be acquired or who will be displaced because of programs or projects financed with Federal funds. The total lands and damages real estate costs for the RP are estimated at $53,546,000. The total utility facility relocation costs are estimated at $87,459,000.

7.1.7 Plan Economics and Cost Sharing

The project first cost, estimated on the basis of October 2013 price levels, is $688,930,000. Estimated average annual costs are $33 million based on a 3.5% interest rate, a period of analysis of 50 years, and construction ending in 2023. The total average annual flood damage reduction benefits would be $87,000,000 with a benefit-cost ratio of 2.6 to 1.

The ASA(CW) has approved an exception to the policy that requires decision documents to recommend the NED Plan. The LPP would cost $297,090,000 more than the NED Plan. The non-federal sponsors would be responsible for the entire extra cost, which increased the non-federal cost share from $136,570,000 for the NED Plan to $433,660,000 for the LPP. The Federal cost share of $255,270,000 is the same for both the NED Plan and the LPP. A summary of cost sharing responsibilities is presented in Table 7-2.

Local interests have completed construction of the Star Bend setback levee to replace a section of the right bank of the Feather River levee to address critical under-seepage, and flow constriction issues. Prior to initiation of construction, local interests requested and by letter dated June 10, 2009, the ASA(CW) approved Section 104 credit consideration for the setback levee construction. In accordance with ER 1162-2-29, *General Credit for Flood Control*, in order to receive credit under Section 104, the local construction must be completed prior to project authorization. Construction of the setback levee was completed in 2010 at an estimated cost of $20,776,349. The Section 104 approval would allow design and construction dollars invested by the local sponsor to be considered for use as credit towards meeting the non-federal cost-share requirements for the project recommended by this feasibility study, if authorized. A determination of the actual value of the eligible work and amount of credit afforded will be made in accordance with the terms and conditions of the PPA for the project authorized by Congress.

7.1.8 Risk and Uncertainty

Risk and uncertainty is fundamental to all water resource planning and communication. As a pilot project, this study incorporated risk management framework principles and risk-informed planning into its plan formulation process.

- Risk analysis and communication was used following ER 1105-2-101, *Risk Analysis for Flood Damage Reduction Studies*, and EM 1110-2-1619, *Risk-Base Analysis for Flood Risk Management Studies.*
- Workshops were held for the project delivery team (PDT) at the start of the pilot study to institute risk-informed decision making into the planning process. An internal document called the risk register is a pilot study planning document developed and used to document and carry forward those risk management concepts.
- Uncertainty was captured through cost engineering's mandatory center of expertise risk assessment process to establish cost contingencies. The economic analysis developed ranges of economic outputs with mid and mean number ranges to best capture uncertainties and identify risks in the risk register.
- Risk and uncertainty ranges were further refined for costs and economics when the final array of alternatives was designed and evaluated to a feasibility level analysis (35%). This analysis confirmed the conceptual numbers were still within the established ranges of uncertainty, validating assumptions and risk decisions.

- The planning strategy addressed residual risk in the development of multi-objective evaluation metrics to assist in assessing alternatives in terms of critical infrastructure and life safety.

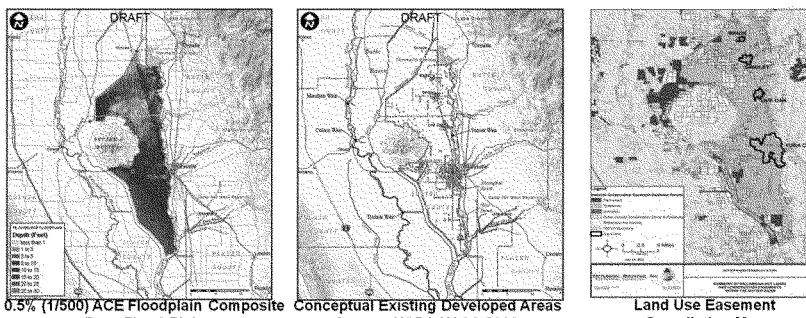
7.1.9 Executive Order 11988

Executive Order (EO) 11988 (May 24, 1977) requires a Federal agency, when taking an action, to avoid short- and long-term adverse effects associated with the occupancy and the modification of a floodplain. The agency must avoid direct and indirect support of floodplain development whenever floodplain siting is involved. In addition, the agency must minimize potential harm to or in the floodplain and explain why the action is proposed. Additional floodplain management guidelines for EO 11988 were provided in 1978 by the Water Resources Council.

The wise use of floodplains concept, as described in EO 11988, was incorporated as a life safety metric for this study. The metric "potentially developable floodplains" was used in the pilot study multi-objective planning process for evaluation and screening. This metric approach was based on pilot study objectives of applying qualitative rather than quantitative analysis; use of existing data/inventory; and professional team judgment. In calculating the potentially developable land metric for the Sutter Basin, the following areas were excluded.

- Areas that are currently developed.
- Areas that are owned in fee by governments or nonprofit organizations and that are protected for open space purposes.
- Areas with flood depths greater than 3 feet for the FEMA 1% (1/100) ACE base flood event because constructing buildings to meet FEMA floodplain management requirements is assumed to be cost prohibitive.
- Areas outside the 0.2% (1/500) ACE floodplain boundary. This prevents high topographic areas along Sutter Buttes from being included.

The 0.2% (1/500) ACE maximum floodplain was determined as the base floodplain. This area covers essentially the entire Sutter Basin outside the Sutter Buttes (Figure 7-2). Also, for baseline reference use only, a map of currently developed areas and a compilation map of existing easements were created (Figure 7-2).

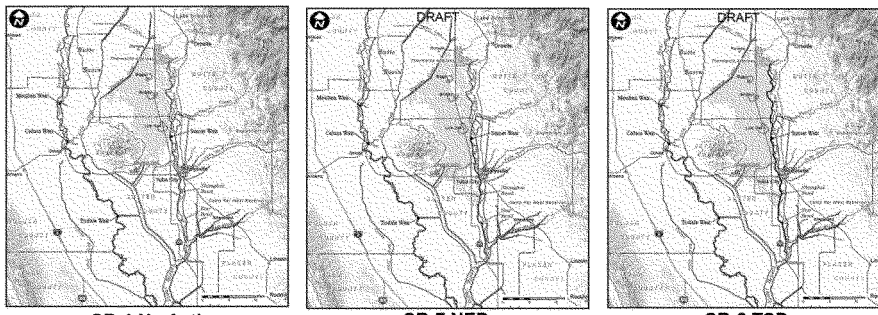


0.5% (1/500) ACE Floodplain Composite Base Flood Plain | Conceptual Existing Developed Areas Source: USDA NASS 2010 | Land Use Easement Compilation Map

(See the *Figures* folder on the CD for full-sized images.)

Figure 7-2. Baseline Information Maps

Using the criteria and assumptions listed above for determining potentially developable floodplain, maps were prepared and acreages were calculated for the No Action, NED Plan, and RP (Figure 7-3). These maps do not forecast future growth. Tables 7-5, 7-6, and 7-7 show the potentially developable land by economic impact area for the No Action Alternative, NED Plan and RP, respectively.



SB-1 No Action 72,000 acres | **SB-7 NED 88,000 acres** | **SB-8 TSP 100,000 acres**

(See the *Figures* folder on the CD for full-sized images.)

Figure 7-3. Potentially Developable Floodplain Comparison Maps

Table 7-5. Potentially Developable Land, Alternative SB-1 No Action

					Potentially Developable Acres			
						Acres by Residual 1/500 ACE Depth		
Economic Evaluation Area	Total Acres	Protected Acres	Developed Acres	Unprotected and Undeveloped Acres	Total	< 2 feet	2 to 15 Feet	>15 Feet
Town of Sutter	115	0	23	92	92	92	0	0
Yuba City Urban	15,748	46	8,379	7,323	872	0	872	0
Biggs Urban	758	0	298	459	230	0	230	0
Gridley Urban	1,286	0	643	643	620	69	551	0
Live Oak Urban	1,377	23	735	620	436	0	436	0
Sutter County Rural	95,914	1,148	5,188	89,578	25,298	2,870	22,429	0
Butte County Rural	68,526	8,838	3,145	56,543	44,284	12,420	31,864	0
Total	**183,724**	**10,055**	**18,411**	**155,257**	**71,832**	**15,450**	**56,382**	**0**

Table 7-6. Potentially Developable Land, Alternative SB-7: Fix In Place Feather River Levees: Sunset Weir to Laurel Avenue

					Potentially Developable Acres			
						Acres by Residual 1/500 ACE Depth		
Economic Evaluation Area	Total Acres	Protected Acres	Developed Acres	Unprotected and Undeveloped Acres	Total	< 2 feet	2 to 15 Feet	>15 Feet
Town of Sutter	115	0	23	92	92	92	0	0
Yuba City Urban	15,748	46	8,379	7,323	6,175	0	6,084	92
Biggs Urban	758	0	298	459	230	0	230	0
Gridley Urban	1,286	0	643	643	620	69	551	0
Live Oak Urban	1,377	23	735	620	436	0	436	0
Sutter County Rural	95,914	1,148	5,188	89,578	36,387	2,870	33,402	115
Butte County Rural	68,526	8,838	3,145	56,543	44,284	12,420	31,864	0
Total	**183,724**	**10,055**	**18,411**	**155,257**	**88,223**	**15,450**	**72,567**	**207**

Table 7-7. Potentially Developable Land, Alternative SB-8: Fix In Place Feather River Levees: Thermalito to Laurel Avenue

					Potentially Developable Acres			
						Acres by Residual 1/500 ACE Depth		
Economic Evaluation Area	Total Acres	Protected Acres	Developed Acres	Unprotected and Undeveloped Acres	Total	< 2 feet	2 to 15 Feet	>15 Feet
Town of Sutter	115	0	23	92	92	92	0	0
Yuba City Urban	15,748	46	8,379	7,323	6,221	0	6,129	92
Biggs Urban	758	0	298	459	459	0	459	0
Gridley Urban	1,286	0	643	643	643	69	574	0
Live Oak Urban	1,377	23	735	620	620	0	620	0
Sutter County Rural	95,914	1,148	5,188	89,578	39,118	2,870	35,583	666
Butte County Rural	68,526	8,838	3,145	56,543	53,076	12,420	40,634	23
Total	**183,724**	**10,055**	**18,411**	**155,257**	**100,230**	**15,450**	**83,999**	**781**

The NED Plan would result in an additional 16,000 acres of potentially developable floodplain consisting of 5,000 acres in the Yuba City urban area and 11,000 acres in the Sutter County rural area outside of Yuba City. The additional increment to implement the RP would result in an additional 12,000 acres of potentially developable floodplain consisting of 500 acres in the urban areas of Yuba City, Biggs, Gridley, and Live Oak; 2,700 acres in the Sutter County rural area; and 8,800 acres in the Butte County rural area.

Development does not occur in the absence of demand. Land use in the basin is primarily dominated by a strong agricultural-based economy and uses. This type of land use and economy does not support rapid, urbanized growth or demand. The necessary basin wide public infrastructure (i.e. roadways, water and sewer systems, and utilities) do not exist for urban growth, and would require a substantial investment from the State, local governments, and the development community. This

type of future investment is unlikely due to the lack of demand from consumers within and outside the basin.

The cities of Biggs, Gridley, Live Oak, and Yuba City are not currently mapped within the FEMA 100-year floodplain. Despite the lack of floodplain development restrictions, development in Biggs, Gridley, Live Oak, and Yuba City has been modest, even during the building boom of the early 2000s. The addition of FRM improvements this study will provide would not change the fundamental drivers of urban growth demand within the Sutter Basin. Lack of economic drivers and development restrictions in place at the local, state, and Federal level, will continue to control and limit urbanized development, even with implementation of the improvements to reduce the risk of flooding, such as the local FRWLP and the Sutter Basin project recommended by this report.

Table 7-8 presents 2070 population estimates for the Sutter Basin using growth rates developed by the Sacramento Area Council of Governments (SACOG). The population figures do not relate directly to demand for developable acreage. In order to estimate the demand for developable land necessary to accommodate the projected population presented in Table 7-8, the population growth rates were applied to existing developed acreage in each jurisdiction. The projected urban development within each city's Sphere of Influence (SOI) as shown in each General Plan is shown in the Tables 7-9 and 7-10.

Table 7-8. Population Projection within the Sutter Basin

		Projected Population (Year 2070) [b]	
Jurisdiction	**2010 Population [a]**	**Median Growth Rate**	**Est. Population**
Yuba City	64,925	2.5%	285,656
Live Oak	8,392	2.6% [c]	39,148
Biggs	1,707	5.2%	35,742
Gridley	6,584	3.5%	51,869
Sutter County	94,737	1.7%	260,482
Butte County	220,000	1.1%	424,123

[a] According to 2010 Census.
[b] Based on Sacramento Area Council of Governments (SACOG) growth rates.
[c] City of Live Oak Growth Rate used because SACOG estimate was not available for Live Oak.

Table 7-9. Projected Sutter County Developed Areas

Sutter County Growth Areas[a]	Existing Developed Acreage[b]	Projected New Urban Acreage from 2010–2030[c]	Projected New Urban Acreage from 2010–2070[d]
Yuba City SOI & Employment Corridor	8,965	12,019	30,479
Live Oak SOI	1,165	6,511	11,667 [e]
Other (Sutter & Tudor)	2,037	2,939	7,465
Subtotal Sutter County	**12,167**	**21,469**	**49,611**

[a] As indicated in the Sutter County General Plan Draft EIR.
[b] Acreage within the City limits is assumed to be fully developed.
[c] As indicated in the Sutter County General Plan Draft EIR. Does not subtract out existing development in the SOI.
[d] Assumes population projected growth rate of 2.6% also applies to urbanized development.
[e] Growth rate of 2.6% applied to new acreage in 2030 (6,511 acres)
SOI = Sphere of Influence.

Table 7-10 Projected Butte County Developed Areas

Butte County Growth Areas	Existing Developed Acreage	Projected New Urban Acreage from 2010-2030[a]	Projected New Urban Acreage from 2010-2070[d]
Biggs SOI	414[b]	541[b]	8,524
Gridley SOI	1,300[c]	2,900[c]	8,941
Subtotal Butte County	5,155	3,441	17,465
Total for Sutter & Butte County	**17,322**	**24,910**	**67,076**

[a] Does not subtract out existing development in the SOI
[b] As indicated in the City of Biggs General Plan
[c] Acreage values not included. Gross acreage scaled off map in Gridley General Plan
[d] Assumes projected growth rate of 5.2% and 3.5% for Biggs and Gridley, respectively. Same growth rates also apply to urbanized development.

The data presented in Tables 7-9 and 7-10 indicate that only about 67,000 new acres are projected to be developed by 2070 within the basin, assuming SACOG projected growth rates are maintained beyond 2030. Furthermore, Yuba City accounts for about half of the demand for developable acreage (approximately 30,000 acres). This estimated projected new urban acreage is far less than the Potentially Developable Land under the No Action, NED, and RP alternatives. This data indicate the estimated demand by 2070 for approximately 67,000 acres of developable land—far less than the 71,800 acres of Potentially Developable Land to be available in the basin under the No Action Alternative.

The developable acreage shown in Table 7-5 is primary located in the northern basin, where current flooding depths are relatively shallow. Land located in the deep floodplain in the southern portion of the basin would not be removed from the floodplain under any alternative, and is, therefore, not included in the potentially developable acreage. The eight-step EO 11988–Floodplain Management

evaluation process is outlined below with discussion of the RP formulation process to demonstrate coordination and compliance with the EO.

Step 1: Determine if a proposed action is in the base floodplain (1/100 year floodplain or 1% ACE).

The proposed RP is within the defined base floodplain. The RP proposes to improve the structural integrity of existing Feather River Federal levees in the Sutter Basin to the authorized levee design elevation, reducing flood risk and addressing residual risk to public and life safety. These levees are part of the overall SRFCP.

Step 2: If the action is in the floodplain, identify and evaluate practicable alternatives to locating in the base floodplain.

The study evaluated all practicable measures and alternatives by following the six-step planning process and evaluating a wide range of measures and alternatives using pilot initiatives of available information, professional judgment, and risk-informed decision making. Practicable alternatives and measures (structural and nonstructural) that were considered included those listed below.

- Construction of Marysville Reservoir: This was screened out because of foundation conditions.
- Improvement of Butte Bypass: This was screened out because of high cost and because it did not address geotechnical levee failure modes.
- Removal of existing development: This was not considered a practicable alternative.
- Ring levees: They were determined not cost effective because of high environmental effects.
- Flood proofing and raising existing structures and infrastructure: This was determined not cost effective.
- Reservoir reoperation: This alternative was screened out because of potential systemwide effects, and because it did not address geotechnical levee failure modes.
- Fix geotechnical issues of existing Federal levees: These measures were retained.

Step 3: Provide public review.

The public has been advised through the integrated NEPA/CEQA process and proposed outreach program. The NEPA/CEQA process requires and provides for public disclosure through various means, such as scoping meetings, public notices, websites, direct mailing, and presentations to various agencies and small groups.

A more detailed accounting of the scoping process is provided in Chapter 5, *Consultation and Coordination.*

Step 4: Identify the impacts of the proposed action and any expected losses of natural and beneficial floodplain values.

The proposed fix-in-place levee improvements under the NED Plan and the LPP minimize the direct impact on the floodplain by confining levee improvements to the existing Feather River West Levees. Because the existing levees are set back from the active channel of the Feather River for the majority of the study area, the wide riparian floodplain waterside of the levees would largely remain unaffected by the project. The total area of floodplain along the right bank of the Feather River adjoining the study area is about 7,650 acres. In its current setback condition, the river will continue to provide opportunity for natural processes that enhance fish and wildlife habitat.

Project construction would cause some loss of floodplain riparian vegetation but would not significantly diminish existing floodplain natural values. Only where existing riparian vegetation abuts the levee toes and is within the Vegetation ETL vegetation-free zone would vegetation be impacted by the project. To compensate for vegetation losses, both the NED Plan and LPP propose revegetation of the floodplain restoration area created at the Star Bend levee setback. This proposal has received strong conceptual support from the fish and wildlife resource agencies. Mitigation at Star Bend represents biodiversity and ecological structure and patch size that far outweigh the individual trees for which the mitigation compensates.

Natural floodplain values located landward of the project levees could be affected by future growth in the Sutter Basin study area. However, any future growth is expected to come from conversion of agricultural land or urban infill rather than from conversion of natural areas. The majority of the land within the study area is in agricultural use. Much of the natural habitat that existed historically has been lost to agriculture and urban development. Only about 12.4% of the land is in natural habitat and these lands are located in State and Federal refuges and other permanently protected areas.

Beneficial impacts of the proposed RP are listed below.

- The probability of flooding of existing infrastructure and agricultural land will be reduced.
- Annualized economic losses to existing infrastructure and agricultural land will be reduced.
- Annualized potential hazardous waste and toxic releases due to flooding of storage areas and infrastructure will be reduced.
- Annualized flood recovery cleanup and disposal tonnage will be reduced.
- Risk to public and life safety due to flooding will be reduced.

Adverse impacts of the proposed RP are listed here.

- Potential for increased development within the areas removed from the currently defined base floodplain. These areas are on the landside of the existing levee system and consist of areas with existing urban communities and agriculture areas in current production.
- Short-term environmental impacts due to construction activities within the project footprint. Impacts are expected to be greatest at the location of seepage berms and lowest where slurry walls would be constructed.

Step 5: Minimize threats to life and property and to natural and beneficial floodplain values. Restore and preserve natural and beneficial floodplain values.

Addressing the geotechnical issues by fixing-in-place the existing Federal levees was determined to be the most effective and cost-efficient measure. No existing floodplain values were changed.

A wide range of measures and alternatives was evaluated that would cost effectively lower flood risk and reduce residual risk to life safety in the northern basin and the towns of Biggs, Gridley, Live Oak, and parts of Yuba City with minimal additional environmental short- and long term-impacts. Chapter 3, *Plan Formation*, compares these alternatives with the RP. Some potential mitigation measures to minimize threats and risk are listed below.

- A flood warning and evacuation plan would be incorporated into the alternative.

- A proposed strategy to control development in the potentially developable land that becomes available due to SB-8.
- A flood risk–awareness program.

Further, in conjunction with the FRWLP project, SBFCA has entered into an MOU with the American Rivers and other parties, as documented in the FRWLP EIS. The signatories to the MOU have agreed to work jointly to seek funding for and to pursue additional elements of a multi-objective approach for the Feather River watershed beyond the FRWLP to further reduce flood risk to the Sutter Basin, mitigate for past degradation of the Feather River ecosystem from facilities of the State Plan of Flood Control, and to advance the objectives of the Central Valley Flood Protection Plan. Such activities would include the following measures.

- In partnership with the Three Rivers Levee Improvement Authority, enhancing and expanding restoration as part of a levee setback area on the east side of the Feather River to serve as habitat mitigation as a near-term component of the FRWLP and other projects as described in the preliminary approved California Department of Water Resources FloodSAFE Environmental Stewardship and Statewide Resources Office grant application signed by SBFCA.
- Developing and implementing a multi-benefit project in the Oroville Wildlife Area to decrease water surface elevations in the Feather River, restore and improve floodplain habitat, improve flood operations, and reduce maintenance costs.
- Creation of approximately 20 acres of riparian habitat by SBFCA in addition to the approximately 20 acres already created by Levee District 1.
- A multi-benefit project at Abbott Lake that would provide levee borrow material to support levee reconstruction while modifying the floodplain surface to be beneficial to fish and wildlife.
- The potential for a setback levee south of Laurel Avenue if there is a willing seller and local support. The project would achieve 100-year flood protection for the southern portion of the basin and help to create a mosaic of riparian floodplain habitat and agriculturally productive land that produces flood management benefits for the Sutter Basin.
- An environmental restoration project located at Nelson Slough as identified by the Lower Feather River Corridor Management Plan.
- A State funded program to purchase agricultural easements from willing sellers to promote agriculture and to meet ecosystem restoration goals identified in the Central Valley Flood Protection Plan and as a public safety strategy to manage long-term risk in the floodplain.

Step 6: Reevaluate alternatives.

A full range of alternatives was analyzed and evaluated using planning criteria of acceptability, effectiveness, efficiency (NED), and completeness. Evaluation metrics framed around life safety were developed with one metric, potentially developable floodplains, developed specifically to address EO 11988. Multi-objective planning looked beyond cost effectiveness and into residual risk and life safety. See Chapter 3, *Plan Formation*, for a comparison of the RP with other alternatives.

Step 7: Issue findings and a public explanation.

The public has been kept advised through the NEPA/CEQA process. To conclude the NEPA process, a record of decision for the early implementation programs (EIPs) will be publically issued following approval of the Final EIS. To conclude the CEQA process, findings will be publically issued following

certification of the Final EIR. A public workshop will be conducted during the Draft EIS/SEIR stage, and a public hearing will be held to decide on project adoption by SBFCA as an action under CEQA.

Step 8: Implement the action.

Alternative SB-8 is the proposed RP.

7.1.10 Natural Floodplain Values

The Sutter Basin study area consists of a natural basin bounded by the Sutter Buttes and a series of mostly Federal levees that are part of the SRFCP (See Plate 1-2) that was completed and documented in 1957. The two main levee elements that define the Sutter Basin are the Sutter Bypass on the west side and the Feather River on Sutter Basin's eastern boundary. The Sutter Bypass is a primary bypass flood structure of the SRFCP during high-water events. The bypass has no defined natural floodplain but has within its boundaries high-value agricultural areas for wintering waterfowl.

Unlike on the Sacramento River, the levees of the Feather River are mostly set back hundreds of feet from the main river channel and bank. Within these waterside setback areas are agricultural and significant remnant riparian areas that are still considered connected to the natural river floodplain with high habitat values. Several wildlife conservations areas are located within these setback areas.

The landside of the leveed basin is primarily agricultural. The natural floodplains were redefined when Sutter Basin was leveed in the early 20th century to reduce risk of flooding to agricultural and urban areas. Remnant but disconnected natural floodplain areas or habitats within the Basin are mostly now in conservation easements or preserve areas that are secured from future development. These conservation easements in conjunction with rice production fields provide high-value stop over areas for the Pacific Flyway migration. (For land use easement compilation map, see Figure 7-2 and associated figures appendix).

The RP effect of induced development in the Sutter Basin's remnant and isolated natural floodplain and habitat areas would be minimal. As stated, the natural floodplains are already disconnected by the existing levee while the majority of natural riverine connected areas remains landside. Other natural floodplain values of groundwater recharging and water quality would be minimally affected by induced development.

7.1.11 Residual Risk

The RP would strengthen approximately 41 miles of existing Feather River levees from Thermalito Afterbay to Laurel Avenue, just south of Yuba City. The RP would provide FRM benefits to the urban areas of Yuba City, Live Oak, Gridley and Biggs, as well as to the rural agricultural areas around the urban areas. The RP incorporates levee superiority by providing landward erosion protection at two initial overflow locations to allow for a more controlled failure and increased evacuation time in the event of hydraulic capacity exceedance. To further increase the resiliency, initial overtopping locations were selected both upstream and downstream of the Yuba River to account for the hydrologic possibility of storms centered over the Feather River or Yuba River watersheds (or both). The remaining 3.3 miles of Feather River levee downstream of Laurel Avenue to the Sutter Bypass, and 18 miles of Sutter Bypass levee will not be strengthened in the RP. Levee assurance within these reaches will continue to be limited by geotechnical conditions.

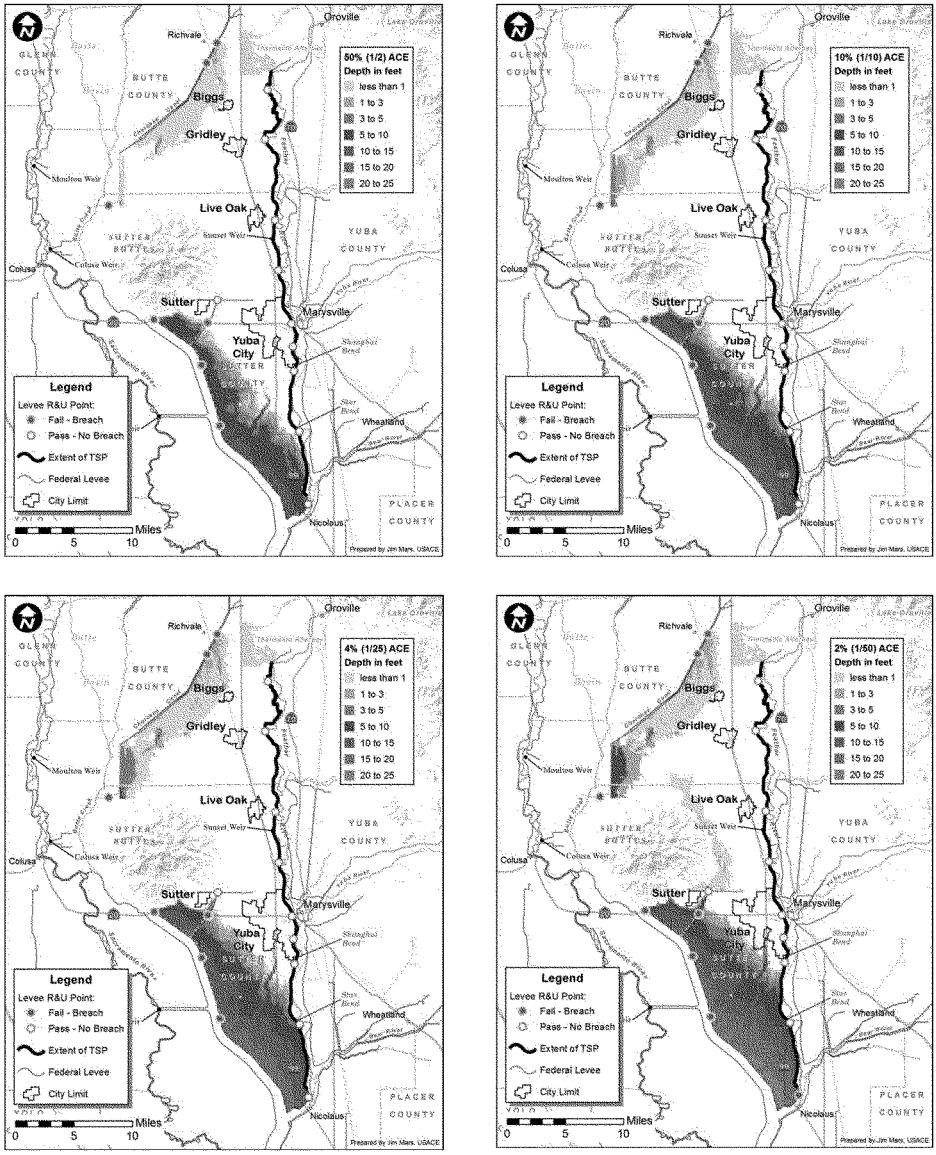
Residual flood risk related to the strengthened levee reaches will be primarily related to overtopping type levee breaches which are forecasted in advance. In comparison, the remaining reaches will have a significantly higher probability of an unforecasted geotechnical-related levee breach prior to overtopping.

Residual flood risk after completion of the RP would vary throughout the study area. Figures 7-4 and 7-5 depict the composite floodplains for flood magnitudes ranging from 50% (1/2) ACE to 0.2% (1/500) ACE. The maps show that the probability of flooding in the northern and Yuba City portions of the study area would be substantially less than in the southern portion of the study area. The following provides a narrative description of residual flood risk within the study area. Flood stages and geotechnical performance are uncertain and actual flood scenarios are highly variable.

The primary source of residual flood risk for the northern urban areas Live Oak, Gridley, and Biggs would be from infrequent large flood events that overtop the existing Feather River levees. As discussed in Appendix C1a, *Hydrology*, and summarized in Section 4.2.2.5.2, an overtopping flood event would likely be preceded by flood warning and river guidance issued by the National Weather Service (NWS) and CNRFC five days in advance. A more accurate warning would likely be made 24 to 36 hours in advance. Initial overtopping would likely start to occur in the superiority reaches with landward erosion protection described above followed by a breach of the levee. The populated areas are located 1 to 2 miles away from the Feather River and evacuation of the northern area would likely occur prior to the overtopping levee breach.

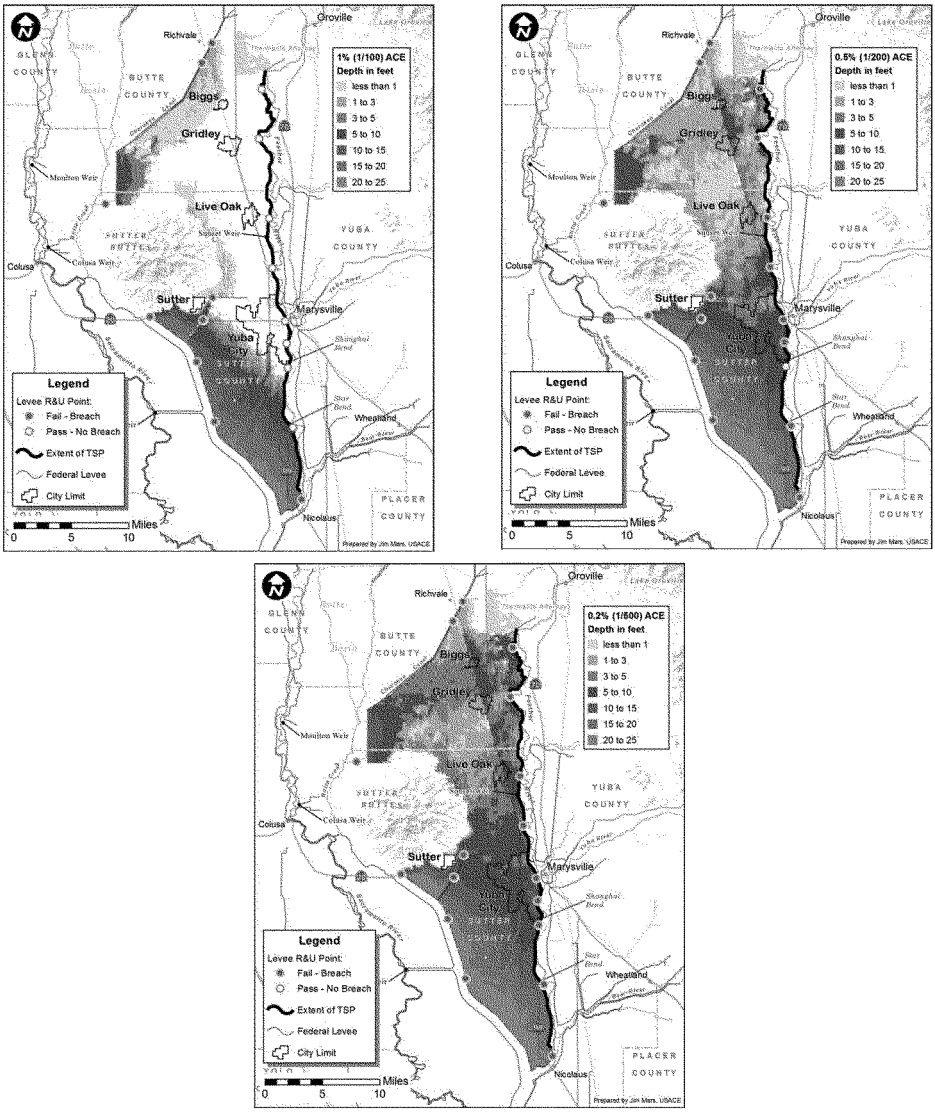
The primary source of residual flood risk for the Yuba City area will also be from infrequent large flood events that overtop the existing Feather River levees. An overtopping flood event would likely be preceded by flood warning and river guidance issued by the NWS and California Nevada River Forecast Center (CNRFC) 5 days in advance. A more accurate warning would likely be made 24 to 36 hours in advance. Initial overtopping would likely start to occur in the levee superiority reaches with landward erosion protection followed by a breach of the levee. A breach to the north of Yuba City would result in flood flow southwest, flanking most of the urban area. A breach to the south of Yuba City would also result in flood flow southwest and which would fill the southern portion of the Basin, then back up into the southern outskirts of Yuba City. Yuba City is located adjacent to the Feather River levees at the confluence of the Yuba River. As a result, the consequences of a levee breach along this reach would be the largest of the three areas described.

The primary source of residual flood risk for the southern rural agricultural area of the Sutter Basin would continue to be from unforecasted geotechnical failure of the levees on the Feather River south of Laurel Road and along the Sutter Bypass. This southern area is at the lowest elevation within the Sutter Basin. Geotechnical levee breeches often occur with little advance warning. A breach in the southern portion of the Sutter Basin would result in a flood flow that would extend along the levee at lower elevations and then spread slowly north and up to the Yuba City area. The areas of highest life safety risk would be near the levee breach, where velocities and inundation times would be the fastest. Evacuation would be directed to the north in advance of the expanding floodwaters. However, this would area would pose an extremely high life safety risk for anyone trapped while evacuating. The floodwaters along the southern portion of this area could achieve depths as great as 25 feet, well above the roof tops of most structures.



(See the *Figures* folder on the CD for a full-sized image.)

Figure 7-4. 50% ACE, 10% ACE, 4% ACE, and 2 % ACE Composite Floodplains



(See the *Figures* folder on the CD for a full-sized image.)

Figure 7-5. 1% ACE, .05% ACE, and .02 % ACE Composite Floodplains

7.1.11.1 Floodplain Population

The estimated 2010 population within the residual composite floodplains of the No Action Alternative and RP are provided Tables 7-11 and 7-12, respectively. The estimates were made by comparing the population within 2010 census blocks to the composite floodplains. The estimates are made for all floodplain depths greater than zero feet.

Table 7-11. Population within No Action Alternative Residual Composite Floodplains

	People within Floodplain depths greater than 0 feet						
Economic Evaluation Area	50% (1/2) ACE	10% (1/10) ACE	4% (1/25) ACE	2% (1/50) ACE	1% (1/100) ACE	0.5% (1/200) ACE	0.2% (1/500) ACE
Biggs Urban	0	1,452	1,452	1,452	1,452	1,452	1,763
Gridley Urban	0	6,379	6,379	6,379	6,379	6,379	6,379
Live Oak Urban	0	4,408	8,362	8,362	8,362	8,362	8,362
Yuba City Urban	0	67,351	67,368	67,368	67,368	67,368	67,368
Butte County Rural	0	4,338	4,776	4,788	4,788	4,793	4,899
Sutter County Rural	1,089	5,346	6,260	6,260	6,269	6,300	6,344
Total	**1,089**	**89,274**	**94,597**	**94,609**	**94,618**	**94,654**	**95,115**

Table 7-12. Population within RP Residual Composite Floodplains

	People within Floodplain depths greater than 0 feet						
Economic Evaluation Area	50% (1/2) ACE	10% (1/10) ACE	4% (1/25) ACE	2% (1/50) ACE	1% (1/100) ACE	0.5% (1/200) ACE	0.2% (1/500) ACE
Biggs Urban	0	19	19	19	19	1,452	1763
Gridley Urban	0	0	0	0	0	6,379	6379
Live Oak Urban	0	0	0	0	0	8,362	8362
Yuba City Urban	0	43	255	2,756	3,467	37,115	67,368
Butte County Rural	0	9	9	9	18	4,793	4,899
Sutter County Rural	1,089	1,718	2,110	2,938	3144	6,293	6,344
Total	**1,089**	**1,789**	**2,393**	**5,722**	**6,648**	**64,394**	**95,115**

7.1.11.2 Life Safety

Population within floodplains with high life loss potential was defined as the population of grid elements with flood depths greater than 15 feet, as rooftops of single story houses would be underwater. The estimated 2010 populations within residual composite floodplains with depths greater than 15 feet are provided in Tables 7-13 and 7-14 respectively. The estimates were made by comparing the population within 2010 census blocks to the composite floodplains. The estimates are made for all floodplain depths greater than 15 feet.

Table 7-13. Population within No Action Alternative Residual Composite Floodplains Depths Greater Than 15 Feet

	People within Floodplain depths greater than 15 feet						
Economic Evaluation Area	50% (1/2) ACE	10% (1/10) ACE	4% (1/25) ACE	2% (1/50) ACE	1% (1/100) ACE	0.5% (1/200) ACE	0.2% (1/500) ACE
Biggs Urban	0	0	0	0	0	0	0
Gridley Urban	0	0	0	0	0	0	0
Live Oak Urban	0	0	0	0	0	0	0
Yuba City Urban	0	0	137	137	137	303	934
Butte County Rural	0	0	0	0	0	0	0
Sutter County Rural	0	499	774	944	958	1,059	1,183
Total	**0**	**499**	**911**	**1,081**	**1,095**	**1,362**	**2,117**

Table 7-14. Population within RP Residual Composite Floodplain Depths Greater Than 15 Feet

	People within floodplain depths greater than 15 feet						
Economic Evaluation Area	50% (1/2) ACE	10% (1/10) ACE	4% (1/25) ACE	2% (1/50) ACE	1% (1/100) ACE	0.5% (1/200) ACE	0.2% (1/500) ACE
Biggs Urban	0	0	0	0	0	0	0
Gridley Urban	0	0	0	0	0	0	0
Live Oak Urban	0	0	0	0	0	0	0
Yuba City Urban	0	0	0	0	0	0	934
Butte County Rural	0	0	0	0	0	0	0
Sutter County Rural	0	0	4	231	303	774	1,183
Total	**0**	**0**	**4**	**231**	**303**	**774**	**2,117**

The USACE Levee Screening Tool (LST) was used to provide an initial quantitative life safety risk. The LST is intended to assist local, state, and Federal stakeholders in identification and prioritization of funding needs for levees of concern. The resulting Life loss estimates for a levee breach in an un-strengthened reach during a flood event near the top-of-levee (approximately a 0.5%, 1/200 ACE event) after construction of the RP are provided in Table 7-15.

Table 7-15. Life Loss Estimate

	No Action		RP	
Community	Day	Night	Day	Night
Biggs	6	8	0	0
Gridley	26	33	0	0
Live Oak	34	43	0	0
Yuba City	276	348	14	18
Rural Butte	20	25	0	0
Rural Sutter	26	32	13	16
Total	**388**	**489**	**27**	**34**

7.1.11.3 Critical Infrastructure

Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy from a national perspective. Most commonly associated with the term are facilities for fire stations, police stations, hospitals, senior living facilities, and prisons. Table 7-16 provides an estimate of the numbers of critical infrastructure that would remain within the 1% (1/100) ACE residual floodplains of the No Action Alternative and RP.

Table 7-16. Critical Infrastructure in Floodplain

	Number of Critical Infrastructure Facilities	
Community	No Action	RP
Biggs	1	0
Gridley	3	0
Live Oak	4	0
Yuba City	19	0
Rural Butte	0	0
Rural Sutter	1	1
Total	**28**	**1**

7.1.11.4 Economic Damages

The residual estimated annual damages after completion of the RP are described in Table 7-17.

Table 7-17. Residual Expected Annual Damages, October 2013 Prices (Values in $1,000s), 3.5% Discount Rate

	Expected Annual Damages ($1,000)	
Community	No Action	RP
Biggs	951	352
Gridley	3,052	452
Live Oak	3,293	529
Yuba City	70,929	10,483
Rural Butte	34,75	1,558
Rural Sutter	54,841	36,141
Total	**136,541**	**49,515**

7.2 Environmental Operating Principles

The USACE Environmental Operating Principles (EOP) are an integral part of the guidance and philosophy for the planning process. They are:

- Foster Sustainability as a way of life throughout the organization.
- Proactively consider environmental consequences of all Corps activities and act accordingly.
- Create mutually supporting economic and environmentally sustainable solutions.
- Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps, which may impact human and natural environments.
- Consider the environment in employing a risk management and systems approach throughout life cycles of projects and programs.
- Leverage scientific, economic and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner.
- Employ an open, transparent process that respects views of individuals and groups interested in Corps activities.

The EOP were incorporated into Sutter Basin Pilot planning process and recommendation through its basis of multi-objective analysis and evaluation using the system of accounts. The system of accounts (national economic development, environmental quality, regional economic development, and other social effects (See Section 3.4.2)) provides a framework for considering the broad array of effects of the alternative plans beyond what is normally considered in the NED analysis. The EOPs were essential in identifying a plan formulation strategy that balanced urban, rural, agricultural, and natural elements within the Sutter Basin. Avoidance of adverse environmental impacts, followed by minimization and then compensation of unavoidable, significant adverse impacts, is the formulation direction that that was followed in accordance NEPA and other environmental laws.

The Pilot Process incorporated all the principles, but was particularly effective with environmental and economic consequences, risk management, collaboration, and an open, transparent process to the public, local sponsors, and the USACE teams.

7.3 USACE Campaign Plan

The mission of USACE is to provide vital public engineering services in peace and war to strengthen the nation's security, energize the economy, and reduce risks from disasters. In order to meet this mission, the agency has developed the USACE Campaign Plan as a component of the corporate strategic management process to establish priorities, focus on the transformation initiatives, measure and guide progress, and adapt to the needs of the future. The goals and supporting objectives of the Campaign Plan are:

- **Ready for all Contingencies**
  - Ready, responsive and reliable
  - USACE supports combat, stability and disaster operations
  - Human resources and family support to promote readiness
  - Institutionalize USACE capabilities in interagency policy and doctrine
- **Transform Civil Works (Engineering Sustainable Water Resources Solutions)**
  - Deliver enduring and essential water resources solutions.
  - Collaborates with partners and stakeholders to find holistic and sustainable solutions.
  - Improve water resources policies and stream line regulatory processes.
  - Enable Gulf Coast recovery
- **Building Effective, Innovative, Sustainable Solutions**
  - Use innovative tools to efficiently and effectively deliver high quality facilities
  - Improve reliability and resiliency of critical infrastructure and reduce risks related to water resources and other DOD infrastructure
  - Use risk-informed asset management
  - Innovative approaches to delivering quality infrastructure
- **Recruiting and Retaining Strong Teams**
  - Build and cultivate a competent, disciplined and resilient team
  - Strengthen critical core technical competencies
  - Communicate strategically with stakeholders and the public
  - Use standardized processes

The Sutter Basin Feasibility Study and the pilot study program have been responsive to these goals and objectives by:

- Transform Civil Works (Engineering Sustainable Water Resources Solutions)
  - The Sutter Basin Feasibility Study was one of a small handful of studies selected as a Pilot Study as part of the USACE National Pilot Program that led the SMART planning groundwork in the transforming of the study process.
- Deliver enduring and essential water resources solutions:

- Designing a project which avoids or minimizes environmental impacts through fix-in-place levee alternatives while reducing flood risk and reducing the residual flood risk for public safety the Sutter Basin.
- The Recommended Plan has minimal impact to existing waterside riparian areas and habitat while maintaining minimal impacts to agriculture and urban areas.

- Improve water resources policies and stream line regulatory processes:
  - For the Pilot Study, the team led the way in development of new SMART planning processes and ways of plan formulation and feasibility study procedures to improve water resource policies and processes.
  - A LPP policy exception request was granted by ASA(CW) allowing recommendation of a Recommended Plan that addresses residual risk.
- Collaborate with partners and stakeholders to find holistic and sustainable solutions.
  - The Feasibility Study team as part of the Pilot development and study process, organized and participated in various Vertical Team and stakeholder meetings, charettes, and public workshops throughout the process and worked with local groups and sponsors to achieve a timely balance of project goals and public concerns.
- Build and cultivate a competent, disciplined and resilient team
  - The study successfully employed the use of Vertical Team coordination, Risk Assessment and Analysis, Charette & VE workshops, District Quality Control (DQC), Agency Technical Review (ATR), and Independent External Peer Review (IEPR) to assist in the review of the development of a technically and policy sound recommendation of Federal Interest.

7.4 Plan Implementation

This section describes the remaining steps to potential authorization of the project by Congress.

7.4.1 Report Approval

After review by Headquarters USACE, the Final Feasibility Report and EIR/SEIS will be circulated for 30 days to all appropriate Federal, state, and local government agencies, and the public. After its review of the final Feasibility Report and EIR/SEIS, including consideration of public comments, USACE Headquarters will prepare the Chief of Engineers' Report. This report will be submitted to ASA(CW), who will coordinate with the Office of Management and Budget and submit the report to Congress.

7.4.2 Project Authorization and Construction

Once the final report is approved by the Chief of Engineers and the project is authorized by Congress, construction funds must be appropriated by Congress before a PPA can be signed by USACE and the sponsor and project construction can proceed.

7.4.2.1 Federal Responsibilities

USACE would complete PED studies. Once the project is authorized and funds are appropriated, a PPA would be signed with the State of California as the non-federal sponsor. After the sponsor

provides the cash contribution, lands, easements, rights-of-way, relocations, and disposal areas, as well as assurances, the Federal Government would begin construction of the project.

7.4.2.2 Non-Federal Responsibilities

Specific items of local cooperation are identified in Chapter 8, *Recommendations*.

7.4.2.2.1 Views of Non-Federal Sponsor

The non-federal sponsors, SBFCA and CVFPB, support the RP and accept responsibility for the additional cost increment beyond the Federal cost share of the NED Plan. Local interests have been supportive of the study and project. Throughout development of this feasibility report, there has been significant coordination with SBFCA, the State of California, and private landowners.

7.4.2.2.2 Financial Capability of Sponsor

The total estimated non-federal first cost of the project is $433,660,000, including lands, easements, rights-of-way, relocations, and disposal areas (LERRDs) using October 2013 price levels. Actual costs may be slightly greater at the time of construction due to inflation.

7.4.2.3 Project Cost-Sharing Agreements

A Design Agreement must be executed between USACE and the non-federal sponsor in order to cost share the development of detailed plans and specifications. Before construction is started, the Federal Government and the non-federal sponsor would execute a PPA. This agreement would define responsibilities of the non-federal sponsor for project construction as well as operation and maintenance, repair, replacement, and rehabilitation and other assurances.

7.5 Schedule

If the project is authorized in 2014, construction activities could start as early as 2017 subject to authorization and appropriation. Table 7-18 contains a schedule showing the approval and construction phases of the project. The construction sequencing strategy addresses high flood risk urban areas first. The construction schedule is not constrained by assumptions of limited appropriations of funds to the government, but is based upon limited window of construction to non-flood months and time required for local acquisition of required LERRDs for each contract.

As discussed in Section 1.7.3.2, the project sponsors propose to initiate construction of the local FRWLP and to request in-kind credit for this work to be applied toward the non-federal cost share of the Sutter Basin project (RP). A Section 221 MOU was executed on June 14, 2013, and construction of the local FRWP was initiated in July 2013.

The construction sequencing of the local FRWLP is aligned with the proposed Federal project phasing. During the PED phase the construction schedule for the Federal project will be adjusted based upon an evaluation of how much of the local FRWLP has been completed and a determination of the Federal project remaining to be constructed.

During the PED phase, minimal additional studies would be conducted as part of developing detailed designs for the project. These potential studies may include the following.

- Additional geotechnical analysis of underlying substrates.

- Topographic surveys for project design.
- Preconstruction surveys to avoid direct effects on nesting birds and other sensitive species.
- Water quality analysis of construction activities and methods.
- Analysis of a Southern Levee Relief Structure for flood waters release in the southern basin (local sponsor initiative).

Table 7-18. Project Schedule

Phases	Scheduled Dates
Division Commander's Notice	2014
Chief of Engineers Report	2014
Potential Authorization	2015
USACE and Sponsor Sign Design Agreement	2015
Preconstruction Engineering and Design	2015–2016
Initiate Construction	2017
Contract A Station 180+00 to 478+68	2022–2023
Contract SBFIP Station 478+68 to 512+00	Not applicable[a]
Contract B Station 512+00 to 845+00	2021–2022
Contract C1 Station 845+00 to 1213+85	2017–2018
Contract C2 Station 1213+85 to 1674+37	2018–2019
Contract D1 Station 1674+37 to 2122+00	2019–2020
Contract D2 Station 2122+00 to 2638+00	2020–2021
Complete Physical Construction	2023

[a] As discussed in Section 1.7.3.1, the local sponsor has completed construction of a setback levee at Star Bend. The ASA(CW) approved credit consideration for this local work in 2010 and in accordance with the provisions of Section 104 WRDA 1998. The fix-in-place component of the Star Bend reach of the Federal plan (RP) will not be constructed, but will be the basis upon which Section 104 credit is evaluated in accordance with ER 1165-2-29.

Embedded Figures

Plate 7-1. RP (SB-8) Levee Improvement and Proposed Design Feature 7-3
Figure 7-1. Recommended Plan: Residual 1% ACE Composite Floodplain under Alternative SB-8 7-6
Figure 7-2. Baseline Information Maps 7-11
Figure 7-3. Potentially Developable Floodplain Comparison Maps 7-12
Figure 7-4. 50% ACE, 10% ACE, 4% ACE, and 2 % ACE Composite Floodplains 7-21
Figure 7-5. 1% ACE, .05% ACE, and .02 % ACE Composite Floodplains 7-22

Chapter 8
Recommendations

This chapter describes the Items of Cooperation for a Structural Flood Risk Management (Single Purpose) Project that will be specifically authorized.

I recommend that the Recommended Plan (Alternative SB-8) be authorized for implementation as a Federal project with such modifications thereof as in the discretion of the Commander, U.S. Army Corps of Engineers, may be advisable. The estimated first cost of the Recommended Plan (RP) is $688,930,000. The estimated Federal cost is $255,270,000 and the estimated non-federal cost is $433,660,000 at October 2013 price levels. Federal cost participation is limited to the Federal cost of the NED Plan (Alternative SB-7). Annual operations and maintenance, repair, replacement, and rehabilitation cost is estimated to be $454,000 (October 2013 price levels).

The RP is a Locally Preferred Plan (LPP) that differs from the National Economic Development (NED) Plan. The LPP would reduce the vulnerability of a larger population and additional critical infrastructure, reduce economic flood risks to a greater extent, and provide more evacuation routes relative to the NED Plan. The LPP would cost about $297,090,000 more than the NED Plan. The non-federal sponsors would be responsible for the entire extra cost, which would increase the non-federal cost share from about $136,570,000 for the NED Plan to about $433,660,000 for the LPP. The Federal cost share of initial construction, estimated at $255,270,000, would remain the same for the NED Plan and the LPP.

Section 104 credit consideration has been approved for the advanced work performed by the project sponsor in construction of the Star Bend setback levee. The advanced work is compatible with the RP as an acceptable substitute to providing FRM benefits and will be incorporated into the Federal plan. The amount of Section 104 credit to be afforded will be the actual costs incurred by the sponsor to provide the substitute FRM measure or the cost of the savings to be realized by the Government in not constructing the fix-in-place slurry wall. The affording of Section 104 credit will not increase the total project cost of the RP.

Federal implementation of the Recommended Plan would be subject to the non-federal sponsors agreeing to pay the full incremental cost between the NED Plan and LPP, estimated to be $297,090,000, and to comply with applicable Federal laws and policies, including but not limited to:

1. Provide a minimum of 35 percent, but not to exceed 50 percent, of total project costs of the NED plan as further specified below:
    a. Provide 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;
    b. Provide, during construction, a contribution of funds equal to 5 percent of total project costs;

c. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operations and maintenance of the project;

d. Provide, during construction, any additional funds necessary to make its total contribution equal to at least 35 percent of total project costs for the NED alternative;

2. Shall not use funds from other Federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized;

3. Not less than once each year, inform affected interests of the extent of protection afforded by the project after construction completion;

4. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs;

5. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 United States Code (USC) 701b-12), which requires a non-federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the project;

6. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

7. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the project affords, hinder operations and maintenance of the project, or interfere with the project's proper function;

8. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 USC 4601-4655), and the Uniform Regulations contained in 49 Code of Federal Regulations (CFR) Part 24, in acquiring lands, easements, and right-of-way required for construction, operations and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

9. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

10. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;
11. Hold and save the United States free from all damages arising from the construction, operations and maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;
12. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 CFR Section 33.20;
13. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 USC 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, titled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 USC 3141–3148 and 40 USC 3701–3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 USC 276a et seq.)), the Contract Work Hours and Safety Standards Act (formerly 40 USC 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 USC 276c et seq.);
14. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 USC 9601–9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operations and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-federal sponsor with prior specific written direction, in which case the non-federal sponsor shall perform such investigations in accordance with such written direction;
15. Assume, as between the Federal Government and the non-federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operations and maintenance of the project;
16. Agree, as between the Federal Government and the non-federal sponsor, that the non-federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

17. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 USC 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 USC 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

BY: _____
Michael J. Farrell
Colonel, U.S. Army
District Engineer

Chapter 9
List of Preparers

This following individuals participated in the preparation of this document.

9.1 U.S. Army Corps of Engineers

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9.2 ICF International

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Alan Barnard	17 years' experience in graphic design, web design, multimedia design, and cartography	Cover Graphics

Chapter 10
List of Recipients

10.1 Elected Officials and Representatives

Honorable Barbara Boxer, U.S. Senator

Honorable Dianne Feinstein, U.S. Senator

Honorable Doug LaMalfa, U.S. Representative, California District 1

Honorable Jim Nielsen, California State Senator, District 4

Honorable Dan Logue, California Assembly Member, District 3

10.2 U.S. Government Departments and Agencies

Bureau of Indian Affairs, Pacific Regional Office, Sacramento, CA

Bureau of Land Management, Sacramento, CA

Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA

Department of Agriculture, Animal and Plant Health and Inspection Service, Sacramento, CA

Department of Agriculture, Farm Service Agency, Washington, DC

Department of Agriculture, National Institute of Food and Agriculture, Washington, DC

Department of Agriculture, Natural Resources Conservation Service, Oroville, CA

Department of Agriculture, Natural Resources Conservation Service, Washington, DC

Department of Agriculture, Natural Resources Conservation Service, Yuba City, CA

Department of Defense, Navy, Washington, DC

Department of Defense, U.S. Marine Corps, Washington, DC

Department of Energy, Washington, DC

Department of Health and Human Services, Americans with Disabilities Act, Washington, DC

Department of Health and Human Services, Centers for Disease Control and Prevention, Atlanta, GA

Department of Health and Human Services, Office of the Secretary, Washington, DC

Department of Homeland Security, Washington, DC

Department of Housing and Urban Development, Region IX, San Francisco, CA

Department of the Interior, Washington, DC

Department of the Treasury, Washington, DC

Department of Veterans Affairs, Washington, DC

Environmental Protection Agency (via e-filing)

Environmental Protection Agency Region 9, San Francisco, CA

Federal Aviation Administration, Flight Standards District Office, Sacramento, CA

Federal Emergency Management Agency, Region IX, Oakland, CA

Federal Highway Administration, California Division, Sacramento, CA

Fish and Wildlife Service, Sacramento Fish and Wildlife Office – Sacramento, CA

Fish and Wildlife Service, Sacramento River National Wildlife Refuge Complex-Willows, CA

General Services Administration, Washington, DC

Geological Survey, Menlo Park, CA

National Marine Fisheries Service, Central Valley Office-Sacramento, CA

National Marine Fisheries Service, Southwest Regional Office-Long Beach, CA

National Park Service, San Francisco, CA

National Science Foundation, Arlington, VA

10.3 State of California Government Agencies

California Air Resources Board

California Department of Conservation

California Department of Fish and Game, North Central Region

California Department of Parks and Recreation, Northern Butte District

California Department of Transportation, District 3

California Department of Water Resources

California Environmental Protection Agency

California Natural Resources Agency

Central Valley Flood Protection Board

Central Valley Regional Water Quality Control Board

Office of Historic Preservation

Office of Planning and Research

State Lands Commission, Environmental Management Division

10.4 Local and Regional Government Agencies

Butte County Air Quality Management District

Butte County Board of Supervisors

Butte County Clerk/Recorder

Butte County Department of Development Services

Butte County Library—Main Branch, Oroville

Butte Environmental Council

City of Biggs Branch Library

City of Biggs City Council

City of Biggs Planning Department

City of Gridley City Council

City of Gridley Planning Department

City of Live Oak City Council

City of Live Oak Planning Department

City of Marysville City Council

City of Marysville Planning Department

City of Yuba City City Council

City of Yuba City Community Development

Feather River Air Quality Management District

Gridley Branch Library

Levee District 1

Levee District 3

Levee District 9

Maintenance Area 16

Maintenance Area 7

Sacramento Area Flood Control Agency

Sutter Butte Flood Control Agency

Sutter Butte Flood Control Agency Board of Directors

Sutter County Board of Supervisors

Sutter County Clerk/Recorder

Sutter County Library—Main Branch, Yuba City

Sutter County Planning Services

Sutter County Public Works Department

Sutter County Resource Conservation District

Three Rivers Levee Improvement Authority

West Sacramento Area Flood Control Agency

Yuba County Planning Department

10.5 Other Interested Parties

Alliance for Nuclear Accountability

American Bird Conservancy

American Federation of Labor and Congress of Industrial Organizations

American Lung Association

American Recreation Coalition

American Rivers

California Farm Bureau Federation

Center for Biological Diversity

Central Valley Flood Control Association

Clean Water Action

Ducks Unlimited

Earth Justice

Edison Electric Institute

Environment America

Environmental Council of the States

Environmental Defense Fund

Environmental Defense Institute

Family Water Alliance

Friends of the Earth

GRACE

Institute for Science and International Security

League of Women Voters

Local Media Representatives

National Association of Attorneys General

National Audubon Society

National Conference of State Legislatures

National Wildlife Federation

Natural Resources Defense Council

Northern California Water Association

Pacific Gas & Electric Company

Partners in Flight

Responsible Environmental Action League

Sacramento River Preservation Trust

Sacramento Valley Landowners Association

Sierra Club

The Nature Conservancy

The Partnership Project

The Wilderness Society

Trout Unlimited

Yuba-Sutter Farm Bureau

10.6 Native American Contacts

Berry Creek Rancheria of Maidu Indians

Butte Tribal Council

Cachil DeHe Band of Wintun Indians (Colusa Rancheria)

Cortina Indian Rancheria of Wintun Indians

Enterprise Rancheria of Maidu Indians

Greenville Rancheria of Maidu Indians

KonKow Valley Band of Maidu

Maidu Cultural and Development Group

Maidu Nation

Maidu/Konkow

Mechoopda Indian Tribe of Chico Rancheria

Mooretown Rancheria of Maidu Indians

National Congress of American Indians

National Tribal Environmental Council

Paskenta Band of Nomlaki Indians of California

Strawberry Valley Rancheria

Tsi-Akim Maidu

United Auburn Indian Community of the Auburn Rancheria

10.7 Members of the Public

All members of the general public who requested a copy of the Draft Report, or who provided comments on the Draft Report, will be mailed either an electronic version (on CD) or a hard copy of this document. Additionally, those who submitted comments during the scoping process, spoke or provided comment cards at the public meeting, and provided complete mailing addresses and those who may be affected by the proposed project will also receive a copy of the Final Report. Comments received on the Draft Report are reproduced in Appendix F.

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☐ Levee Repair Alternatives and Parametric Cost Estimates

☐ Construction Schedule

☐ Project Cost and Schedule Risk Analysis Report

☐ Estimated Project Cost for Draft Array of Alternatives Comparison

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Appendix D Environmental

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US Army Corps
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Sacramento District

Planning Division

Sutter Basin Pilot Feasibility Report - Environmental Impact Report / Supplemental Environmental Impacts Statement

Butte and Sutter Counties, California

APPENDIX A - ECONOMICS

August 2013

Revised: October 2013

Economic Analysis – Sutter Basin Pilot Feasibility Study	
Project Name:	Sutter Basin Pilot Feasibility Study—Flood Risk Management Project
Project Briefing:	The study area is located in Sutter and Butte Counties, California and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area covers approximately 300 square miles and includes the communities of Yuba City, Live Oak, Gridley, Biggs and Sutter with a total urban population of approximately 84,000.
Study Authority:	The authority for USACE to study Flood Risk Management and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962 (Public Law 87-874).
Purpose and Scope:	The purpose of this document is to present the economic analysis conducted for the Sutter Basin Pilot Feasibility Study. This includes descriptions of the methodologies, assumptions, data and results of both the without and with project conditions. The document presents findings related to flood risk, potential flood damages, and flood risk management benefits. Additionally, this analysis coincides with the planning modernization paradigm of employing sound qualitative analysis guided by professional judgment rather than heavily based quantitative processes during the planning phase of study process. The economic analysis is in accordance with standards, procedures, and guidance of the U.S. Army Corps of Engineers. The Planning Guidance Notebook (ER 1105-2-100) serves as the primary source for evaluation methods. Also, guidance for risk-based analysis was obtained from EM 1110-2-1619 and ER 1105-2-101. Unless otherwise noted, benefits and costs values are expressed in October 2013 prices utilizing the FY14 discount rate of 3.5% and analyzed over a 50-year period of analysis. Economic Modeling was performed using the Corps FRM-PCX certified HEC-FDA (v1.2.5a) model.
Organization of Document:	This document is organized as follows: • Section 1 describes the study area and planning process conducted to date • Section 2 reviews the data used in the analysis and without-project conditions • Section 3 evaluates the final array of alternatives • Section 4 compares the final array of alternatives • Section 5 presents the Other Social Effects analysis • Section 6 discusses the Regional Economic Development impacts • Section 7 summarizes the economic analyses
Authorship:	Economic Risk Analysis Section, (CESPK-PD-WE) Planning Division, Sacramento District U.S. Army Corps of Engineers

1. STUDY BRIEFING

Planning Study. The Sutter Basin Pilot Feasibility Study was selected for inclusion in the National Pilot Program in February 2011. The pilot initiative provides an opportunity to test principles that have been outlined in the U.S. Army Corps of Engineers (USACE) *Recommendations for Transforming the Current Pre-Authorization Study Process* (January 2011), which was drafted by a workgroup of planning and policy experts from USACE and the Officer of the Assistant Secretary of the Army for Civil Works, ASA (CW), referred to as the 17+1 Team. This new process requires heavy involvement as well as input and decisions from the Vertical Team at multiple points throughout the study. The pilot study is divided into four phases, each with a key decision point and associated In-Progress Reviews (IPRs). Table 1 summarizes the four pilot study phases and associated decision points. Based on the pilot program principles, the Sutter Basin Pilot Feasibility Study strategy focuses on utilizing an appropriate level of detail based on the decisions being made at each stage of the study. This strategy includes qualitative and quantitative analysis that will be increasingly detailed at each Decision Point or IPR and early screening of alternatives with low likelihood of federal interest.

Table 1. Pilot Study Phases and Associated Decision Points

Pilot Study Phase	Decision Point	Date
Scoping	1 – Federal Interest Determination	Aug 2011
Analysis	2 – Tentatively Selected Plan and Draft Report	March 2013
Review	3 – Civil Works Review Board	Fall 2013
Confirmation	4 – Chief's Report	*Winter 2013*

**Tentative*

Throughout the planning process, the Sutter Project Delivery Team (PDT) has recorded major milestones in the following documents:

- Appendix I, Measure Screening and Alternative Selection— This Progress Document details the broad array of management measures that were developed based on information from existing reports and studies, as well as public input and professional judgment. This document provides descriptions of the measures evaluated at the Critical Thinking Charette and indicate whether each one was retained or dropped and the reason(s) for screening.
- Appendix II, Draft Alternative Evaluation and Selection of Final Alternatives— This Progress Document is a compilation of a series of memorandums from the following disciplines: economics, civil design, real estate, cost engineering, hydrology, hydraulics, and geotechnical. These documents form the basis for selection of the final array of alternatives.

This documentation is in support of Appendix III, Evaluation and Comparison of the Final Array of Alternatives and Identification of the Recommended Plan. This document includes the description, refinement, evaluation and comparison of the final array of alternatives. For additional detail on the economic methodologies and steps taken in the screening of alternatives from the preliminary array to the draft array of alternatives leading up to the final array, please see the Economic Appendix to Progress Document #2 (included in this report as Attachment 1).

Study Area. The 300 square mile study area is located in Butte and Sutter Counties California. A map showing the location of the study area relative to the watershed is provided in Section 1 of Attachment 1.

A map of the study area topography can be found in the Main Report and the Hydraulic Appendix, which shows elevation ranges from 110 feet to 30 feet. The study area is encircled by federal project levees along the Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal and the high ground of the Sutter Buttes. The federal levees are features of the Sacramento River Flood Control Project (SRFCP), authorized by Congress in 1917. The SRFCP incorporated features such as levees, weirs, and pumping facilities into a system of leveed river channels and flood bypass channels to provide Flood Risk Management benefits to the Sacramento Valley.

Population estimates were estimated by overlaying a shapefile of the 2010 US Census population by census block and the Economic Impact Areas (EIA) in GIS. These numbers may differ slightly from the official 2010 Census population estimates by city. Note that the Town of Sutter is not included here as modeling shows very limited flooding for the 0.2% ACE event.

Table 2. Population

Economic Impact Area	Population
Yuba City Urban	67,370
Biggs Urban	1,760
Gridley Urban	6,380
Live Oak Urban	8,360
Sutter County Rural	6,340
Butte County Rural	4,900
Total	**95,110**

The highest risk sources of flooding within the study area are the Sutter Bypass and the Feather River, although flooding can also occurs from the Butte Basin, Cherokee Canal, Wadsworth Canal, and local interior drainage. Flood depths and frequency vary throughout the study area. Probability of flooding within the study area is primarily related to the stage of floodwaters within the river channels and the geotechnical probability of levee failure at flood stage. The Sacramento River Flood Control Project levees were often constructed of poor foundation materials such as river dredge spoils that does not meet current engineering standards. These legacy levees are relied upon today to provide FRM for numerous communities within the Sacramento Valley.

Historical Assessment. In 1955, flood waters from a levee breach encompassed a significant portion of the study area inundating 6,000 homes, drowning 38 people, injuring 3,200 individuals, and requiring 600 people to be rescued by helicopter. From 1950 to 2011, extensive flood fighting has occurred during 19 events, and levee failures adjacent to the Sutter Basin took place in 1986 and 1997. Flooding historically has occurred during the months of December through February with air temperatures of 38 to 55°F and water temperatures of 45 to 55°F; temperatures which significantly increase risk of death by exposure.

Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees within the study area do not meet USACE levee design standards and are at risk of breach failure at stages less than overtopping. This was evidenced by historical boils and heavy seepage at stages less than authorized design flows. Underseepage failures are sudden and unpredictable, resulting in minimal warning time, and ineffectiveness of evacuation plans. Though, almost every location within the study area is afforded some flood risk reduction by these levees, the risk of unexpected levee failure coupled with the consequence of flooding presents a continued threat to public safety, property, and critical infrastructure.

2. REVIEW OF EXISTING CONDITIONS

Floodplain Area and Economic Inventory. An economic inventory was assembled following standard USACE methods. For the study area, a base geographic information system (GIS) inventory with parcel attribute data was provided by the local sponsor for both Sutter and Butte Counties. Field visits were conducted to collect and validate the base inventory data. Parcels with structures were categorized by land use and grouped into residential, commercial, industrial or public categories. The value of damageable structures was estimated based on depreciated replacement values. The total value of damageable property (structures and contents) within the Sutter Basin study area is estimated at $7 billion (Table 3). Table 4 displays the structural inventory by land use category.

Table 3. Value of Damageable Property
October 2013 Prices (Values in 1,000's)

Economic Impact Area	Structures and Contents				
	Commercial	Industrial	Public	Residential	Total
Biggs	6,700	2,400	0	75,700	**84,800**
Gridley	73,200	52,600	3,600	290,900	**420,300**
Live Oak	26,000	3,800	42,600	324,500	**396,900**
Yuba City	1,070,000	423,800	339,200	3,645,300	**5,478,300**
Rural Butte	4,000	46,400	0	203,200	**253,600**
Rural Sutter	9,100	40,200	18,800	279,000	**347,100**
Total	**1,189,000**	**569,200**	**404,200**	**4,818,600**	**6,981,000**

Table 4. Structural Inventory –Existing Conditions
Number of Structures within 0.2% (1/500) Annual Chance Floodplain

Economic Impact Area	Commercial	Industrial	Public	Residential	Total
Biggs	18	1	0	586	**605**
Gridley	81	7	4	1,931	**2,023**
Live Oak	51	5	23	2,088	**2,167**
Yuba City	872	210	122	18,760	**19,964**
Rural Butte	10	16	0	1,242	**1,268**
Rural Sutter	10	29	8	1,162	**1,209**
Total	**1,042**	**268**	**157**	**25,769**	**27,236**

HEC-FDA Modeling Efforts. For the economic analysis, the existing levees were separated into thirteen levee reaches and a representative breach location was chosen for each reach. When the study area becomes inundated, the floodwaters flow from north to south and then pool in the southern portion of the study area to twenty feet or more. Therefore, a levee breach at the northern section of the Feather River would result in a larger inundation area than a breach at the southern portion, but does not necessarily mean that a northern breach has the highest risk (probability and consequence). Because the levees around the Sutter study area have distinct deficiencies, each has a different probability of failure in any

given flood event. The probability of flooding from each source is based on the hydrologic frequency, stage-discharge relationship and geotechnical performance. These parameters serve as inputs into the Corps FRM-PCX certified HEC-FDA model (v1.2.5a).

Without-Project Damages. The main analytical tool used to perform the economic analysis was the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software. This program stores the engineering probability data (hydrologic, hydraulic, and geotechnical) and the economic consequence data (structure/content inventory and depth-percent damage curves), and is used to model the flooding problem and potential alternative solutions in the study area. By relating the economic inventory data to the floodplain data, the HEC-FDA software computes economic stage-damage curves. Through integration of the main engineering relationships (exceedance probability-discharge curves, rating curves, and geotechnical levee fragility curves) and the main economic relationship (stage-damage curves), the HEC-FDA software computes project performance statistics and expected annual damages/benefits. The results of the economic modeling are then used as input into the net benefit and benefit-to-cost analyses and may also aid in plan formulation, all of which are performed external to the HEC-FDA software.

Agricultural Damages. ER 1105-2-100, Appendix E, beginning on page E-113 includes specific guidance for studies where the primary damages occur to agricultural crops. Primary damages in this evaluation focus on the crop damage, loss of stored crops, and loss of farm equipment. These damages are directly related, and evaluated with special consideration for the expected time of seasonal flooding as well as the variability associated with crop prices and yields. The identified hydrologic/hydraulic variables, discharge associated with exceedence frequency and conveyance roughness and cross-section geometry, also apply to agricultural studies. Based on empirical analyses conducted for past Corps projects, subject matter expertise from the agricultural economist and professional judgment, the project delivery team expects agricultural damages to total 10-15% of total project damages; amounts which are not expected to drive plan selection. A simplified approach was developed for this study based on stage-damage curves for land use types within the study area and simplifying calculations by utilizing 1,000 ft by 1,000 ft hydraulic model grid elements. For detailed information regarding data collection, assumptions, and methodology see the Memorandum for File titled "Agricultural Damages for Final Alternative Comparison" dated 22 February 2013 (Attachment 2).

Cleanup and Emergency Costs. Depreciated structure and structure content damages measure the cost of replacing damaged portions of structures and structure contents with those of similar use and condition. It does not, however, fully account for all the various costs incurred following a damaging flood event. For the final array of alternatives, four additional categories of damages directly related to structure and structure content damages were considered: cleanup costs, temporary housing and relocation assistance costs and other emergency costs (including repairs to roads, bridges, utilities, etc.). Though these damages categories won't likely drive plan formulation and selection due to their high correlation with structure and content damages, they are justified as legitimate flood damage reduction benefit categories and should not be ignored in the calculation of total project benefits. More detail about these damage categories and methodologies used in the estimation of related damages and benefits can be found in Attachment 3.

The HEC-FDA without project conditions model results (expected annual damages) for structures, contents, automobiles, and agriculture, emergency and cleanup costs are shown, by economic impact area

(EIA) in Table 5. The total study area without project damages are estimated to be approximately $137 million. For more detail about the HEC-FDA modeling and the other standard damage categories, see Attachment 1.

Table 5. Expected Annual Damages—Without Project Condition October 2013 Prices (Values in $1,000s), 3.75 Discount Rate

Economic Impact Area	Damage Category							
	Agriculture	Autos	Cleanup & Emergency	Commercial	Industrial	Public	Residential	Total
Biggs	4	89	252	81	30	0	495	**951**
Gridley	5	179	520	1,012	300	49	987	**3,052**
Live Oak	9	243	734	327	53	471	1,456	**3,293**
Yuba City	250	4,235	13,639	15,700	6,433	4,267	26,405	**70,929**
Rural Butte	1,902	136	351	52	264	0	770	**3,475**
Rural Sutter	16,460	1,956	7,384	1,126	5,741	3,432	18,742	**54,841**
Total	**18,630**	**6,838**	**22,880**	**18,298**	**12,821**	**8,219**	**48,855**	**136,541**

Without Project Performance. In addition to damages estimates, HEC-FDA reports flood risk in terms of project performance. Three statistical measures are provided, in accordance with ER 1105-2-101, to describe performance risk in probabilistic terms. These include annual exceedance probability, long-term risk, and assurance by event.

- Annual exceedance probability measures the chance of having a damaging flood in any given year.
- Long-term risk provides the probability of having one or more damaging floods over a period of time.
- Assurance is the probability that a target stage will not be exceeded during the occurrence of a specified flood.

The worst project performance statistics may not necessarily be associated with the breach location producing the largest economic damages. For example, an impact area may be subject to flooding from two different rivers. River A might have a higher likelihood of flooding than River B but River B's associated floodplain (consequence) may be larger and cause more damages. If that is the case, then project performance (likelihood of flooding) is not the primary dictator in consequence. Nevertheless, if a proposed project alleviates River B's floodplain, the project performance is still limited by River A's performance. For the Yuba City economic impact area, performance is dictated by an index point along the Sutter Bypass. However, the associated floodplain does not significantly impact Yuba City until the 0.2% ACE whereas a break along the Feather River poses imminent damages due to its associated consequence (floodplain) even though it statistically has a higher performance when compared to the Sutter Bypass. Project performance statistics for each area under without project conditions is displayed in Table 6. Some project performance statistics have been updated slightly for the final array based on revisions to existing TOL stages.

Table 6. Project Performance by Economic Impact Area—Without Project Condition

Economic Impact Area	Breach Location	Annual Exceedance Probability		Long Term Risk			Assurance by Event				
		Median	Expected	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.4%	0.20%
Biggs	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	44%	32%
Gridley	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	44%	32%
Live Oak	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	44%	32%
Yuba City	F5.0R	0.04	0.04	33%	70%	86%	85%	67%	60%	40%	22%
Rural Butte	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	44%	32%
Rural Sutter	S4.0L	0.45	0.52	99%	99%	99%	33%	30%	22%	11%	6%

Future Population Growth and Development. A discussion regarding future population growth, wise use of floodplains (EO 11988) and residual risk can be found in Chapter 4 below. Population growth and future development were considered, but were not included in the economic damage analysis, as it would have little impact on project benefits and would not change NED identification, the recommended plan or economic feasibility. Factors that led to the future without project condition assumptions used for this study from a planning and economic standpoint were: 1) CA Senate Bill 5 will limit future development in the study area under future without project conditions given that the study area would not have 0.5% ACE ("200yr") level of flood protection. According to current USACE floodplain modeling, this area would be within the 0.5% ACE ("200yr") without project floodplain. 2) Given #1 above, any development that did take place would likely occur above the mean 0.5% ACE "200yr" WSEL, meaning very infrequent damaging flooding which would be discounted to present values. The result is low equivalent annual damages which would not significantly impact plan selection or project benefits. 3) Within USACE, a greater emphasis is now being placed upon wise use of floodplains and the potential to induce development by building an FRM project (EO11988). For purposes of justifying this pilot project economically, it is not prudent to "count on" benefits associated with future floodplain development to increase the project's net benefits or BCR.

3. ALTERNATIVE EVALUATION

Plan Formulation and Description of Alternatives. The plan formulation process develops and evaluates alternative plans to address the needs and desires of society as expressed in specific planning objectives. Accordingly, the Recommended plan best satisfies the objectives as well as the Federal interests, which are consistent with the Federal Water Resources Council's Principles and Guidance (P&G) and the Planning guidance Notebook (ER-1105-2-100). What follows is a brief timeline of the planning process leading up to the final array of alternatives. More detail can be found in Progress Document #1.

(1) Management Measures (Critical Thinking Charette): A broad array of management measures was developed based on information from existing reports and studies, as well as public input and professional judgment. Following the initial screening of measures, the team identified four themes (strategies) for plan formulation (1- Consequence Management Focused on Public Safety, 2-Urban FRM, 3-Maximize Existing System with FRM Focus, and 4-Ecosystem Restoration Focus). These themes were used to establish a preliminary array of conceptual alternatives by grouping measures according to the primary focus of each theme.
(2) Preliminary Array of Alternative: Each alternative was further developed and quantities, costs and economic benefits were estimated at a reconnaissance level. The use of these results was solely to screen out those preliminary alternatives that did not appear economically justified even in the most favorable conditions.
(3) Refinement of Draft Array of Alternatives (Value Engineering Study): The remaining alternatives were furthered refined. This resulted in combining and eliminating some of the alternatives as well as refining and optimizing those that were retained by adding or removing measures in order to ensure a robust array of draft alternatives. The draft array of alternatives were then evaluated in further detail, and screened to a final array of alternatives. See Attachment 1 of this report for the economic documentation used in support of Appendix II, Draft Alternative Evaluation and Selection of Final Alternatives, for more detail.
(4) Final Array of Alternatives: The final array of alternatives carried forward for final comparison include:
    - Alternative SB-1: No Action
    - Alternative SB-7: Fix-in-place the Feather River, Sunset Weir to Laurel Avenue
    - Alternative SB-8: Fix-in-place the Feather River, Thermalito to Laurel Avenue

Climate Change: A climate change analysis was completed for the draft array of alternatives to ensure that the relative ranking of alternatives was not particularly sensitive to climate change. The results of the analysis confirmed the insensitivity to Alternative rankings based on NED Equivalent Annual Net Benefits and a detailed writeup of the analysis and results can be found in the Hydrology Appendix.

With-Project Modeling Results. Benefits were determined by incorporating increments of levee fixes into the HEC-FDA model that represent various with-project improvements. Under with-project conditions, levee fragility curves were not used and it was assumed levees would not fail until the WSEL reached 0.1ft above the top of levee. Flood risk management benefits (Table 8) equal the difference between the without project damages (Table 5) and the with-project residual damages (Table 7).

Table 7. Expected Annual Damages—Alternative Conditions October 2013 Prices (Values in $1,000s), 3.75 Discount Rate

Alternative	Economic Impact Area						Total
	Biggs	Gridley	Live Oak	Yuba City	Rural Butte	Rural Sutter	
SB-1: No Action	951	3,052	3,293	70,929	3,475	54,841	136,541
SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue	951	3,052	3,293	10,491	3,475	36,496	57,758
SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue	352	452	529	10,483	1,558	36,141	49,515

Table 8. Annual Benefits—Alternative Conditions October 2013 Prices (Values in $1,000s), 3.75 Discount Rate

Alternative	Economic Impact Area						Total
	Biggs	Gridley	Live Oak	Yuba City	Rural Butte	Rural Sutter	
SB-1: No Action	-	-	-	-	-	-	-
SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue	-	-	-	60,438	-	18,345	78,783
SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue	599	2,600	2,764	60,446	1,917	18,700	87,026

Probability Distribution of Damages Reduced. In accordance with ER 1105-2-101, flood damages reduced were determined as mean values and by probability exceeded. Table 9 shows the benefits for each alternative for a probability distribution and expected value. The damage reduced column represents the expected benefits for each alternative, while the probability damage reduced indicate the confidence of benefits exceeding the indicated amount. For example, Alternative SB-7 has expected benefits of $64 million at the 50% confidence interval, and 75% confidence that benefits will be equal to or greater than $43 million. The range in probability distribution of damages reduced is indicative of the uncertainty in the benefits estimates, which incorporates all the uncertainties in hydrology, hydraulics, geotechnical and economics in the HEC-FDA model. The uncertainty in damages reduced is a critical component when selecting an optimal plan during the plan formulation process. Professional judgment guides the determination of an alternative meeting a reasonable level of confidence regarding positive net benefits.

Table 9a. Probability Distribution of Damages Reduced—Study Area October 2013 Prices (Values in $1,000s), 3.75 Discount Rate

Alternative	Annual Damages			Probability Damage Reduced		
	Without Project	With Project	Damage Reduced	75%	50%	25%
SB-1: No Action	136,541	136,541	0	0	0	0
SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue	136,541	57,758	78,783	43,111	63,972	108,792
SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue	136,541	49,515	87,026	46,299	72,113	120,350

Table 9b. Project Performance by Economic Impact Area—Alternative SB-7

Economic Impact Area	Breach Location	Annual Exceedance Probability		Long Term Risk			Assurance by Event				
		Median	Expected	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.4%	0.20%
Biggs	F9.0R	0.070	0.080	55%	91%	98%	82%	61%	58%	44%	32%
Gridley	F9.0R	0.070	0.080	55%	91%	98%	82%	61%	58%	44%	32%
Live Oak	F9.0R	0.070	0.080	55%	91%	98%	82%	61%	58%	44%	32%
Yuba City	F5.0R	0.002	0.003	2%	6%	10%	99%	99%	99%	82%	55%
Rural Butte	F9.0R	0.070	0.080	55%	91%	98%	82%	61%	58%	44%	32%
Rural Sutter	S4.0L	0.450	0.520	99%	99%	99%	33%	30%	22%	11%	6%

Table 9b. Project Performance by Economic Impact Area—Alternative SB-8

Economic Impact Area	Breach Location	Annual Exceedance Probability		Long Term Risk			Assurance by Event				
		Median	Expected	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.4%	0.20%
Biggs	F9.0R	0.002	0.002	2%	7%	11%	99%	99%	97%	81%	64%
Gridley	F9.0R	0.002	0.002	2%	7%	11%	99%	99%	97%	81%	64%
Live Oak	F9.0R	0.002	0.002	2%	7%	11%	99%	99%	97%	81%	64%
Yuba City	F5.0R	0.002	0.003	2%	6%	10%	99%	99%	99%	82%	55%
Rural Butte	F9.0R	0.002	0.002	2%	7%	11%	99%	99%	97%	81%	64%
Rural Sutter	S4.0L	0.450	0.520	99%	99%	99%	33%	30%	22%	11%	6%

4. ALTERNATIVE COMPARISON

Net Benefit Analysis. Economic feasibility and project efficiency are determined through a benefit-cost analysis. For a project to be feasible, benefits must exceed costs and the most efficient alternative is one that maximizes net benefits (annual benefits minus annual costs). The identification of such alternative is referred to the National Economic Development Plan (NED). Table 10 summarizes the net benefit analysis of the final array of alternatives using probability reduced damages at varying confidence intervals in terms of benefits and costs (25%, 50% and 75%), while Table 11 shows the net benefit analysis using the mean computed benefits and cost at an 80% confidence level[1] per standard USACE practice. While the varying confidence intervals in Table 10 do not show the full range of possible Net Benefits and BCR's, it does show the most likely range and meets the intent of ER-1105-2-101. For a more detailed breakdown of costs and interest during construction calculations, please see Attachment 5. With $61 million in equivalent annual net benefits, SB-7 is identified as the NED plan.

Table 10. Net Benefits[2] (Varying Confidence Intervals)—Final Array of Alternatives October 2013 Prices (Values in $Millions), 3.5% Discount Rate

Category	Alternative						
	SB-1: No Action	SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue			SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue		
		Low	Mid	High	Low	Mid	High
Total First Costs[1]		355	370	386	632	659	688
Sunk PED (-)		0	0	0	0	0	0
Interest During Construction (+)		34	36	37	88	92	96
Subtotal		***389***	***406***	***423***	***720***	***751***	***784***
Interest and Amortization		17	17	18	31	32	33
OMRR&R		0.28	0.28	0.28	0.45	0.45	0.45
Annual Cost		17	17	18	31	32	33
Annual Benefits		43	64	109	46	72	120
Net Benefits[2]		**34**	**54**	**79**	**23**	**47**	**74**
Benefit to Cost Ratio[2]		**2.9**	**4.1**	**5.5**	**1.7**	**2.4**	**3.3**

[1] Cultural resources data recovery costs ($1.6 million for SB-7 and $3.0 million for SB-8) are not included in economic costs per Corps policy (ER 1105-2-100, Appendix e, paragraph E-63.f.(5)).

[2] Net Benefits and Benefit to Cost Ratios are a result of Monte Carlo simulations using triangular distributions of annual benefit and annual costs confidence intervals as inputs.

[1] Standard practice in Corps Feasibility Studies.

[2] Net Benefits and Benefit to Cost Ratios are a result of Monte Carlo simulations using triangular distributions of annual benefit and annual costs confidence intervals as inputs.

Table 11. Net Benefits (Mean, Standard Corps Practice)—Final Array of Alternatives October 2013 Prices (Values in $Millions), 3.5% Discount Rate

Category	Alternative		
	SB-1: No Action	SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue	SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue
Total First Costs[1]		390	686
Sunk PED (-)		0	0
Interest During Construction (+)		38	94
Subtotal		***428***	***780***
Interest and Amortization		18	33
OMRR&R		0.28	0.45
Annual Cost		18	33
Annual Benefits		79	87
Net Benefits		**61**	**54**
Benefit to Cost Ratio		**4.4**	**2.6**
Benefit to Cost Ratio (@ 7%)		***2.3***	***1.3***

[1] Cultural resources data recovery costs ($1.6 million for SB-7 and $3.0 million for SB-8) are not included in economic costs per Corps policy (ER 1105-2-100, Appendix e, paragraph E-63.f.(5)).

Residual Floodplains: Residual 1% ACE floodplains[3] for the final array of alternatives are shown in figures below. These floodplains represent composite floodplains for all breaches that have less than a 90% level of assurance to pass the 1% ACE flood event. While this floodplain is larger than would likely be seen in a single flood/breach event, it is meant to represent the relative residual risk for the area from all remaining breach locations. Composite floodplains are for presentation only and were not used in the calculation of economic damages and benefits. SB-7 reduces adverse flooding effects but benefits are primarily centered on Yuba City. The alternative features do not address the significant flooding risk in the communities of Biggs, Gridley, and Live Oak. SB-8 reduces the residual risk for these northern communities.

[3] 1% floodplains are based on the inundation from any levee having less than 90% assurance. The assurance estimate was based on geotechnical, hydraulic, and hydrologic uncertainty.

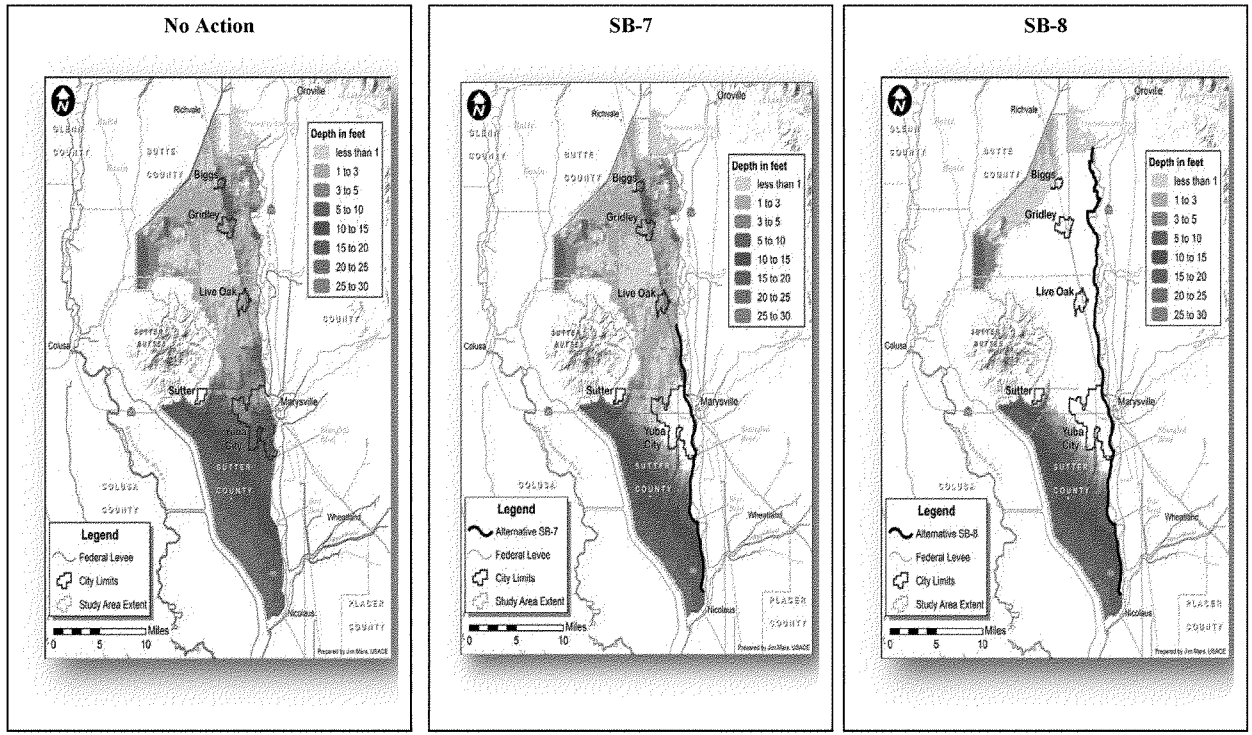
Residual Population at Risk (PAR)[4]: PAR within the 1% ACE floodplain for the No Action Alternative is 94,600. SB-7 reduces the 1% floodplain PAR to 38,200, while SB-8 reduces PAR to approximately 6,600.

Structures within the Residual Floodplains: The number of structures within the residual floodplain for the No Action Alternative is approximately 26,800. SB-7 reduces the structures within the 1% ACE floodplain to 7,600, while SB-8 reduces structures within the floodplain to approximately 1,700 with most of these structures residing on the outskirts of Yuba City and the Rural Sutter, southern part of the basin. For more detail, see Chapter 3 of the main report.

[4] PAR within the 1% ACE floodplain is calculated by overlaying 2010 population by Census block and the residual floodplains. These numbers may differ slightly from the official 2010 Census by city.

Figure 1: 1% ACE Residual Floodplains for the Final Array

(Based on composite floodplains from all potential residual breach locations with less than 90% assurance)



Population growth and Wise Use of Floodplains: Executive Order (EO) 11988 (May 24, 1977) requires a Federal agency, when taking an action, to avoid short and long term adverse effects associated with the occupancy and the modification of a floodplain. The agency must avoid direct and indirect support of floodplain development whenever floodplain siting is involved. In addition, the agency must minimize potential harm to or in the floodplain and explain why the action is proposed. Additional floodplain management guidelines for EO 110988 were also provided in 1978, by the Water Resources Council.

The wise use of floodplains concept, as described in EO 11988, was incorporated as a life safety metric for this study. The metric, "potentially developable floodplains," was used in the pilot study multi-objective planning process for evaluation and screening. This metric approach was based on pilot study objectives of applying qualitative rather than quantitative analysis; use of existing data/inventory; and professional team judgment. In calculating the "potentially developable land" metric for the Sutter Basin, the following areas were excluded.

- Areas that are currently developed.
- Areas that are owned in fee by governments or nonprofit organizations and that are protected for open space purposes.
- Areas with flood depths greater than 3 feet for the FEMA 1% (1/100) Annual Chance Exceedance (ACE) base flood event because constructing buildings to meet FEMA floodplain management requirements is assumed to be cost prohibitive.
- Areas outside the 0.2% (1/500) ACE floodplain boundary to prevent high topographic areas along Sutter Buttes from being included.

Under existing conditions there are approximately 71,000 acres of potentially developable land within the Sutter Basin. SB-7 would result in an additional 16,000 acres of potentially developable floodplain consisting of 5,000 acres in the Yuba City urban area and 11,000 acres in the Sutter County rural area outside of Yuba City. The additional increment to implement SB-8 would result in an additional 12,000 acres of potentially developable floodplain consisting of 500 acres in the urban areas of Yuba City, Biggs, Gridley, and Live Oak; 2,700 acres in the Sutter County rural area; and 8,800 acres in the Butte County rural area.

Development does not occur in the absence of demand. Land use in the basin is primarily dominated by a strong agricultural based economy and uses. This type of land use and economy does not support rapid, urbanized growth or demand. The necessary basin wide public infrastructure (i.e. roadways, water/sewer systems, utilities, etc) do not exist for urban growth, and would require a substantial investment from the State, County, and development community. This type of future investment is not likely due to the lack of demand from consumers (within and outside the basin).

The cities of Biggs, Gridley, Live Oak, and Yuba City are not currently mapped within the FEMA 1% ACE ("100- year") floodplain Despite the lack of floodplain development restrictions, development in Biggs, Gridley, Live Oak, and Yuba City has been modest even during the building boom of the early 2000's. The addition of FRM improvements this study will provide will not change the fundamental drivers of urban growth demand within the Sutter Basin. Lack of market/economic drivers, and

development restrictions in place at the local, state, and federal level, will continue to control and limit urbanized development, even with implementation of the improvements to reduce the risk of flooding, such as the local FRWLP and the Sutter Basin project recommended by this report.

The table below presents 2070 population estimates for the Sutter Basin using growth rates developed by the Sacramento Area Council of Governments (SACOG). The population figures do not relate directly to demand for developable acreage. In order to estimate the demand for developable land necessary to accommodate the projected population presented below, the population growth rates were applied to existing developed acreage in each jurisdiction. The projected urban development within each City's Sphere of Influence (SOI) as shown in each General Plan is shown in the Tables 13 and 14

Table 12. Population Projections within the Sutter Basin

Jurisdiction	2010 Population [1]	Projected Population (Year 2070) [2]	
		Med Growth Rate	Est. Population
Yuba City	64,925	2.5%	285,656
Live Oak	8,392	2.6% [3]	39,148
Biggs	1,707	5.2%	35,742
Gridley	6,584	3.5%	51,869
Sutter County	94,737	1.7%	260,482
Butte County	220,000	1.1%	424,123

[1] According to 2010 Census by city and county
[2] Based on Sacramento Area Council of Governments growth rates
[3] City of Live Oak Growth Rate used since SACOG estimate was not available for Live Oak

Table 13. Population Projections within the Sutter Basin – Sutter County

Sutter County Growth Areas[1]	Existing Developed Acreage[2]	Projected New Urban Acreage from 2010-2030[3]	Projected New Urban Acreage from 2010-2070[4]
Yuba City SOI & Employment Corridor	8,965	12,019	30,479
Live Oak SOI	1,165	6,511	11,667[5]
Other (Sutter & Tudor)	2,037	2,939	7,465
Subtotal Sutter County	**12,167**	**21,469**	**49,611**

[1] As indicated in the Sutter County General Plan Draft EIR
[2] Acreage within the City limits are assumed to be fully developed
[3] As indicated in the Sutter County General Plan Draft EIR. Does not subtract out existing development in the SOI
[4] Assumes population projected growth rate of 2.6% also applies to urbanized development
[5] Growth rate of 2.6% applied to new acreage in 2030 (6,511 acres)

Table 14. Population Projections within the Sutter Basin – Butte County

Butte County Growth Areas	Existing Developed Acreage	Projected New Urban Acreage from 2010-2030[3]	Projected New Urban Acreage from 2010-2070[4]
Biggs SOI	414[2]	541[2]	8,524
Gridley SOI	1,300[3]	2,900[3]	8,941
Subtotal Butte County	**5,155**	**3,441**	**17,465**
Total for Sutter & Butte County	**17,322**	**24,910**	**67,076**

[1] Does not subtract out existing development in the SOI
[2] As indicated in the City of Biggs General Plan
[3] Acreage values not included – gross acreage scaled off map in Gridley General Plan
[4] Assumes projected growth rate of 5.2% and 3.5% for Biggs and Gridley, respectively, also applies to urbanized development

The data presented in Tables 13-14 indicates that only about 67,000 new acres are projected to be developed by 2070 within the basin, assuming SACOG projected growth rates are maintained beyond 2030. Furthermore, Yuba City accounts for about half of the demand for developable acreage (approx. 30,000 acres). This estimated projected new urban acreage is far less than the Developable Area under the No Action, SB-7, and SB-8 alternatives. Therefore, this data indicates the estimated demand by 2070 for approximately 60,000 acres of developable land – far less than the 71,000 acres projected to be available in the basin under the no-action alternative.

For a more detailed writeup of developable acreages, population growth and wise use of floodplains, please see Attachment 4.

5. OTHER SOCIAL EFFECTS

Purpose and Methodology. This portion of the economic analysis documents the results of the Other Social Effects (OSE) account analysis associated with the Sutter Basin Pilot Feasibility Study. The analysis is intended to provide a portrait of the social landscape of the study area and offer a glimpse as to the vulnerability of the populations that call Sutter Basin their home.

A concern for social effects associated with water resources development and management has long been part of federal water resources planning guidance, appearing as the Social Well-being Account in 1972 *Principles and Standards*, and later as the OSE account in the *Principles and Guidance* (P&G) adopted in 1983 and in the Corps' ER 1105-2-100. However, since the adoption of the P&G there has been a tendency to discount the role and importance of OSE factors in water resources planning. Now, new guidance is being promulgated and implemented—principally EC 1105-2-409 *Planning in Collaborative Environment*—is placing much greater emphasis on the importance of including a broad range of considerations in planning. In addition to NED factors, other considerations, including social factors addressed in the OSE account, are to be used to develop appropriate water resources solutions.

Essentially, the OSE account serves to answer the following question:

> *How are social connectedness, community social capital, and community resiliency likely to change in the absence of a solution to a water resource issue? How are vulnerable populations likely to be affected?*
>
> **Metrics:**
> - Social Connectedness will be measured using Gender, Race & Ethnicity, Age, Rural/Urban Communities, Rentals vs. Homeownership and Occupation.
> - Community Social Capital will be measured using Education, Family Structure, Rural vs. Urban Communities and Population Growth.
> - Community Resilience will be measured using Income, Political Power, Prestige, Employment Loss, Residential Property, Infrastructure/Lifetime, Family Structure and Medical Services.

This assessment is in accordance with standards, procedures, and guidance of the U.S. Army Corps of Engineers. The *Planning Guidance Notebook* (ER 1105-2-100) serves as the primary source for evaluation methods of flood risk management studies and was used as a reference for this analysis. Additionally, the Institution for Water Resources *Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning* (IWR 09-R4) served instrumental in conducting the analysis.

This report analyzes the social effects related to the without and with-project conditions. The 1% annual chance exceedance (ACE) floodplain serves as the basis for the analysis of impact.

Historic Digest. The topography of the Sutter Basin is composed primarily of the gentle flatlands of the Sacramento Valley. Prior to the settlement of European populations, the basin was dominated by immense wetlands and riparian forest. The historic habitats of Sutter Basin supported large populations of waterfowl and other wildlife. In the 1830s, European settlers started to cultivate the basing for

agricultural use. Other practices included livestock grazing and controlled burns. The late 1800s brought gold miners during the Gold Rush and later cattle drivers that stayed to continue to use the rich soil for agriculture production. This resulted in lower areas and interior valleys being sparsely inhabited by ranchers and farmers. By the 1930s, the majority of the basin was cultivated for agricultural production and cattle grazing. Currently, the basin is a major agricultural center in northern California. Sutter basin is composed of two counties, Sutter and Butte. Both of which are primarily agricultural communities. The *2001 Census of Agriculture* classifies 88% of Sutter County's acreage of being in farms. The five leading crops based are rice, peaches, walnuts, dried plums, and tomatoes. Within the Sutter Basin study area boundary, Sutter County includes two cities (Yuba City and Live Oak), and Butte County includes another two cities (Biggs and Gridley).

Social Profile. A first key step in helping the decision-makers gain a better understanding of the social landscape—e.g., identifying who lives in the study area, who has a stake in the problem or issue and why it is important to them. This fundamental step entails performing a profile of the area in terms of basic social statistics, and to make such presentation of information meaningful by providing useful comparisons and rankings. The preparation of the social profile is not the OSE analysis. Social profiling provides the basic level of understanding about the social conditions, but more in-depth analysis is required to target areas of special concern or relevance to the specifics of the water resources issues. The basic social statistics discussed below are indicators used to portray basic information about the social life and the processes of the area under study. The development of these basic social characteristics (Table 15) present a portrait of the study area.

The 300 square mile study area is home to over 95,110 people. Approximately 88% of the total population abides in one of four incorporated cities. Yuba City makes up the majority of the population with 64,900 individuals. The communities of Live Oak, Gridley and Biggs have 8,400, 6,600, and 1,700 persons, respectively. The remainder of the population of 11,240 individuals reside in the surrounding rural areas of Sutter and Butte Counties. The study has seen a significant increase in population over the last decade. The growth has been primarily centered in Yuba City, which saw its population grow from 36,760 people in 2000 to 60,510 in 2006, a 65% increase.

The median age of the study area is consistent with State and national averages; as is the population over 65. However, the population under 18 years of age is higher in the study are (>28%) compared to State (25%) and national (24%) averages. Education statistics indicate lower levels of attainment. The percent of individuals over 25 with a high school degree (or equivalent) and percent of college graduates are lower than State and national averages.

Variances in race and ethnicity in communities may impose language and cultural barriers that affect ability to cope with natural hazards. The Hispanic presence is evident given they make up at least 28% of the population in each community. Live Oak's population is composed of 48.8% of individuals of Hispanic origin, which is significantly higher than the State average of 37.6% and greatly exceeds the national average of 16.3%.

Median household income for the study area ranges from $36,563 (Gridley) to $48,830 (Yuba City). Both of which are below State ($61,632) and national (52,762) averages. The persons living at or below the poverty level in the study area are 22.7%, 21.4% and 15% for Biggs, Gridley and Yuba City, respectively. All of which are larger than the State (14.4%) and national (14.3%) averages.

The total labor force in the study area is estimated at 40,000, with an unemployment rate of 14.7%, 8.4%, and 9.3% in Biggs, Gridley and Yuba City, respectively. Total private wage or salary workers estimated to be 75% (Biggs), 65% (Gridley) and 69% (Yuba City) with 17% (Biggs), 25% (Gridley) and 20% (Yuba City) of the labor force rated as government workers. Approximately, 7% (Biggs), 11% (Gridley) and 11% (Yuba City) of the labor force was considered to be self-employed, not incorporated. The average wage per job so the study area is between $22,300 to $28,100.

Table 15. Basic Social Characteristics—Sutter Basin Study Area
2010 Census Demographic Data

Basic Social Statistic	Study Area Community				California	National
	Biggs	Gridley	Live Oak	Yuba City		
Population						
Current Population (2010)	1,760	6,380	8,360	67,370	37,254,000	308,746,000
Age						
Median Age	35.1	33.1	31.7	33	35.2	37.2
% 65 and above	10.9%	14.1%	10.7%	11.7%	11.4%	13.0%
% under 18	28.1%	28.7%	30.6%	28.2%	25.0%	24.0%
Race and Ethnicity						
Asian	0.5%	3.7%	11.4%	17.0%	12.8%	4.7%
Black	0.4%	0.5%	1.4%	2.2%	5.8%	12.2%
Hispanic	34.0%	45.6%	48.8%	28.4%	37.6%	16.3%
White	60.5%	46.7%	35.0%	47.4%	40.1%	63.7%
Other	4.6%	3.5%	3.4%	5.0%	3.7%	3.1%
Education						
% HS Graduates	75.1%	64.6%	n/a-	77.6%	80.8%	85.4%
% College Graduates	9.3%	10.1%	n/a-	19.2%	30.2%	28.2%
Income and Poverty Status						
% Unemployed	14.7%	8.4%	n/a-	9.3%	6.5%	5.6%
Median Household Income	$44,485	$36,563	$41,773-	$48,830	$61,632	$52,762
Persons below Poverty (%)	22.7%	21.4%	24.2%-	15.0%	14.4%	14.3%
Housing						
Homeownership Rate	69.4%	57.8%	65.9%	56.9%	55.9%	65.1%
% of Mobile Homes	2.7%	3.6%	n/a-	4.4%	3.9%	6.6%
Quality of Life						
Average Household Size	3.37	3.63	3.88	3.49	3.45	2.58
Language Other than English Spoken at Home	32.6%	43.7%	n/a-	40.1%	43.2%	20.3%
Mean travel time to work (minutes)	26.4	21	n/a-	28	27	25.4

Social Effects Assessment.

Social Vulnerability and Resiliency: Social vulnerability is a term described by the sensitivity of a population to natural hazards, where as resiliency refers to the population's ability to respond to and recover from the impacts of such hazard. The characteristics that are recognized as having an influence on social vulnerability generally include age, gender, race and socioeconomic status. Other characteristics include population segments with special needs or those that lack the normal social safety nets necessary in disaster recovery, such as the physically or mentally challenged, non-English speaking immigrants, transients and seasonal tourists. The quality of human settlements (housing type and construction, infrastructure and lifelines) and the built environment are also important in understanding social vulnerability, especially as these characteristics influence potential economic losses, injuries, and fatalities from natural hazards. Table 16 provides discussion of factors that may dictate vulnerability and ability to cope with natural hazards, along with an assessment as it relates to the Sutter Basin study area.

Table 16. Social Vulnerability and Resiliency Indicators Assessment of the Sutter Basin Study Area

Indicator	Discussion[1]	Assessment
Income, political power, and prestige	This measure focuses on ability to absorb losses and enhance resilience to hazard impacts. Wealth enables communities to absorb and recover from losses more quickly due to insurance, social safety nets, and entitlement programs.	As a measure, median household income of the study area is less than the State and national average. The communities may be at a disadvantage in recovery efforts.
Gender	Women can have a more difficult time during recovery than men, often due to sector-specific employment, lower wages and family care responsibilities.	Although data is not specifically available concerning the wage rate of male versus female for the study area, it is recognized that a smaller percent of women are employed in the labor force in the study area than in the larger metropolitan city of Sacramento. However, the percent of variation of this factor is quite small.
Race and Ethnicity	Race and ethnicity may impose language and cultural barriers that affect access to post-disaster funding and residential locations in high hazard areas.	It is recognized that the study areas has a significant Hispanic population, which may pose a risk to the resiliency of the community. Of particular note is the fact that between 33-43% of the population speak a language other than English at home.
Age	Extremes of the age spectrum inhibit the movement out of harm's way. Parents lose time and money caring for children when daycare facilities are affected, elderly may have mobility constraints or mobility concerns increasing the burden of care and lack of resilience.	Those over 65 years of age are estimated at 11-14%, which is similar to State and national averages. Those under 5 years of age are estimated at around 8%, which is slightly above State and national averages.
Employment Loss	The potential loss of employment following a disaster exacerbates the number of unemployed workers in a community, contributing to a slower recovery from the disaster.	The current unemployment rate of the study area is higher than the State, which indicates that there may be financial issues in dealing with re-establishing housing.
Rural/Urban	Rural residents may be more vulnerable due to lower incomes, and more dependent on locally based resource extraction economies (farming and fishing). High-density areas (urban)	Because 12% of the population reside in the rural areas of the study area, there may be concern in their ability to recover from

	complicate evacuation from harm's way.	natural hazards.
Residential Property	The value, quality, and density of residential construction affect potential losses and recovery. For example, expensive homes are costly to replace, while mobile homes are easily destroyed and less resilient to hazards.	Percentage of mobile homes are similar to State averages, both of which are less than the national average.
Infrastructure and Lifelines	Loss of sewers, bridges, water, communications, and transportation infrastructure may place an insurmountable financial burden on the smaller communities that lack the financial resources to rebuild.	The smaller communities of Biggs, Gridley, and Live Oak are at a greater risk of coping with a natural hazard given their lack of financial resources when compared to the larger urban community of Yuba City.
Renters	People that rent typically do so because they are either transient or do not have the financial resources for home ownership. They often lack access to information about financial aid during recovery. In the most extreme cases, renters lack sufficient shelter options when lodging become uninhabitable or too costly to afford.	Housing rentals range between 30-43% of Sutter Basin's households. The high rental population highlights indications of community cohesion issues. Research indicates that renters do not have the same community pride as owners thereby having more barriers to direct community involvement in redeveloping the community after a natural hazard.
Occupation	Some occupations, especially those involving resource extraction, may be severely impacted by a hazard event. Self-employed fisherman suffer when their means of production is lost and may not have the requisite capital to resume work in a timely fashion and thus will seek alternative employment. Migrant workers engaged in agriculture and low skilled service jobs (housekeeping, childcare, and gardening) may similarly suffer, as disposable income fades and the need for services decline. Immigration status also affects occupational recovery.	Because the study area's industry is primarily driven by agricultural production, many workers may have a difficult time coping with natural hazards.
Family Structure	Families with large numbers of dependents or single-parent households often have limited finances to outsource care for dependents, and thus must juggle work responsibilities and care for family members. All affect the resilience torecover from hazards.	The literature indicates that families having over 4 or more persons have more financial difficulty than those of lesser numbers. Accordingly, community planners need to be aware of pending issues.
Education	Education is strongly linked to socioeconomic status, with higher educational attainment resulting in greater lifetime earnings. Lower education constrains the ability to understand warning information and access to recovery information.	With between 23-35% of Sutter Basin's residents having less than high school education there may be constraints in the ability of those residents to adequately deal with local, state, and federal information requirements surrounding recovery efforts.
Population Growth	Counties experiencing rapid growth lack available quality housing and the social services network may not have had time to adjust to increased populations. New migrants may not speak the language and not be familiar with bureaucracies for obtaining relief or recovery information, all of which increases vulnerability.	Sutter Basin has grown significantly in the past 10 years. A rapid growth rate in population is highly correlated with low community cohesion. The sense of belonging, cooperation, and strong sense of community pride are dynamic factors, which assist in the restoration of the community after a catastrophic event. Due to rapid growth in Yuba City, community bonds and sense of owning community issues may not be as strong as other more slowly growing cities like Biggs, Gridley, and Live Oak.

Medical Services	Health care providers, including physicians, nursing homes, and hospitals are important post-event sources of relief. The lack of proximate medical services will lengthen immediate relief and result in longer recovery from disasters.	Sutter Basin has many medical facilities available to its general population. This indicates very high medical assistance should natural hazard occur. Additionally, the nearby city of Sacramento is equipped to provide some medical assistance to the residents of Sutter Basin.

[1] Source: *Social Vulnerability to Environmental Hazards.* SOCIAL SCIENCE QUARTERLY, Volume 84, Number 2, June 2003.

Environmental Justice: Executive Order 12898 concerning environmental justice provides direction on the analysis of social and economic effects that would be applicable to proposed flood risk management projects. Signed by President Clinton in 1994, EO 12898 (Federal Actions to Address Environmental Justice in Minority and Low-Income Populations) requires that environmental analyses of proposed Federal actions address any disproportionately high and adverse human health or environmental effects on minority and low-income communities. Additionally, EO 13045 (Protection of Children from Environmental Health Risks and Safety Risks) requires Federal agencies to identify, assess, and address disproportionate environmental health and safety risks to children from Federal actions.

(1st Step) According to the guidelines established to assist the Federal and State agencies in examining potential for environmental justice impacts, the first step in conducting an environmental justice analysis is to define minority and low income populations. Based on these guidelines, a minority and low-income population is present in a project study area if:

- The minority population of the affected area exceeds 50 percent or the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.
- The project study area is composed of 50 percent or more people living below the poverty threshold, as defined by the U.S. Census Bureau, or it is significantly greater than the poverty percentage of the general population or other appropriate unit of geographic analysis.

(2nd Step) The second step of an environmental justice analysis requires a finding of a high and adverse impact. The executive orders address the impacts on the demographic, economic, and social factors that could measurably alter the economic condition (i.e., the availability of employment), the accessibility of goods, infrastructure and services, and the quality of life in the area of influence. These types of impacts would be significant to the affected population. More specifically, a proposed project alternative would have a significant socioeconomic impact if it were to result in any of the following effects:

- Long-term increase in population that could not be accommodated by regional infrastructure (i.e., housing, utilities, roads, hospitals and schools) or services (such as police and emergency services)
- A reduction in the availability of affordable housing, which could occur either through a large increase in housing prices or a large decline in the supply of affordable housing
- Long-term displacement of population that could not be accommodated within the region

- Long-term displacement or disruption of local businesses that could not be accommodated within the region
- A loss in community facilities, events, populations, or major industry that would result in an overall loss in community cohesion
- Disruption of emergency services or creation of a public health risk that could not be avoided by the public, especially if it would particularly affect the health and safety of children

(3rd Step) A proposed project alternative would have an environmental justice impact if it were to cause impacts that are disproportionately high and adverse, either directly, indirectly or cumulatively. To make a finding that disproportionately high and adverse effects would likely fall on a minority or low-income population, three conditions must be met simultaneously:

- There must be a minority or low-income population in the impact zone
- A high and adverse impact must exist
- The impact must be disproportionately high and adverse on the minority or low-income population

Review of real estate records and discussion with USACE Sacramento District PDT disclosed that the construction of Alternative SB-7 and SB-8 have no major direct impact to residents in the immediate area. Implementing the proposed alternative would have a beneficial impact on the regional economy due to increased expenditures in the regional economy during the construction period. However, increased construction-related traffic, delays, and detours as well as an increased population due to the presence of a construction workforce can result in increased social tension during the construction period. Nevertheless, the conclusion based on the environmental justice criteria, is that there is no highlt adverse impact due to construction of either alternative project.

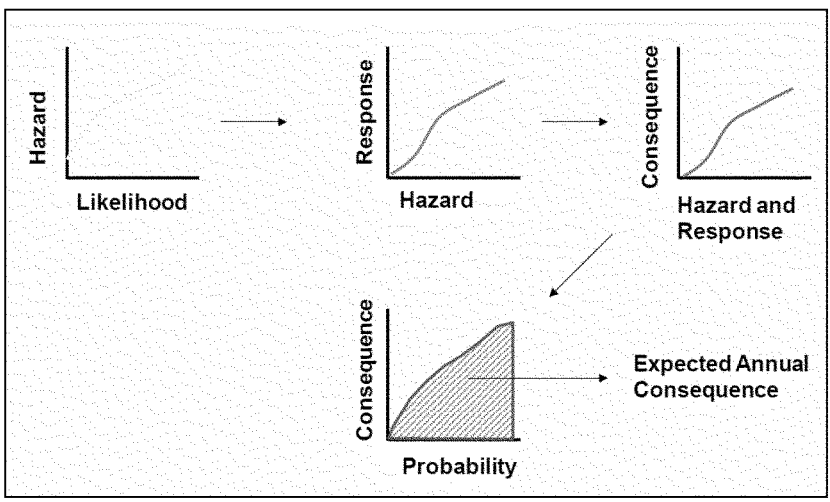
Life Safety Evaluation. Methods to calculate economic losses from natural hazards are fundamental to the planning process. However, such losses only capture part of the impact of natural hazards, and alternatives based only on reducing such damages miss a wide range of other important effects. A critical missing element from the current flood damage assessment approach is estimating the potential for loss of life and injury associated with flood events and flood damage reduction interventions. Current methodology has reached high level of sophistication but requires significant technical resources. However, the planning modernization paradigm calls for approaches that employ sound qualitative analysis guided by professional judgment rather than heavily focused high resource consuming quantitative processes.

Economists conducting the Sutter Basin Pilot Feasibility Study decided to make use of the Levee Screening Tool (LST) to facilitate preliminary assessment of the general condition and associated risks of levees in support of loss of life estimation. The LST provides an initial quantitative risk estimate to assist local, state, and Federal stakeholders in identification and prioritization of funding needs for levees of concern. All inputs for the LST will be estimated from readily available data. Estimates of the flood loading are made from information such as design documents, gage records, flood insurance studies, or project specific studies. An assessment of performance is based on results of the routine levee inspection and an engineering assessment of performance related items from the levee inspection checklist based on

a review of design documents and other relevant engineering data. Life safety consequences within the study area are estimated from readily available data.

The risk associated with levee segments and systems can be characterized by considering the magnitude and likelihood of a hazard (i.e. loading), the conditional response of the levee given the loading (i.e. performance), and the potential consequences that result from the combination of loading and response. Various loading scenarios may be possible as a result of the types of loading (e.g. flood), operational performance (e.g. gate closure), human intervention (e.g. sandbagging during a flood fight), or outcomes external to the levee system (e.g. upstream reservoir operations or failure of a nearby levee system). Performance of the levee can be described by one of the following inundation scenarios: 1) Breach prior to overtopping, 2) Overtopping with breach, 3) Overtopping without breach, and 4) Component malfunction. Multiple performance modes (e.g. seepage and piping, overtopping, floodwall stability) can influence performance of the levee system and each performance mode can have different consequences depending on the location and severity of a levee breach. Consequences can also be influenced by various factors such as the effectiveness of warnings and evacuations and the depth, velocity, and rate of rise of flooding. The three primary inputs (load, performance, consequences) can be combined using probabilistic methods to obtain a risk estimate represented as a probability distribution of potential consequences. The expected value of risk (i.e. average annual) is often computed from this distribution and used as a point estimate of the risk. Point estimate results are commonly displayed on an f,N chart with the vertical axis representing the annual likelihood of inundation and the horizontal axis representing the average magnitude of consequences. A conceptual representation of the risk framework is provided in Figure 1.

Figure 2. Conceptual Risk Framework



The consequence portion of the LST includes computation that allow for an estimate of loss of life caused by inundation due to breach or overtopping of a levee. Readily available data and information are used

along with limited analysis to assess the potential consequences related to a breach prior to overtopping of a levee segment. The consequences section of the LST is subdivided into the categories of general information, evacuation effectiveness, fatality rate computation, and critical infrastructure. For additional information on methodology please see the *Levee Screening Tool: Methodology and Application* (November 2011, RMC-CPD-1).

The computed statistical fatalities under a breach scenario for the without-project condition are estimated to be 388 and 489 for day and night settings, respectively. Table 17 indicates the results of the application of the LST to the estimated population under each alternative scenario. To the approximately 38,300 people at risk under Alternative SB-7, the potential statistical life loss estimate is 157 (day) and 197 (night) statistical lives lost. And to approximately 6,640 people at risk under Alternative SB-8, the potential life loss estimate is 27 (day) and 34 (night). These statistical Life Loss estimates are for a levee breach in an un-strengthened reach during a flood event near the top-of-levee (approximately a 0.5%, 1/200 ACE event) after construction of a given alternative.

Table 17. Statistical Life Loss Estimate

Community	Alternative					
	SB-1		SB-7		SB-8	
	Day	Night	Day	Night	Day	Night
Biggs	6	8	6	8	0	0
Gridley	26	33	26	33	0	0
Live Oak	34	43	34	43	0	0
Yuba City	276	348	47	59	14	18
Rural Butte	20	25	20	25	0	0
Rural Sutter	26	32	24	30	13	16
Total	**388**	**489**	**157**	**197**	**27**	**34**

In addition to life loss evaluation, other metrics were developed to assess the vulnerability of individuals living in the study area. Table 18 describes the metrics used to further evaluate life safety and Table 19 shows their results by alternative.

Table 18. Description of Metrics

Evaluation Metric	Description
Population at Risk (People)	Number of people within the 1% ACE Floodplain based on the 2010 census block GIS data.
Critical Infrastructure (Facilities)	Number of fire stations, police stations, hospitals, senior living facilities, and jails that are of life safety significance.
Evacuation Routes (# of Routes)	Assesses the vulnerability of populations with regards to the number of escape routes available during flood events.
Wise Use of Floodplains (Acres)	Potentially developable land within the 0.2% ACE floodplain. Acres of land with 1% ACE flood depths less than 3 feet.

Table 19. Summary of Life Safety Metrics

Evaluation Metric	Alternative		
	SB-1	SB-7	SB-8
Population at Risk (People)	94,600	38,200	6,600
Critical Infrastructure (Facilities)	28	11	1
Evacuation Routes (# of Routes)	0	1	5
Wise Use of Floodplains (Acres)	71,800	88,200	100,200

Population at Risk. The population at risk of flooding from a 1% ACE flood event is 94,600 for the without project condition (Alternative SB-1). A remaining population of 38,200 and 6,600 are at risk of flooding from Alternative SB-7 and SB-8, respectively. Of special concern is the population over the age of 65 living within the study area since those individuals have been shown to be at higher risk of life loss in flood events. The community of Gridley has above average representation of individuals age 65 or older.

Critical Infrastructure. A significant amount of critical infrastructure is located within the Sutter study area. Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy from a national perspective. Most commonly associated with the term are facilities for fire stations, police stations, hospitals, senior living facilities, and prisons. The benefits of Alternative SB-7 are primarily centered around Yuba City and still at risk are 11 of the critical infrastructure in the communities of Biggs, Gridley and Live Oak.

Evacuation Routes. The primary urban centers in the region are Yuba City, Biggs, Gridley, and Live Oak. These communities are all located on or near California State Route 99, which runs north-south through the region. Each community is also relatively close to California State Route 20, a major east-west roadway, which could also be used in an evacuation. Highway 20 takes a generally straight east-west path across the Sacramento River and the Sutter Bypass on its way to Yuba City. The route crosses Highway-99 west of central Yuba City, and runs east through the northern Yuba City to the Feather River, which it crosses on the 10th Street Bridge into Marysville. The Sutter County Evacuation and Mass Shelter/Care Plan identifies Highway 20, 99 and 113 as the primary evacuation routes in the region. These routes are subject to change since these routes are event-specific and official routes are established by the County Sheriff's office during an emergency. The Butte County Office of Emergency Management does not have published evacuation routes at this time, but anticipates Highway 99, 162 and Colusa Highway could be used as conditions allow. During the 1997 event, seven different evacuation zones were established over seven days due to constantly changing conditions and levee breaks[5]. The main evacuation routes used for this flood event were Highway-99 north and Highway-113 south. Highway-20 west and Highway-99 south were used intermittently since all portions of these roads were not accessible at all times during the flood.

Evacuation preparation can be made days in advance for predictably rain events. For example, a 0.2% ACE (1/500 year event) rain storm would be identified by meteorologist and residents could be given notice days in advance. As a significant rain event nears, warnings and evacuation efforts would be

[5] Source: Sutter County Office of Emergency Management.

increased and reiterated. This would allow time for evacuation of immobile residents and other people with special evacuation needs (hospitals, rest homes, jails, elderly individuals, schools) via the established routes. However, none of the historical flooding evacuations in the region have been due to foreseen weather events. Historical flood evacuations in the region have been from levee failures due to underseepage, which is characterized by its unpredictability and sudden occurrence. The result is evacuations after levees have failed and widespread flooding is in progress. The 1955 flood occurred due to a levee break in late December where no prior evacuation notice was given. In the 1997 flood, Yuba City was evacuated and during the evacuation a levee on the east side of the Feather River near Olivehurst (which was not evacuated) broke.

The residual 1% ACE (1/100 year event) resulting from Alternative SB-7 impacts every major urban center and nearly every primary evacuation route in the region. The floodplain is due to potential levee failure upstream of Sunset Weir. All routes out of Biggs, Gridley and Live Oak are impacted by the residual floodplain. The only egress from Yuba City would be Highway 20 east into Marysville, which is a community surrounded by a ring levee. Additionally, heading eastbound entails driving over a four lane bridge that is not expected to adequately handle the additional traffic flow, and may create a bottle neck limiting evacuation.

Wise Use of Floodplains. A determination must be made as to whether the increase in potentially developable floodplain area is acceptable under Corps policy, or can be avoided or mitigated to an acceptable level within a justified cost. It is important to remember that the floodplain metric used in this analysis is a simple index based on physical parameters. The metric does not attempt to forecast future population growth, economic conditions, or government decisions that will constrain future floodplain development. Those factors should be considered in conjunction with the metric.

Without and With-Project Comparison. Corps assessment of beneficial and adverse effects are based on comparison of with-project alternatives to the future without-project alternative condition expected to prevail. The social effects of the alternatives have both direct and indirect effects. Direct effects result immediately from construction of the projects, whereas indirect effects result from the effects of the project on the existing social landscape in the study area. A first step is describing or characterizing the alternatives in terms of descriptors such as magnitude (number of individuals affected), location (concentration of effects), timing and duration (when the effects will start and how long they are expected to last), and associated risks. Table 20 provides a description of the effects of each alternative, including the no action.

Table 20. Characterization of Alternative Effects

	SB-1	SB-7	SB-8
1. ALTERNATIVE DESCRIPTION			
	Alternative SB-1: The No Action provides no physical project constructed by the Federal Government.	Alternative SB-7: The plan is a Feather River fix-in-place levee alternative from Sunset Weir to Laurel Avenue.	Alternative SB-8: The plan is a Feather River fix-in-place levee alternative from Thermalito to Laurel Avenue.
2. OTHER SOCIAL EFFECTS			
Summary	Continued flood risk and consequences in the Sutter Basin including the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Significant life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs are significantly reduced.
Population at Risk	Approximately **96,600** individuals are within the 1% ACE floodplain.	**38,200** people remain in the 1% ACE floodplain. (60% of population is removed from the 1% ACE residual floodplain.)	**6,600** people remain in the 1% ACE floodplain. (93% of population is removed from the 1% ACE residual floodplain)
Loss of Life	Potential loss of lives: **Day-388, Night-489**	Potential loss of lives: **Day-157, Night-197**	Potential loss of lives: **Day-27, Night-34**
Critical Infrastructure	**28** structure deemed as critical from a national perspective are at risk from floods.	**11** structures remain at risk from floods.	**1** structure is at risk from floods.
Evacuation Routes	In the event of a flood, no evacuation route is available out of the basin.	Offers **one** problematic route for evacuation during a flood event. A flood warning and evacuation plan would not be as effective and limited.	**5** evacuation routes are available in the event of a flood. A flood warning and evacuation plan would have more robustness and redundancy.
Wise Use of Floodplains	Currently, 71,800 acres of land are potentially available for future development.	88,200 acres would be potentially available for future development.	100,200 acres of land would be potentially available for future development.
Social Vulnerability	The social vulnerability index score (SoVi) indicates the study area to be medium to high vulnerability. The No Action alternative may leave communities unable to cope with the recovery from a flood hazard.	Majority of the community of Yuba City is afforded flood risk reduction, however the communities of Live Oak, Gridley, and Biggs remain at risk of flood hazards and may be unable to cope and recover.	The four existing communities are provided flood risk reduction, and social vulnerability is minimized due to a decrease in the probability of flood hazards occurring.
Residual Risk and Consequences	Residual Risk remains high throughout the study area	Residual Risk for Life Safety is reduced for most of the Yuba City urban area.	Residual Risk for Life Safety is reduced in the high risk communities: Yuba City, Live Oak, Gridley and Biggs.

6. REGIONAL ECONOMIC DEVELOPMENT

Purpose and Methodology. The U.S. Army Corps of Engineers (USACE) *Planning Guidance Notebook* (ER 1105-2-100) states that while National Economic Development and Environmental Quality accounts are required, display of the Regional Economic Development effects are discretionary. The Corps' NED procedures manual affirms that RED benefits are real and legitimate; however, the concern (from a Federal perspective) is that they are often offset by RED costs in other regions. Nevertheless, for the local community these benefits are important and can help them in making their preferred planning decisions.

Although the RED account is often examined in less detail than NED, it remains useful. For example, Hurricane Katrina caused a significant economic hardship to not just the immediate Gulf Coast but for entire counties, watersheds, and the State of Louisiana. Besides the devastating damage to homes (which are often captures by the NED account), hundreds of thousands lost their jobs, property values fell, and tourism and tax revenues declined significantly and moved to other parts of the U.S. In this example, the RED account can provide a better depiction of the overall impact to the region.

The distinction between NED and RED is a matter of perspective, not economics. A non-federal partner may consider the impacts at the state, regional, and local levels to be a true measure of a project's impact or benefit, whereas from the Corps' perspective, this may not constitute a national benefit. Gains in RED to one region may be partially or wholly offset by losses elsewhere in the nation. For example, if a Federal project enables a firm to leave one state to locate in the newly-protected floodplain of another state, the increase in regional income for the project area may come at the expense of the former area's loss. As such, they may not influence the net value of the nation's output of goods and services and should be excluded from NED computations.

RED Concepts. The RED account has been given less emphasis in the Corps' past or current guidance. Perhaps the most extensive statement on RED appeared in the Principles and Guidance earlier version, the Principles and Standards:

> *"Through its effects—both beneficial and adverse—on a region's income, employment, population, economic base, environment, social development and other factors, a plan may exert a significant influence on the course and direction of regional development. The regional development account embraces several types of beneficial effects, such as (a) increased regional income, (b) increased regional employment, (c) population distribution, (d) diversification of regional economic base, and (e) enhancement of environmental conditions of special regional concern."*

Econometric analysis allows for the evaluation of the full range of economic impacts related to specific economic activities (construction and procurement) by calculating the direct, indirect and induced effects of the activities in the specific geographical designation.

- Direct Effects: consist of economic activity contained exclusively within the designated sector. This includes all expenditures made by the companies or organizations in the industry and all employees who work directly for them.
- Indirect Effects: define the creation of additional economic activity that results from linked business, suppliers of goods and services, and provisions of operating inputs.

- Induce Effects: measure the consumption expenditures of direct and indirect sector employees.

Input-output(I/O) models are characterized by their ability to evaluate the effects of industries on each other. Unlike most typical measures of economic activity that examine only the total output of an industry or the final consumption demand provided by a given output, I/O models provide a much more comprehensive view of the interrelated economic impacts. I/O analysis is based on the notion that there is a fundamental relationship between the volume of output of an industry and the volume of the various inputs used to produce that output. Industries are often grouped into production, distribution, transportation, and consumption. Additionally, the I/O model can be used to quantify the multiplier effect. In economics, the multiplier effects refers to the idea that an increase in spending can lead to even greater increase in income and consumption, as monies circulate or multiply through the economy.

Flood Risk Management RED Considerations. There are particular effects for each type of project improvement as they relate to the RED account. The estimation of RED flood-related effects can be very complex. At a minimum, the RED analysis should include a qualitative description of the types of businesses at risk from flooding, particularly those that could have a significant adverse impact (output, employment, etc.) upon the community or regional economies if their operations should be disrupted by flooding and how this would be affected by the recommended project. The potential RED effects to flood risk management projects are summarized in Table 21.

Table 21. Potential RED Effects to Flood Risk Management

RED Factor	Potential RED Effects
Construction	Additional construction related activity and resulting spillovers to suppliers
Revenues	Increased local business revenues as a consequence of reduced flooding, particularly from catastrophic floods
Tax Revenues	Increased income and sales taxes from the direct project and spillover industries
Employment	Short-term increase in construction employment; with catastrophic floods, significant losses in local employment (apart from the debris and repair businesses, which may show temporary gains)
Population Distribution	Disadvantage groups may benefit from the creation of a flood-free zone
Increased Wealth	Potential increase in wealth for floodplain residents as less is spent on damage property, repairs, etc and potential increase in property values.

Regional Economic System Results. A variety of software programs are available to determine the RED impacts for each project. Depending on the level of effort, project purpose, precision requirements and size of the study area, application will most likely vary. The Corps of Engineers' Institute for Water Resources along with the Louis Berger Group has developed a regional economic impact modeling tool called Regional Economic System (RECONS) that provides estimates of regional and national job creation, retention and other economic measures. The expenditures made by the USACE for various services and products generate economic activity that can be measures in jobs, income, sales and gross regional product. RECONS automates calculations and generates estimates of economic measures associated with USACE's annual civil work program spending. RECONS was built by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE's project locations by the Minnesota IMPLAN Group. These multipliers were then imported into a database and RECONS matches various spending profiles to the matching industry sectors by location to produce economic impact estimates. RECONS will be used as a means to

document the performance of direct investment spending of the USACE, as it allows users to evaluate project and program expenditures associated with the annual expenditure.

The economic impacts presented below show the Sutter study area and the State of California's inter-related economic impacts resulting from an infusion of flood reduction construction funds. For this analysis, the study area and the State of California were both used as the geographic designation to assess the overall economic impacts of the construction funds. This places a frame around the economic impacts where the activity is internalized. Leakages (payments made to imports or value added sectors, which do not in turn re-spend the dollars within the area) are not included in the total impacts.

Table 22 serves to demonstrate the complex nature of the Yuba City Metropolitan Statistical Area (MSA) in 2008. There are approximately 64,844 persons employed in the MSA of Yuba City, California providing an output to the national of $8,332,000,000 annually.

Table 22. Regional Profile
Yuba City Metropolitan Statistical Area, California
(Values in Millions, 2013 Dollars)

Industry	Output	Labor Income	GRP	Employment
Accommodations and Food Service	$193	$63	$95	3,507
Administrative and Waste Management Services	$182	$81	$111	2,682
Agriculture, Forestry, Fishing and Hunting	$708	$179	$331	6,260
Arts, Entertainment, and Recreation	$50	$14	$21	753
Construction	$547	$225	$246	3,686
Education	$266	$225	$254	4,491
Finance, Insurance, Real Estate, Rental and Leasing	$510	$113	$355	3,523
Government	$1,220	$871	$1,092	11,767
Health Care and Social Assistance	$603	$340	$391	6,389
Imputed Rents	$688	$90	$437	3,901
Information	$347	$38	$76	603
Management of Companies and Enterprises	$38	$14	$19	233
Manufacturing	$1,131	$154	$236	2,698
Mining	$246	$57	$149	555
Professional, Scientific, and Technical Services	$262	$120	$146	2,421
Retail Trade	$582	$243	$396	7,058
Transportation and Warehousing	$272	$102	$143	2,476
Utilities	$168	$28	$78	201
Wholesale Trade	$320	$122	$209	1,639
Total	**$8,332**	**$3,080**	**$4,786**	**64,844**

The total remaining costs for the project is estimated at 430,000,000 and 691,000,000 for alternative SB-7 and SB-8, respectively. In conducting the regional economic development analysis, the costs needed to be adjusted for two items: (1) interest during construction and (2) purchase of land. Interest during construction is the interest that is paid back to the federal treasury to cover the bond payments made in the construction of the project. These funds are not expended within the region and therefore are not included

within the regional analysis. Similarly, the purchase of land, not counting administrative costs, are considered as transfer payments from one party to another and not considered in the analysis.

Table 23 is based on the average annual regional expenditures that are expected over the remaining construction period. The construction schedule for alternative SB-7 is five years and seven years for alternative SB-8. Over that period of construction, a total of $342 million (SB-7) and $629 million (SB-8) is anticipated to be spent in the Sutter Basin study area in order to complete construction effort and place the project beneficial status. The average construction expenditure is the anticipated amount divided by the years of constructions, $68 million (SB-7) and $89 million (SB-8).

Table 23. Input Assumptions
Yuba City Metropolitan Statistical Area, California
(Values in Thousands, 2013 Dollars)

Category	Spending	Spending Amount		Local Percentage Capture		
		SB-7	SB-8	Local	State	National
Aggregate Materials	10%	34,186	62,984	94%	96%	99%
Other Materials	1%	3,419	6,298	100%	100%	100%
Equipment	35%	119,650	220,443	90%	99%	100%
Construction Labor	54%	184,603	340,111	100%	100%	100%
Total	100%	341,857	629,836	-	-	-

Direct expenditures expected for construction of earthen levees are spent primarily in two sectors of the economy, construction labor and equipment. Both account for 89% of the total project expenditures. Local capture rates are computed with RECONS to show where the output from expenditures are realized. As indicated in Table 20, all of the construction labor is expected to occur within the MSA, and 90% of the equipment is expected to be provided from within the study area, and 99% from within the State of California.

Table 21 summarizes the expected economic impacts in terms of monetary output, number of jobs, labor income and gross regional product. USACE is planning on expending approximately $78,000,000 for SB-7 or $99,000,000 for SB-8 on the project. Of this total project expenditure, approximately $75,000,000 for SB-7 or $96,000,000 for SB-8 will be captured within the regional impact area. The rest will be leaked out to the State of California or the nation. The expenditures made by the USACE for various services and products are expected to generate additional economic activity, which can be measured in jobs, income, sales, and gross regional product as summarized in Table 22-24.

Of significant note to the study area is the creation of jobs. Currently, the unemployment rate in the study area (8.4% in Gridley, 9.3% in Yuba City and 14.7% in Biggs) is higher than state (6.5%) and national (5.6%) averages, and the number of jobs gained within the region demonstrates the multiplier effect of this infusion of construction funds for this project.

Table 21. Summary of Economic Impacts
Yuba City Metropolitan Statistical Area, California
(2013 Dollars)

Total Spending		Alternative SB-7			Alternative SB-8		
		Regional	State	National	Regional	State	National
		$389,583,648	$389,583,648	$389,583,648	$696,564,551	$696,564,551	$696,564,551
Direct Impact	Output	$74,773,140	$77,321,802	$77,800,655	$95,494,472	$98,749,426	$99,360,980
	Job	5,421	5,463	5,474	9,693	9,768	9,788
	Labor Income	$52,207,466	$52,884,703	$53,058,423	$66,675,338	$67,540,253	$67,762,115
	GRP	$60,332,499	$61,751,971	$62,020,277	$77,052,002	$78,864,842	$79,207,502
Total Impact	Output	$127,772,992	$155,527,257	$205,466,249	$163,181,784	$198,627,385	$262,405,604
	Job	7,429	8,215	9,605	13,283	14,688	17,173
	Labor Income	$69,479,772	$79,789,624	$95,800,668	$88,734,192	$101,901,137	$122,349,205
	GRP	$91,926,674	$108,402,306	$136,103,550	$117,401,639	$138,443,042	$173,820,929

Table 22. Economic Impacts—Regional Level
Yuba City Metropolitan Statistical Area, California
(2013 Dollars)

Industry Sector		Alternative SB-7				Alternative SB-8			
		Sales	Jobs	Labor Income	GRP	Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$22,009,401	$124	$11,489,718	$13,332,689	$39,352,187	$223	$20,543,290	$23,838,471
	Wholesale trade businesses	$385,064	$2	$158,569	$295,542	$688,482	$4	$283,517	$528,420
	Transport by rail	$583,568	$2	$179,004	$309,500	$1,043,403	$3	$320,053	$553,377
	Transport by water	$89,119	$0	$35,602	$38,623	$159,342	$0	$63,655	$69,059
	Transport by truck	$12,952,591	$92	$6,595,905	$7,663,482	$23,158,865	$164	$11,793,292	$13,702,088
	Construction of other new nonresidential structures	$4,675,004	$31	$1,612,504	$2,156,066	$8,358,775	$55	$2,883,112	$3,854,985
	Commercial & industrial machinery & equipment rental/leasing	$122,795,785	$403	$30,590,856	$67,491,423	$219,555,391	$721	$54,695,587	$120,672,755
	Labor	$210,375,170	$4,767	$210,375,170	$210,375,170	$376,144,857	$8,523	$376,144,857	$376,144,857
Total Direct Effects		$373,865,699	$5,421	$261,037,328	$301,662,495	$668,461,303	$9,693	$466,727,365	$539,364,015
Secondary Effects		$264,999,257	$2,008	$86,361,532	$157,970,873	$473,811,182	$3,590	$154,411,976	$282,447,457
Total Effects		$638,864,958	$7,429	$347,398,860	$459,633,369	$1,142,272,486	$13,283	$621,139,341	$821,811,471

Table 23. Economic Impacts—State Level
Yuba City Metropolitan Statistical Area, California
(2013 Dollars)

Industry Sector		Alternative SB-7				Alternative SB-8			
		Sales	Jobs	Labor Income	GRP	Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$22,009,401	$124	$11,489,718	$13,332,689	$39,352,187	$223	$20,543,290	$23,838,471
	Wholesale trade businesses	$572,707	$3	$241,125	$441,650	$1,023,984	$6	$431,124	$789,656
	Transport by rail	$853,694	$3	$264,852	$454,789	$1,526,380	$5	$473,549	$813,149
	Transport by water	$296,773	$1	$118,556	$130,732	$530,622	$1	$211,975	$233,745
	Transport by truck	$12,952,591	$92	$6,595,905	$7,663,482	$23,158,865	$164	$11,793,292	$13,702,088
	Construction of other new nonresidential structures	$4,675,004	$31	$1,612,504	$2,156,066	$8,358,775	$55	$2,883,112	$3,854,985
	Commercial & industrial machinery & equipment rental/leasing	$134,873,671	$443	$33,725,684	$74,205,277	$241,150,310	$792	$60,300,569	$132,676,938
	Labor	$210,375,170	$4,767	$210,375,170	$210,375,170	$376,144,857	$8,523	$376,144,857	$376,144,857
Total Direct Effects		$386,609,009	$5,463	$264,423,514	$308,759,854	$691,245,981	$9,768	$472,781,769	$552,053,892
Secondary Effects		$391,027,274	$2,752	$134,524,604	$233,251,676	$699,145,713	$4,920	$240,526,190	$417,047,405
Total Effects		$777,636,283	$8,215	$398,948,118	$542,011,530	$1,390,391,694	$14,688	$713,307,957	$969,101,296

Table 24. Economic Impacts—National Level
Yuba City Metropolitan Statistical Area, California
(2013 Dollars)

Industry Sector		Alternative SB-7				Alternative SB-8			
		Sales	Jobs	Labor Income	GRP	Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$22,009,401	$124	$11,489,718	$13,332,689	$39,352,187	$223	$20,543,290	$23,838,471
	Wholesale trade businesses	$580,472	$3	$244,541	$447,695	$1,037,868	$6	$437,233	$800,467
	Transport by rail	$1,110,386	$3	$347,187	$594,122	$1,985,339	$6	$620,760	$1,062,272
	Transport by water	$429,826	$1	$171,710	$191,336	$768,517	$2	$307,011	$342,103
	Transport by truck	$13,667,937	$97	$6,960,184	$8,086,722	$24,437,886	$174	$12,444,613	$14,458,829
	Construction of other new nonresidential structures	$4,675,004	$31	$1,612,504	$2,156,066	$8,358,775	$55	$2,883,112	$3,854,985
	Commercial & industrial machinery & equipment rental/leasing	$136,155,077	$448	$34,091,102	$74,917,585	$243,441,429	$800	$60,953,926	$133,950,525
	Labor	$210,375,170	$4,767	$210,375,170	$210,375,170	$376,144,857	$8,523	$376,144,857	$376,144,857
Total Direct Effects		$389,003,273	$5,474	$265,292,116	$310,101,385	$695,526,857	$9,788	$474,334,804	$554,452,511
Secondary Effects		$638,327,972	$4,130	$213,711,226	$370,416,366	$1,141,312,370	$7,385	$382,109,629	$662,293,992
Total Effects		$1,027,331,245	$9,605	$479,003,341	$680,517,751	$1,836,839,227	$17,173	$856,444,434	$1,216,746,503

7. ECONOMIC SUMMARY

A summary table of the cost benefit analysis, other social effects assessment and the regional economic development benefits is detailed in Table 25.

Table 25. Summary of Analyses

	SB-1	SB-7	SB-8
1. PLAN DESCRIPTION			
	Alternative SB-1: The No Action provides no physical project constructed by the Federal Government.	Alternative SB-7: The plan is a Feather River fix-in-place levee alternative from Sunset Weir to Laurel Avenue.	Alternative SB-8: The plan is a Feather River fix-in-place levee alternative from Thermalito to Laurel Avenue.
2. SUMMARY OF IMPACT ANALYSES			
A. National Economic Development (NED)			
1. Annual Damages	$ 137,000,000	$ 58,000,000	$ 50,000,000
2. Annual Benefits	$ -	$ 79,000,000	$ 87,000,000
3. Total Economic Costs[1]	$ -	$ 390,000,000	$ 686,000,000
a. IDC	$ -	$ 38,000,000	$ 94,000,000
b. O&M	$ -	$ 280,000	$ 450,000
c. Annual Cost	$ -	$ 18,000,000	$ 33,000,000
d. Construction Period		5 years	7 years
4. Annual Net Benefits	$ -	$ 61,000,000	$ 54,000,000
5. Benefit-to-Cost Ratio	-	4.4	2.6
B. Other Social Effects (OSE)			
Population at Risk[2]	Approximately **96,600** individuals are within the 1% ACE floodplain.	**38,200** people remain in the 1% ACE floodplain. (60% of population is removed from the 1% ACE residual floodplain.)	**6,600** people remain in the 1% ACE floodplain. (93% of population is removed from the 1% ACE residual floodplain)
Loss of Life	Potential loss of lives: **Day-388, Night-489**	Potential loss of lives: **Day-157, Night-197**	Potential loss of lives: **Day-27, Night-34**
Critical Infrastructure	**28** structure deemed as critical from a national perspective are at risk from floods.	**11** structures remain at risk from floods.	**1** structure is at risk from floods.
Evacuation Routes	In the event of a flood, no evacuation route is available out of the basin.	Offers **one** problematic route for evacuation during a flood event. A flood warning and evacuation plan would not be as effective and limited.	**5** evacuation routes are available in the event of a flood. A flood warning and evacuation plan would have more robustness and redundancy.
Wise Use of Floodplains	Currently, 71,800 acres of land are potentially available for future development.	88,200 acres would be potentially available for future development.	100,200 acres of land would be potentially available for future development.
Social Vulnerability	The social vulnerability index score (SoVi) indicates the study area to be medium to high vulnerability. The No Action alternative may leave	Majority of the community of Yuba City is afforded flood risk reduction, however the communities of Live Oak, Gridley, and Biggs remain at	The four existing communities are provided flood risk reduction, and social vulnerability is minimized due to a decrease in the probability of

	SB-1	SB-7	SB-8
	communities unable to cope with the recovery from a flood hazard.	risk of flood hazards and may be unable to cope and recover.	flood hazards occurring.
Residual Risk and Consequences	Residual Risk remains high throughout the study area	Residual Risk for Life Safety is reduced for most of the Yuba City urban area.	Residual Risk for Life Safety is reduced in the high risk communities: Yuba City, Live Oak, Gridley and Biggs.
C. Regional Economic Development (RED)—Regional Direct Impacts			
Output	$8,332,000,000	SB-1 + $74,773,000 (5yrs)	SB-1 + $95,494,000 (7yrs)
Job	64,844	SB-1 + 5,344 (5yrs)	SB-1 + 9,556 (7yrs)
Labor Income	$3,080,000,000	SB-1 + $52,207,000 (5yrs)	SB-1 + $66,675,000 (7yrs)
Gross Regional Product	$4,786,000,000	SB-1 + $60,332,000 (5yrs)	SB-1 + $77,052,000 (7yrs)

[1] Cultural resources data recovery costs ($1.6 million for SB-7 and $3.0 million for SB-8) are not included in economic costs per Corps policy (ER 1105-2-100, Appendix e, paragraph E-63.f.(5)).

[2] Population at Risk was calculated by GIS overlays of: 1) composite residual floodplains showing less than 90% assurance for the 1% ACE event, 2) population by census block and 3) Economic Impact Areas. These figures may differ slightly from those presented previously as official Census data in this document.

Attachment 1: Economic Appendix to support Decision Point #2 (September 2012)

1 Overview

The study area is located in Sutter and Butte Counties, California and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area covers approximately 300 square miles and is approximately 43 miles long and 9 miles wide. The study area includes the communities of Yuba City, Live Oak, Gridley, Biggs, and Sutter with a total population of approximately 80,000. Yuba City is the largest community in the study area, with a population of approximately 65,000. A map of the study area can be found in Figure 1-1.

The study area is essentially encircled by project levees of the Sacramento River Flood Control Project and high ground of the Sutter Buttes. In 1917, the Federal government authorized the Sacramento River Flood Control Project, which adopted a system of locally built levees as Federal levees, and constructed additional levees, bypasses, overflow weirs, and pumping facilities. Although the Sacramento River Flood Control Project levees were often constructed of poor foundation materials such as river dredge soils that would not meet today's engineering standards, the levees are relied upon today to provide FRM for numerous communities.

The primary sources of flooding within the study area are the Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and local interior drainage. Flood depths and frequency vary throughout the study area. Probability of flooding within the study area is primarily related to the stage of floodwaters within the river channels and the geotechnical probability of levee failure at flood stage.

The Sutter Bypass is a flood control channel approximately three quarters of a mile wide, bordered on each side by levees. The bypass is an integral feature of the Sacramento River Flood Control Project's flood bypass system, conveying flood waters from the Butte Basin, Sacramento River, and Feather River to the confluence of the Sacramento River and Yolo Bypass at Fremont Weir; additional flood flows from the Sacramento River enter the Sutter Bypass through Tisdale Bypass. The lower portion of the Sutter Bypass also conveys water from the Feather River. Within this reach the Feather River is separated from the main conveyance of the bypass by a low levee. This design maintains higher velocities and sediment transport capacity within the Feather River during low flow events while utilizing the large conveyance of the Sutter Bypass during larger events. The Sutter Bypass also receives minor natural flow and agricultural return flow from Reclamation District 1660 to the west and from Wadsworth Canal and DWR pumping plants 1, 2, and 3 to the east. The Sutter Bypass is described by four hydrologic reaches based on tributary inflows: Butte Slough to Wadsworth Canal, Wadsworth Canal to Tisdale Bypass, Tisdale Bypass to Feather River, and Feather River to Sacramento River.

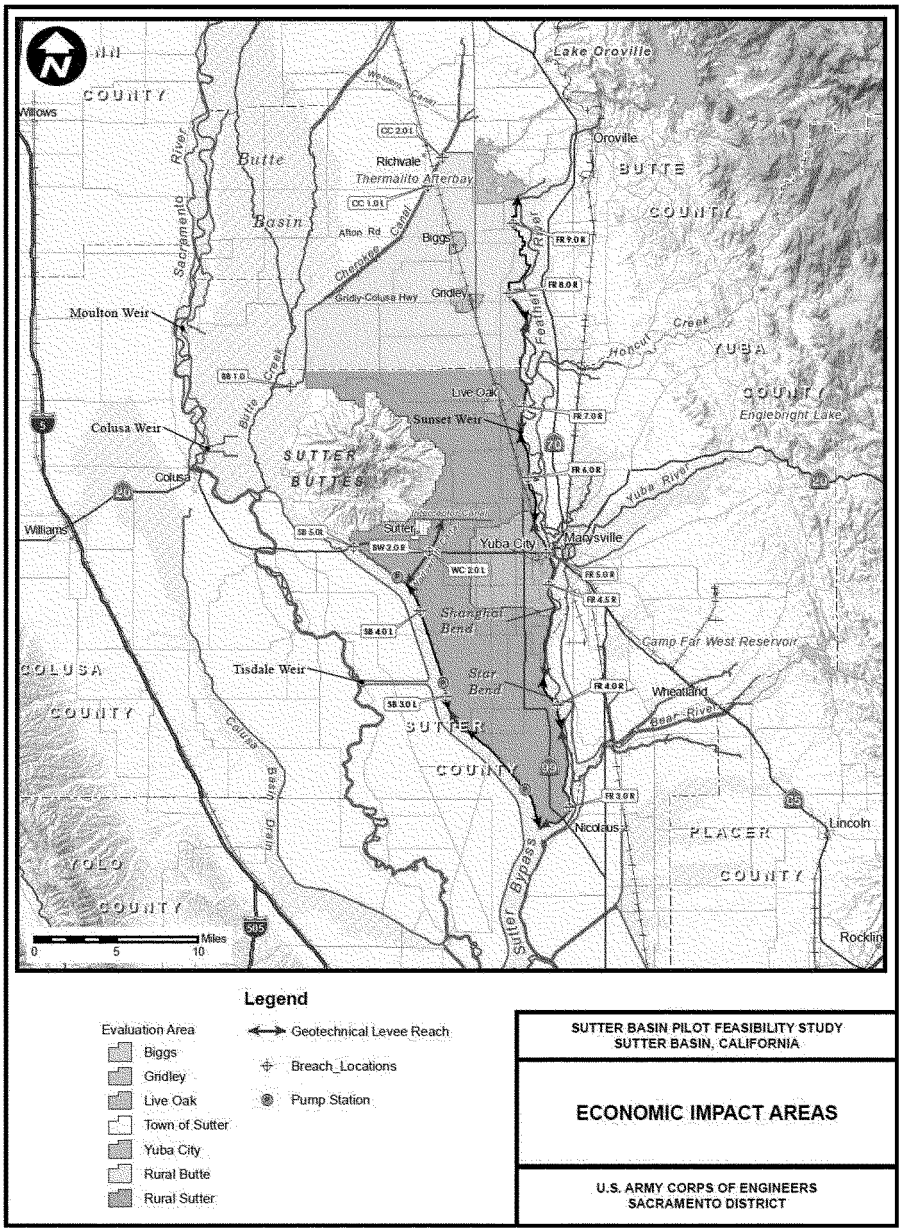
The Feather River is a major tributary to the Sacramento River, merging with the Sutter Bypass upstream from the Sacramento River and Fremont Weir. The Yuba and Bear Rivers are major

tributaries to the Feather River. Two major flood management reservoirs are located within the Feather River watershed: Oroville on the Feather River and New Bullards Bar on the Yuba River. The Feather River is described by four hydrologic reaches based on significant inflows: Thermalito to Honcut Creek, Honcut Creek to Yuba River, Yuba River to Bear River, and Bear River to Sutter Bypass.

The Cherokee Canal is a tributary to Butte Creek and the Butte Basin. The leveed canal was constructed between 1959 and 1960 by USACE. The canal drainage area is 94 square miles and varies in elevation from 70 feet to 2200 feet. The drainage area is bounded by the Feather River watershed to the east and southeast, Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south.

The Wadsworth Canal is a leveed tributary to the Sutter Bypass near the town of Sutter. The canal conveys flow from the East and West interceptor canals to the Sutter Bypass. The East and West interceptor canals collect runoff from canals and shallow floodplain runoff into the Wadsworth Canal. The capacity of the East and West Interceptor is limited by levees that are lower than the Wadsworth Canal. As result, inflows to the Wadsworth canal are limited to around 1,500 cfs while excess flows bypass the canal entrance. The design provides resiliency because it reduces the probability that high Wadsworth Canal flows into the Sutter Bypass would combine with high stages in the Sutter Bypass resulting in a possible overtopping failure near the Sutter Bypass and Feather River confluence.

Figure 1-1: Sutter Basin Study Area and Economic Impact Areas



2 Purpose and Scope of Economic Analysis

The purpose of this report is to present the results of the economic analysis performed for the Pilot Feasibility Study of the Sutter Basin. The report documents the existing condition within the study area and proposed alternative plans to improve flood risk management, and designate the tentative National Economic Development (NED) Plan for purposes of estimating federal interest for the Sutter Basin. The report presents findings related to flood risk, potential flood damages and potential flood risk management benefits.

2.1 Methodology

This economic analysis is in accordance with standards, procedures, and guidance of the U.S. Army Corps of Engineers. The Planning Guidance Notebook (ER 1105-2-100, April 2000) serves as the primary source for evaluation methods of flood risk management studies and was used as reference for this analysis. Additional guidance for risk-based analysis was obtained from EM 1110-2-1619, *Engineering and Design – Risk-Based Analysis for Flood Damage Reduction Studies (August 1996)* and ER 1105-2-101, *Planning Risk-Based Analysis of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Damage Reduction Studies (March 1996)*. Economic evaluation was performed over a 50-year period of analysis. All values are presented in October 2011 price levels, and amortization calculations are based on the Fiscal Year 2012 federal discount rate of 4.0 percent as published in Corps of Engineers Economic Guidance Memorandum (EGM).

3 Floodplain Area and Inventory

3.1 Structural Inventory

A structural inventory was completed based on data gathered from assessor's parcel data and on-site inspection of structures within the flood plain. Structures were determined to be within the economic study area by using Geographical Information Systems (GIS) to compare the 0.2% (1/500) Annual Chance Exceedance (ACE) flood plain boundary (plus a buffer) with the spatially referenced assessor parcel numbers (APN). Information from the assessor's parcel database (such as land use, building square footage, address) was supplemented during field visitation for each parcel within the flood plain by adding fields for foundation height, specific business activity (non-residential), building condition, type of construction, and number of units, for example. Where square footage data was not available, the Google Earth measuring tool was used to estimate square footage. Parcels with structures were categorized by land use and grouped into the following structural damage categories:

1) **Single Family Residential** – includes all parcels represented by a single unit such as detached single family homes, individually owned condominiums and townhouses.
2) **Multiple Family Residential** – includes residential parcels with more than one unit such as apartment complexes, duplexes and quadplex units. Each parcel may have multiple structures.
3) **Commercial** – includes retail, office buildings, restaurants, etc.
4) **Industrial** – includes warehouses, light and heavy manufacturing facilities.
5) **Public** – includes both public and semi-public uses such as post offices, fire departments, government buildings, schools and churches.
6) **Agriculture** – Agricultural inventory was developed using assessor's parcel data and land use codes.

All parcels with structures were assigned to one of the listed categories. Single family and multi-family have been grouped together as "Residential" for presentation purposes.

The without-project damages and with-project benefits are based on potential damages to residential structures and contents, non-residential (commercial, industrial and public) structures and contents, automobiles and agriculture. The study area was divided into seven Economic Impact Areas (EIA's) for purposes of this analysis: Gridley, Biggs, Live Oak, Yuba City, Town of Sutter, Rural Butte and Rural Sutter. The delineation of these impact areas can be found in Figure 1-1.

Structure counts (assuming levee breaches) for a 0.2% (1/500) ACE event are presented by EIA in Table 3-1. Note that the Town of Sutter is not inundated by a 0.2% ACE event.

Table 3-1: Structural Inventory –Existing Conditions
Number of Structures within 0.2% (1/500yr) Annual Chance Floodplain if Levee Failures Occurs

Economic Impact Area	Commerical	Industrial	Public	Residential	TOTAL
Biggs	18	1	0	586	**605**
Gridley	81	7	4	1,931	**2,023**
LiveOak	51	5	23	2,088	**2,167**
Yuba City	872	210	122	18,760	**19,964**
Town of Sutter	0	0	0	0	**0**
Rural Butte	10	16	0	1,242	**1,268**
Rural Sutter	10	29	8	1,162	**1,209**
TOTAL	**1,042**	**268**	**157**	**25,769**	**27,236**

3.2 Value of Damageable Property – Structures and Contents

The value of damageable structures was estimated based on depreciated replacement values. The depreciated replacement value of a structure was determined by multiplying the structure's square footage by the cost per square foot and a remaining-value ratio. Values for cost per square foot were obtained from the Marshall and Swift Valuation Service based on land use, building type, construction class, and quality. The remaining-value ratio was based on the factors such as condition of the structure and the year the structure was built.

The value of damageable building contents was estimated as a percentage of depreciated structure value based on associated land use. Content percentages were based on the expert elicitation findings used in the *American River Watershed Common Features Natomas Basin Post-Authorization Change Report and Interim General Reevaluation Report* (USACE, 2010).

The total value of damageable property (structures and contents) within the Sutter Basin 0.2% (1/500) ACE event is estimated at $6.9 billion. Table 4 displays the total value of damageable property by damage category.

Table 3-2: Value of Damageable Property – Existing Conditions
Within the 0.2% (1/500) Annual Chance Floodplain if Levee Failure Occurs
October 2011 Prices ($1,000's)

Economic Impact Area	Commercial		Industrial		Public		Residential		TOTAL	
	Structures	Contents	Structures	Contents	Structures	Contents	Structures	Contents	Structures	Contents
Biggs	3,780	2,829	1,759	601	0	0	49,747	24,873	**$55,286**	**$28,304**
Gridley	37,534	34,694	36,953	14,942	2,175	1,290	191,168	95,584	**$267,830**	**$146,509**
LiveOak	14,621	11,022	1,389	2,269	31,064	10,984	213,262	106,631	**$260,335**	**$130,906**
Yuba City	585,935	468,893	234,644	183,184	239,100	95,338	2,395,719	1,197,860	**$3,455,399**	**$1,945,276**
Town of Sutter	0	0	0	0	0	0	0	0	**$0**	**$0**
Rural Butte	1,659	2,261	32,091	13,571	0	0	133,513	66,756	**$167,262**	**$82,588**
Rural Sutter	3,585	5,436	24,389	15,246	12,868	5,661	183,350	91,675	**$224,192**	**$118,018**
TOTAL	**$647,114**	**$525,135**	**$331,225**	**$229,814**	**$285,207**	**$113,273**	**$3,166,758**	**$1,583,379**	**$4,430,304**	**$2,451,601**

4 Depth-Damage Relationships

Damages to structures and contents were determined based on depth of flooding relative to the structure's first floor elevation. First floor elevations were determined based upon visual estimates during windshield surveys in the study area. To compute these damages, depth-damage (DD) curves were used. These curves assign loss as a percentage of value for each parcel. The deeper the relative depth, the greater the percentage of value damaged. The sources of the relationships were different depending on land use. For residential structures, the IWR DD curves were used in accordance with EGM-04-01. The non-residential structure DD curves used here were originally developed for the May 1997 "Morganza to the Gulf, Louisiana Feasibility Study." These curves have been used extensively in Sacramento District, including on the American River studies. For Sutter, the long duration versions of the DD curves were used. Depth-damage curves for non-residential contents were taken from the American River Watershed Economic Re-evaluation Report (ERR) expert elicitation for long duration flooding. Depth Damage relationships are shown in the tables below.

Table 4-1: Depth Damage Curves for Residential (Structure and Content)

CATEGORY		DEPTH OF FLOODING ABOVE THE FIRST FLOOR IN FEET							
		-4.0	-1.0	0.0	1	3	5	10	15
1 Story	Structure	0%	3%	13%	23%	40%	53%	73%	80%
	Content	0%	2%	8%	13%	22%	29%	38%	40%
2 Story	Structure	0%	3%	9%	15%	26%	36%	56%	68%
	Content	0%	1%	5%	9%	16%	21%	32%	37%
Split	Structure	0%	6%	7%	9%	17%	29%	63%	84%
	Content	0%	2%	3%	5%	11%	20%	46%	61%
1 Story w/base	Structure	5%	19%	26%	32%	46%	59%	80%	81%
	Content	6%	13%	16%	19%	25%	30%	39%	39%
2 Story w/base	Structure	5%	14%	18%	22%	32%	42%	65%	76%
	Content	5%	10%	12%	14%	18%	22%	34%	49%
Split w/base	Structure	5%	14%	19%	23%	33%	44%	65%	69%
	Content	4%	9%	12%	14%	18%	22%	26%	26%
Mobile Home-Short Duration	Structure	0%	6%	10%	45%	46%	66%	66%	66%
	Content	0%	0%	0%	38%	69%	90%	90%	90%
Mobile Home-Long Duration	Structure	0%	6%	10%	45%	96%	96%	96%	96%
	Content	0%	0%	0%	85%	99%	99%	99%	99%

Table 4-2: Depth Damage Curves for Non-Residential Structures

CATEGORY	DEPTH OF FLOODING ABOVE THE FIRST FLOOR IN FEET						
	-1.0	0	1	3	5	10	15
1 Story Short Duration	0	7	16	28	31	46	50
2 Story Short Duration	0	5	10	18	22	38	38
1 Story Long Duration	0	7	22	31	32	54	86
2 Story Long Duration	0	5	15	22	23	46	80

Table 4-3: Depth Damage Curves for Non-Residential Content 1-story

CATEGORY	DEPTH OF FLOODING ABOVE THE FIRST FLOOR IN FEET						
	-1.0	0	1	3	5	10	15
Food Stores	0	0	78	100	100	100	100
Furniture-Retail	0	0	98	100	100	100	100
Grocery Store	0	0	87	100	100	100	100
Hotel-Full Service	0	0	88	100	100	100	100
Medical	0	0	75	100	100	100	100
Office	0	0	97	100	100	100	100
Restaurant	0	0	91	100	100	100	100
Rest-Fast Food	0	0	88	100	100	100	100
Retail	0	0	80	100	100	100	100
Service-Auto	10	10	74	100	100	100	100
Shopping Centers	0	0	96	100	100	100	100
Heavy	0	0	33	77	100	100	100
Light	0	0	88	99	100	100	100
Warehouse	0	0	84	100	100	100	100
Churches	0	0	73	99	99	99	100
Government	0	0	97	100	100	100	100
Recreation	0	0	98	100	100	100	100
Schools	0	0	88	100	100	100	100
Farms	0	0	56	100	100	100	100

5 Uncertainty and Other Categories

5.1 FLO-2D Grid Cells and Parcel Assignments using GIS

GIS was used to assign centroids to each parcel within the study area and these "points" were then overlaid onto the grid-cells of the FLO-2D model, resulting in the assignment of each parcel (structure) to a specific grid-cell within the hydraulic model. Due to the non-uniform nature of parcel shapes compared to the uniform (i.e. 1000ftx1000ft) nature of the FLO-2D grid-cells, some grid-cells contain zero parcels and other grid-cells have multiple parcels assigned to them. The water surface elevation of the grid-cell now becomes the water surface elevation for all parcels contained therein. Using the grid-cell assignments along with the depths of flooding for the 50% (1/2), 10% (1/10), 4% (1/25), 2% (1/50), 1% (1/100), 0.5% (1/200), 0.2% (1/500) ACE flood events, water surface profiles were developed and imported into HEC-FDA.

5.2 Economic Uncertainty Parameters

Many of the factors that determine flood damages can be represented by a range of values instead of a single number. Errors in measurement, variation in classification and judgment can lead to differences in values. For this study, in accordance with EM 1110-2-1619, uncertainties in the following parameters were considered in the damage estimation:

- Structure Value
- Content Ratio
- Depth-Damage Percentage
- First Floor Elevation (Foundation Height)

Structure values were determined as a function of Marshall& Swift values per square foot, square footage and estimated depreciation. To estimate the mean value of structures, a triangular distribution (minimum, most likely and maximum values) for each of these parameters were set in the model as discussed in detail.

In addition, standard deviations for all 4 variables were used for all land use/structure types within the FDA model and applied during FDA's Monte Carlo simulation of the Expected Annual Damages. These coefficients of variation were based upon @Risk Monte Carlo simulations for representative structures for each damage category and land use type.

Risk and uncertainty was also included in the Depth Damage Percentages for residential structures and contents that were imported into FDA and applied during the Monte Carlo simulations.

Standard Deviation for foundation heights was set equal to 0.5 feet.

5.3 Other Damage Categories

5.3.1 Agricultural Losses

ER 1105-2-100, Appendix E, beginning on page E-113 includes specific guidance for studies where the primary damages occur to agricultural crops. Primary damages in this evaluation focus on the crop damage, loss of stored crops, and loss of farm equipment. These damages are directly related, and evaluated with special consideration for the expected time of seasonal flooding as well as the variability associated with crop prices and yields. The identified hydrologic/hydraulic variables, discharge associated with exceedence frequency and conveyance roughness and cross-section geometry, also apply to agricultural studies.

Based on empirical analyses conducted for past Corps projects, subject matter expertise from the agricultural economist and professional judgment, the project delivery team expects agricultural damages to total 10-15% of total project damages; amounts which are not expected to drive plan selection. A simplified approach was developed for this study based on stage-damage curves for land use types within the study area and simplifying calculations by utilizing 1,000 ft by 1,000 ft hydraulic model grid elements.

Expected Annual Damages associated with Agricultural land uses will be used in the comparison and screening of refined alternatives for the Sutter Basin Feasibility Study. The final array of alternatives (Tentative Selected Plan, National Economic Development Plan, and Locally Preferred Plan) will be selected from these refined alternatives. The final array of alternatives will be evaluated in further detail in the next phase of the study.

A more detailed writeup of the Agriculture analysis is available upon request in a technical memorandum.

5.3.2 Automobile Losses

Losses to automobiles were determined as a function of the number of vehicles per residence, average value per automobile, estimated percentage of autos removed from area prior to inundation, and depth of flooding above the ground elevation. Depth-damage relationships for autos were taken from EGM 09-04 and modified based on weighted average of distributions of car types (SUV, truck, sedan, sports car, etc) in California. Damages for autos begin once flood depth has reached 0.5 feet, and this damage curve can be seen in Table 5-1. Vehicle counts were estimated using an assumption of 2 vehicles per residential structure. Evacuation (autos moved out of the flooded area) was assumed to be 50%, as used on American River and other Corps studies. Depreciated replacement value of autos was based on a price adjusted Bureau of Labor Statistics average used car value of $8,865[6]. Uncertainty was incorporated using a normal distribution and a standard deviation at 15%.

[6] $8,865 was derived from taking a value of $7,988 from the 2010 Natomas PAC and adjusting for price level using CPI for used cars and trucks.

Table 5-1: Automobile Depth Damage Function

Damage Category	Depth in Feet													
	-1	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
	% Damage to Structure/Content													
Automobiles	0	0	3	24	34	43	60	75	86	94	97	99	100	100
Std. Dev	0	0	10	8	7	6	5	3	4	7	7	7	8	8

5.3.3 Emergency Costs, Cleanup Costs, Road Damages and Traffic Disruption

An expert-opinion elicitation panel comprised of professionals having significant, relevant experience in the field of emergency response convened in Sacrament, CA (2009) with the goal of developing estimates of the economic cost associated with various emergency related damage categories (evacuation, debris activities, public services, utilities, etc). Initial model calculations for other district studies, as proportion of structure and content damages, range from 1-3%. Additionally, road damages and traffic-related costs associated with detours and extra time traveled experienced by motorists due to potential flooding in the Sutter Basin was forgone based on prior experiences, which have shown such damage categories to be relatively minimal when compared to structural damages. Nevertheless, it is recognized that in order to detail the magnitude of flooding problems in the Sutter Basin, the economic analyses can be conducted. However, because these damage categories are not expected to drive plan selection, they were omitted from the analysis. If deemed necessary, emergency costs, road damages and traffic disruption analyses can be conducted during refinement of the TSP.

6 Without Project Damages

6.1 HEC-FDA Model

For the Sutter Basin Pilot Feasibility Study, expected annual damages were estimated using the US Army Corps of Engineers, FRM-PCX certified risk-based Monte Carlo simulation program HEC-FDA v. 1.2.5a. Risk is a function of both probability and consequence, and the fact that risk inherently involves chance leads directly to a need to describe and plan for uncertainty. Corps policy has long been to acknowledge risk and uncertainty in anticipating floods and their impacts and to plan accordingly[7]. Historically, that planning relied on analysis of the expected long-term performance of flood-damage reduction measures, application of safety factors and freeboard, designing for worse case scenarios, and other indirect solutions (such as engineering judgment) to compensate for uncertainty. These indirect approaches were necessary because of the lack of technical knowledge of the complex interaction of uncertainties in estimating hydrologic, hydraulic, geotechnical, and economic factors due to the complexities of the mathematics required for doing otherwise. However, with advances in statistical hydrology and the availability of computerized analysis tools (such as HEC-FDA described below), it is now possible to improve the evaluation of uncertainties in the hydrologic, hydraulic, geotechnical, and economic functions. Through this risk analysis, and with careful communication of the results, the public can be better informed about what to expect from flood-damage reduction projects and thus can make more informed decisions. The determination of EAD for a flood reduction study must take into account complex and uncertain hydrologic, hydraulic, geotechnical, and economic information:

- **Hydrologic** - The discharge-frequency function describes the probability of floods equal to or greater than some discharge Q,
- **Hydraulics** - The stage-discharge function describes how high (stage) the flow of water in a river channel might be for a given volume of flow discharge,
- **Geotechnical** - The geotechnical levee failure function describes the levee failure probabilities vs. stages in channel with resultant stages in the floodplain, and
- **Economics** - The stage-damage function describes the amount of damage that might occur given certain floodplain stages.

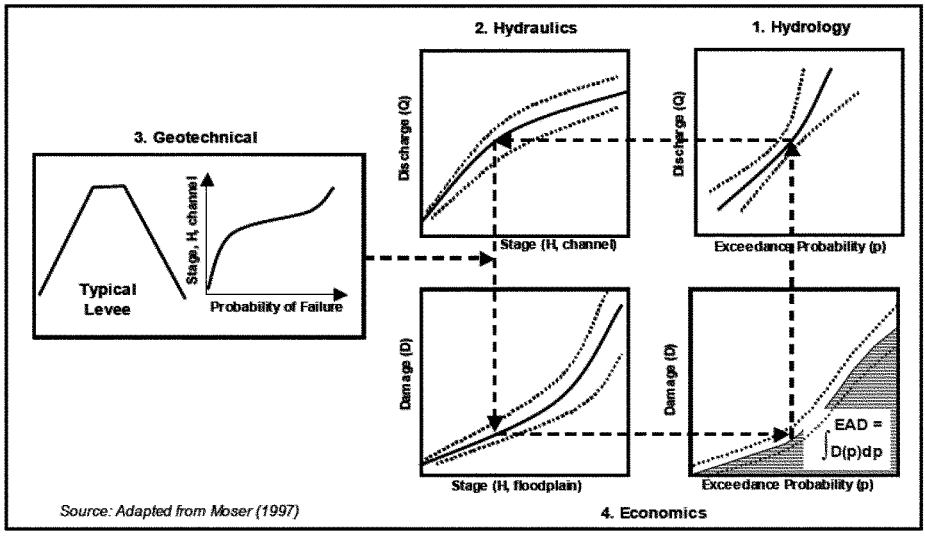
6.2 Estimation of Expected Annual Damages

To find the damage for any given flood frequency, the discharge for that frequency is first located in the discharge-frequency graph (graph #1), then the river channel stage associated with that discharge value is determined in the stage-discharge graph (graph #2). Once the levees fail and water enters the floodplain, the stages (water depths) in the floodplain inundate structures and cause damage (graph #4, left side). HEC-FDA uses a sampling of the curves within the uncertainty bounds of these relationships to generate the probability damage curves used in EAD calculations. By plotting this damage and repeating for process many times, the damage-frequency curve is determined (graph #4, right side). EAD is then computed by finding the area under the flood damage-frequency curve by integration for the without,

[7] In a flood risk management study, risk is defined as the probability of failure during a flood event and the resulting consequence. Uncertainty is the measure of the imprecision of knowledge of variables in a project plan.

interim, and with project conditions. Reductions in EAD attributable to projects are flood reduction benefits. Uncertainties are present for each of the functions discussed above and these are carried forth from one graph to the next, ultimately accumulating in the EAD. These uncertainties are shown in Figure 6-1 as "error bands" located above and below the hydrologic, hydraulic and economics curves.

Figure 6-1: Uncertainty in Discharge, Stage and Damage in Determination of Expected Annual Damages



Some of the important uncertainties specific to the Sutter Basin Feasibility Study include:

- **Hydrologic** - Uncertainty factors include hydrologic data record lengths that are often short or do not exist, precipitation-runoff computational methods that are not precisely known, and imprecise knowledge of the effectiveness of flow regulation.[8]
- **Hydraulics** - Uncertainty arising from the use of simplified models to describe complex hydraulic phenomena, including the lack of detailed geometric data, misalignments of hydraulic structures, debris load, infiltration rates, embankment failures, material variability, and from errors in estimating slope and roughness factors. For all EIA's a standard deviation in stage of 1.5 feet was used. (EM-1110-2-1619 guidance for minimum uncertainty).
- **Geotechnical** – Under without project conditions, levee fragility curves were developed and input into HEC-FDA for each of the 15 levee reaches identified in section 6.3 below.

[8] The hydrologic data record lengths (period of record) are the number of years of a systematic record of peak discharges at a stream gage. This parameter directly influences the uncertainty associated with the frequency-discharge function shown in Figure 6-1 and consequently the project performance statistics. In general, a longer period of record implies less uncertainty associated with this function. The period of record used for the Sutter Basin is 94 years.

- **Economics** - Uncertainty concerning land uses, depth/damage relationships, structure/content values, structure locations, first floor elevations, the amount of debris and mud, flood duration, and warning time and response of floodplain inhabitants (flood fighting).

6.3 Levee Breach and Floodplain Assignments by Economic Impact Area and Event

As mentioned in section 1, the study area is surrounded by project levees and high ground of the Sutter Buttes. For this study, the existing levees were separated into 15 levee reaches and a representative breach location was chosen for each reach. These breach locations can be found in Figure 1-1. When the study area becomes inundated, the floodwaters flow from north to south and then pool up in the southern portion of the Sutter Basin. Therefore, a breach on the northern section of the Feather River would cause a larger inundation area than a breach on the southern portion, but that does not necessarily mean it has the highest risk (probability & consequence).

For without project conditions, each EIA was assigned a dominating breach location which represents the breach where significant flooding starts to occur. A specific breach location was also assigned to each ACE event floodplain for each EIA based on the worst risk for that particular event by EIA. Risk is a function of both probability and consequence. Determining Breach and Floodplain assignments by EIA and event was a two step process:

1. Probability for floodplain assignments was measured in terms of Annual Exceedance Probabilities (AEP) for each breach location. If an ACE event was close to or lower the breach AEP, then that floodplain was "in play" for consideration. For example, if we are trying to determine which 4% ACE floodplains are "in play" and Breach A has an AEP of 0.1, Breach B has an AEP of 0.37 and Breach C has an AEP of 0.01, then Breach A and Breach B would be considered for Step 2 of the process, while flooding from Breach C would not be considered until looking at the 1% ACE floodplain and lower probability events. AEP for this study are highly dependent on levee fragility curves. A summary of Breach AEP's and associated levee fragility curves are shown in Table 6-1.

2. Consequence for breach and floodplain assignments was determined based on depth and extent of flooding within each EIA. For each ACE event, those floodplains that were determined to be "in-play" during step one were then compared based on the total number of grid cells inundated and the total depth of flooding within each EIA. The "in-play" breach floodplain that caused the highest total depths and/or the highest number of grid cells inundated was chosen to be used in the water surface profile to be used in HEC-FDA calculation of aggregated stage damage functions. Most of the time the breach with the highest cumulative depth and number of grid cells was the same, but in a few cases where it wasn't, professional judgment was used and usually the breach with the greater inundation extent was chosen.

The dominating breach and breach/floodplain assignments by ACE event for without project conditions are shown in Table 6-2.

Table 6-1: Levee Breach Location AEP's and Associated Probability-Failure Functions

	Feather River F3.0R	Feather River F4.0R	Feather River F4.5R	Feather River F5.0R	Feather River F6.0R	Feather River F7.0R	Feather River F8.0R	Feather River F9.0R	Cherokee Canal CC01L	Cherokee Canal CC02L	Sutter Bypass SB3.0L	Sutter Bypass SB4.0L	Sutter Bypass SB5.0L	Wadsworth Canal W2.0L	Wadsworth Canal W2.0R
WO Project AEP	0.0399	0.0429	0.027	0.0417	0.0417	0.023	0.0426	0.0426	0.2246	0.2246	0.2962	0.2954	0.0787	0.0683	0.4217
ACE Event:															
50% (1/2)	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.21	0.21	0.06	0.03	0.45
10% (1/10)	0.13	0.15	0.02	0.14	0.14	0.01	0.08	0.08	0.27	0.27	0.35	0.35	0.15	0.10	0.80
4% (1/25)	0.22	0.24	0.09	0.30	0.30	0.18	0.34	0.34	0.32	0.32	0.45	0.43	0.34	0.27	0.86
2% (1/50)	0.26	0.27	0.12	0.34	0.34	0.28	0.34	0.34	1.00	1.00	0.49	0.49	0.49	0.47	0.90
1% (1/100)	0.28	0.29	0.13	0.35	0.35	0.27	0.34	0.34	1.00	1.00	0.55	0.56	0.66	0.68	0.95
0.5% (1/200)	0.35	0.38	0.22	0.56	0.56	0.48	0.51	0.51	1.00	1.00	0.61	0.63	0.84	0.85	0.99
0.2% (1/500)	0.44	1.00	0.47	0.91	0.91	1.00	1.00	1.00	1.00	1.00	0.67	1.00	0.90	1.00	0.99

Table 6-2: Without Project - Levee Breach & Floodplain Assignments by ACE Event and EIA

EIA	Dominating Index Point (Significant Flooding Starts)	FDA Index Point	Annual Chance Exceedance Event						
			50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Biggs	F9.0R	F9.0R	None	CC.02	F9.0R	F9.0R	F9.0R	F9.0R	F9.0R
Gridley	F9.0R	F9.0R	None	None	F9.0R	F9.0R	F9.0R	F9.0R	F9.0R
Live Oak	F9.0R	F9.0R	None	None	F9.0R	F9.0R	F9.0R	F9.0R	F7.0R
Yuba City	F5.0R	F5.0R	None	S4.0L	F5.0R	F5.0R	F5.0R	F5.0R	F5.0R
Town of Sutter	None	None	None	None	None	None	None	None	None
Rural Butte	F9.0R	F9.0R	None	CC.02	F9.0R	F9.0R	F9.0R	F9.0R	F9.0R
Rural Sutter	S4.0L	S4.0L	None	S4.0L	F5.0R	F5.0R	F5.0R	F6.0R	F6.0R

6.4 Event Damages

Single-event damages for the 50%, 10%, 4%, 2%, 1%, 0.5% and 0.2% ACE flood events were computed in the HEC-FDA model. Floodplains were based upon existing levee's being breached (the levee was modeled with a hole in it at the breach location), which means that the event damage curve, (prior to levee insertion in FDA) may appear relatively flat with high damages beginning at frequent events. This issue it mitigated by the insertion of a levee height and fragility curve into HEC-FDA. The application of the levee fragility curve in FDA truncates the stage damage curve during EAD calculations for those events where a levee failure or overtopping does not occur. The 4% (1/25) and the 0.2% (1/500) annual chance events damages are presented below in Table 6-3 and represent the damages if a levee breach from the dominating breach location by reach were to occur. These damages can be cross-referenced with Table 6-1 and Table 6-2 above to identify the probability of occurrence. For example, Table 6-3 shows Yuba City damages to be $2.2 billion for the 1/25 chance event and $2.8 billion for the 0.2% annual chance event, but these damages have a 30% and 91% chance of occurrence due to a levee failure respectively. The damages listed here represent probability damages prior to the application of economic uncertainty parameters.

Table 6-3: Without Project Probability-Damage Functions (structure and contents) – by EIA
October 2011 Prices ($1,000's), 4.0% Discount Rate

Economic Impact Area	Commercial		Industrial		Public		Residential		TOTAL	
	4% event	0.2% event	4% event	0.2% event	4% event	0.2% event	4% event	0.2% event	4% event	0.2% event
Biggs	3,149	3,717	756	1,131	0	0	17,427	26,861	**$21,332**	**$31,709**
Gridley	40,214	45,079	12,048	14,323	1,759	1,980	29,423	59,634	**$83,445**	**$121,016**
LiveOak	12,925	16,287	2,246	2,645	17,545	23,521	42,675	107,226	**$75,391**	**$149,679**
Yuba City	629,541	737,631	266,963	300,244	177,653	210,395	1,092,447	1,598,342	**$2,166,603**	**$2,846,613**
Town of Sutter	0	0	0	0	0	0	0	0	**$0**	**$0**
Rural Butte	1,805	1,848	8,115	9,328	0	0	24,985	44,594	**$34,905**	**$55,770**
Rural Sutter	4,711	5,165	14,855	28,149	12,415	13,355	72,040	104,439	**$104,021**	**$151,107**
TOTAL	**$692,345**	**$809,727**	**$304,983**	**$355,819**	**$209,373**	**$249,251**	**$1,278,996**	**$1,941,097**	**$2,485,696**	**$3,355,894**

6.5 Expected Annual Damages – Without Project Conditions

The HEC-FDA without project conditions model results (Expected Annual Damages) for structures, contents, automobiles and agriculture are shown, by EIA, in Table 6-4. Total study area without project expected annual damages are approximately $108 million.

Table 6-4: Expected Annual Damages - Without Project Conditions
October 2011 Prices ($1,000's), 4.0% Discount Rate

EIA	Expected Annual Damages (EAD) by Category ($1,000's)						
	Automobiles	Commercial	Industrial	Public	Residential	Agriculture	TOTAL
Biggs	102	90	30	0	554	4	780
Gridley	201	1,149	341	54	1,094	5	2,844
Live Oak	270	366	59	521	1,569	10	2,795
Yuba City	4,050	14,825	6,081	4,025	24,764	269	54,014
Town of Sutter	0	0	0	0	0	0	0
Rural Butte	154	52	263	0	857	1,316	2,642
Rural Sutter	2,218	1,255	6,391	3,790	20,828	10,910	45,392
TOTAL	6,995	17,737	13,165	8,390	49,666	12,514	108,467

6.6 EAD Future Conditions and Equivalent Annual Damages

The without-project equivalent annual damage reflects the damage value associated with the without-project condition over the period of analysis and under changing hydrology, hydraulic (H&H), and economic conditions in the study area. Essentially, equivalent annual damages are expected annual damages that have been converted to a single present worth value and then amortized over the analysis period using the federally mandated discount rate of 4.0%. Existing conditions represent inventory, H&H and geotechnical performance within the study area currently. The future without-project condition is the most likely condition expected to exist in the future in the absence of a proposed water resources project and constitutes the benchmark against which alternatives are evaluated. For the purposes of the identification of the TSP, economics has assumed that future without-project conditions are equal to existing conditions. Once the TSP is identified, the future conditions within HEC-FDA will be set according to the Future Without-Project Conditions portion of the main report. Because any future without project development would take place outside/above the mean 1% annual chance floodplain boundary/WSEL and because any future damages would be discounted back to present value, the future condition is not expected to impact the plan formulation process significantly.

6.7 Project Performance – Without Project Conditions

In addition to damages estimates, HEC-FDA reports flood risk in terms of project performance. Three statistical measures are provided, in accordance with ER 1105-2-101, to describe performance risk in probabilistic terms. These include annual exceedance probability, long-term risk, and assurance by event.

- Annual exceedance probability measures the chance of having a damaging flood in any given year.
- Long-term risk provides the probability of having one or more damaging floods over a period of time.
- Assurance is the probability that a target stage will not be exceeded during the occurrence of a specified flood.

The worst project performance statistics may not necessarily be associated with the breach location producing the most economic damages (as described in section 6.3). For example, both the Feather River and the Sutter Bypass can cause flooding in the Yuba City EIA. Even though the Feather River (F5.0R) causes more significant annual damages in the area, the project performance is worse for the Sutter Bypass. Because economic consequences are higher for the Feather breach, that's what was used in HEC-FDA, but project performance is still limited by the Sutter Bypass. Project performance statistics for each impact area under without project conditions is displayed in Table 6-5 below.

Table 6-5: Project Performance by EIA - Without Project Conditions

Economic Impact Area	Breach Location	Annual Exceedance Probability		Long-Term Risk			Assurance by Event			
		Median	Expected	10 Year Period	30 Year Period	50 Year Period	10%	2%	1%	0.20%
Biggs	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
Gridley	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
Live Oak	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
Yuba City	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
Town of Sutter	None	None	None	None	None	None	None	None	None	None
Rural Butte	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
Rural Sutter	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%

7 With-Project Damages and Benefits

This section will describe how benefits of flood risk management of the final array of alternatives were estimated. Non-monetary outputs such as environmental measures, which may vary for the final array of alternatives, are not included but may factor in the plan formulation decision process.

Benefits were determined by incorporating increments of levee fixes into the FDA model that represent various with-project improvements. Flood risk management benefits equal the difference between the without project damages and the with-project residual damages.

7.1 Conceptual Alternatives

Many conceptual alternatives were considered during the plan formulation process. See the main report for a detailed description of all conceptual alternatives.

7.2 Refined Array of Alternatives

Economic benefits were estimated for each alternative in the Refined Array. The first step was to estimate the maximum economic benefit of fixing all levees to their design height. For each alternative, the benefit was estimated by applying a ratio based on visual inspection of the without and with project floodplains by Hydraulic Design and Economics. Project costs were based on initial parametric project cost estimates (see main report and cost appendix for more detail). These benefits and costs were then compared to screen out those refined alternatives do not appear economically justified even in the most favorable benefit/cost ratio ranges (highest benefit and lowest cost) and/or to compare costs of plans with very similar outputs from a cost effectiveness perspective cost effectiveness. For a more detailed description of this screening, please see the main report. The table below summarizes the findings of the screening. As a result of this screening, only 5 plans (Yuba City Ring Levee, Little J, Minimal Fix-in-Place, Fix in Place Thermalito to Star Bend and Fix-in-Place w/o raising) were carried forward into the Draft Array for identification of the TSP.

Table 7-1: Benefits and Costs for Refined Array of Alternative
October 2011 Prices ($Millions), 4.0% Discount Rate

Alternative	Total First Cost ($Millions)		Annualized Cost ($Millions)		Annual Benefits ($Millions)		Annual Net Benefits ($Millions)		Benefit to Cost Ratio	
	Low	High	Low	High	Low	High	Low	High	Low	High
2.1 - Ring Levees:										
Yuba City	313	671	15	31	12	47	-10	29	0.4	3.2
Gridley	95	204	4	9	1	4	-6	0	0.1	0.9
Live Oak	82	177	4	8	1	3	-5	0	0.1	0.9
Biggs	60	129	3	6	0	1	-5	-2	0.0	0.3
2.2 - Big J	703	1,506	33	70	16	63	-35	26	0.2	1.9
2.3 - Little J	560	1,201	26	56	16	63	-24	32	0.3	2.4
2.4 Minimal Fix in Place	177	381	8	18	5	19	-8	9	0.3	2.3
2.5 Fix in Place Thermalito to Star Bend	422	905	20	42	13	53	-17	29	0.3	2.7
3.1 Fix in Place w/o Raising	737	1,579	34	73	17	68	-36	29	0.2	2.0
3.2 Primarily Fix in Place including modest	882	1,900	41	88	17	68	-48	22	0.2	1.6
4.1 Setbacks with Ecosystem Restoration	1,543	3,308	72	154	17	68	-100	-3	0.1	0.9

7.3 Draft Array of Alternatives – TSP Identification

The draft array of alternatives is listed below. These alternatives were analyzed in more detail to estimate project benefits and identify a TSP. For a detailed description of project measures, please refer to the main report.

SB-1: No Action
SB-2: Minimal Fix-in-Place plus Non-structural
SB-3: Yuba City Ring Levee
SB-4: Little J Levee
SB-5: Fix-in-Place, Thermalito to Star Bend
SB-6: Fix-in-Place, Feather River, Sutter Bypass and Wadsworth Canal
SB-7: Fix-in-Place, Sunset Weir to Laurel Avenue
SB-8: Fix-in-Place, Thermalito to Laurel Avenue

Maps showing the locations of project features for each alternative can be found in Enclosure 3.

7.3.1 With-Project Levee Breach and Floodplain Assignments by Economic Impact Area and Event

With-Project floodplains and index point assignments were done using the same two-step process described in section 6.3 of this report. Without project floodplains were utilized for the with-project runs. With-project benefits result from the reduction in flood depths/extents as the fixed levee reaches are no longer "in play" during water surface profile creation and floodplain assignments. With-project levee breach and floodplain assignments by event and EIA can be found in Enclosure 4. Table 7-2 summarizes the levee reach fixes and residual breach locations by alternative.

Table 7-2: Levee Reach Fixes by Alternative

Alternative	Fixed Index Points	Residual Index Points
SB-1: No Action		F3, F4, F4.5, F5, F6, F7, F8, F9, S3, S4, CC1, CC2, W2
SB-2: Minimal Fix in Place	F4.5, F5, F6	F3, F4, F7, F8, F9, S3, S4, CC1, CC2, W2
SB-3: Yuba City Ring Levee	F4.5, F5	*F3, F4, F6, F7, F8, F9, S3, S4*, CC1, CC2, W2[9]
SB-4: Little J Levee	F5, F6, F7, F8, F9	*F3, F4, F4.5, S3, S4*[10], CC1, CC2, W2
SB-5: Fix-in-Place, Thermalito to Star Bend	F4.5, F5, F6, F7, F8, F9	F4, F3, S3, S4, CC1, CC2, W2
SB-6: Fix-in-Place, Feather River, Sutter Bypass and Wadsworth Canal	F3, F4, F4.5, F5, F6, F7, F8, F9, S3, S4, W2	CC1, CC2
SB-7: Fix-in-Place, Sunset Weir to Laurel Ave	F4, F4.5, F5, F6, F7, F8, F9	F3, S3, S4, CC1, CC2, W2
SB-8: Fix-in-Place, Thermalito to Laurel Ave	F4, F4.5, F5, F6, F7, F8, F9	F3, S3, S4, CC1, CC2, W2

[9] For Yuba City Economic Impact Area, only the 500 year residual flooding. All other economic impact areas equal the without project depths and damages.
[10] For F3, F4, F4.5, S3 and S4 residual floodplain depths with the Little J Levee in place were used.

7.3.2 Annual Benefits and Residual Damages

The with-project floodplain and levee assignments described above were then input and run in HEC-FDA to determine residual damages and annual benefits. Residual damages can be found in Table 7-3 and annual benefits can be found in Table 7-4.

Table 7-3: Residual Annual Damages by Alternative and EIA
October 2011 Prices ($1,000's), 4.0% Discount Rate

Alternative	Expected Annual Damages (EAD) ($1,000's)							
	Biggs	Gridley	Live Oak	Yuba City	Town of Sutter	Rural Butte	Rural Sutter	TOTAL
SB-1: No Action	780	2,844	2,795	54,014	0	2,642	45,392	108,467
SB-2: Minimal Fix in Place	780	2,844	2,795	14,568	0	2,642	32,058	55,687
SB-3: Yuba City Ring Levee	780	2,844	2,795	2,789	0	2,642	45,392	57,242
SB-4: Little J Levee	171	315	381	10,136	0	1,008	31,416	43,427
SB-5: Fix-in-Place, Thermalito to Star Bend	171	318	381	14,568	0	1,008	32,058	48,504
SB-6: Fix-in-Place, Feather River, Sutter Bypass and Wadsworth	171	318	381	2,752	0	1,008	1,589	6,219
SB-7: Fix-in-Place, Sunset Weir to Laurel Ave	780	2,844	2,795	3,694	0	2,642	27,773	40,528
SB-8: Fix-in-Place, Thermalito to Laurel Ave	171	318	381	3,694	0	1,008	27,773	33,345

Table 7-4: Annual Benefits by Alternative
October 2011 Prices ($1,000's), 4.0% Discount Rate

Alternative	Expected Annual Benefits ($1,000's)							
	Biggs	Gridley	Live Oak	Yuba City	Town of Sutter	Rural Butte	Rural Sutter	TOTAL
SB-1: No Action	0	0	0	0	0	0	0	0
SB-2: Minimal Fix in Place	0	0	0	39,446	0	0	13,334	52,780
SB-3: Yuba City Ring Levee	0	0	0	51,225	0	0	0	51,225
SB-4: Little J Levee	609	2,529	2,414	43,878	0	1,634	13,976	65,040
SB-5: Fix-in-Place, Thermalito to Star Bend	609	2,526	2,414	39,446	0	1,634	13,334	59,963
SB-6: Fix-in-Place, Feather River, Sutter Bypass and Wadsworth Canal	609	2,526	2,414	51,262	0	1,634	43,803	102,248
SB-7: Fix-in-Place, Sunset Weir to Laurel Ave	0	0	0	50,320	0	0	17,619	67,939
SB-8: Fix-in-Place, Thermalito to Laurel Ave	609	2,526	2,414	50,320	0	1,634	17,619	75,122

7.3.3 Probability Distribution of Damages Reduced

In accordance with ER 1105-2-101, flood damages reduced were determined as mean values and by probability exceeded. The table below shows the benefits for each alternative for the 75%, 50% and 25% probability that benefit exceeds indicated value. The damage reduced column represents the mean benefits for each increment and the 75%, 50% and 25% represent the probability that the flood damage reduction benefits exceed the number in that column for that increment. For example, Alternative SB-2 has an average (mean) benefit of $50.3 million, but a 50% chance that benefits could be greater than $38.4 million, 75% confidence that benefits will be equal or greater than $24.3 million and 25% confidence that benefits could exceed $72.7 million. This range is the probability distribution of damages reduced and represents the uncertainty in the benefit estimates and incorporates all the uncertainties in hydrology, hydraulics, geotechnical and economics in the HEC-FDA model. The uncertainty in damages reduced should be considered when selecting an optimal plan during the plan formulation process. Judgment should be used to determine if an alternative meets a reasonable level of confidence regarding positive net benefits and identifying if changes in net benefits from alternative to alternative are significant.

Table 7-5: Probability Distribution of Damages Reduced – TOTAL Study Area
October 2011 Prices ($1,000's), 4% Interest Rate

Alternative	Annual Damages ($1,000's)			Probability Damage Reduced		
	Without Project	With Project	Damage Reduced	75%	50%	25%
SB-1: No Action	95,954	95,954	0	0	0	0
SB-2: Minimal Fix in Place	95,954	45,686	50,268	24,301	38,376	72,685
SB-3: Yuba City Ring Levee	95,954	44,950	51,004	24,851	40,716	71,125
SB-4: Little J Levee	95,954	34,854	61,100	31,497	46,103	86,746
SB-5: Fix-in-Place, Thermalito to Star Bend	95,954	39,128	56,826	28,627	44,861	81,220
SB-6: Fix-in-Place, Feather River, Sutter Bypass and Wadsworth Canal	95,954	4,287	91,667	45,913	73,277	134,087
SB-7: Fix-in-Place, Sunset Weir to Laurel Ave	95,954	31,296	64,658	31,698	51,348	91,999
SB-8: Fix-in-Place, Thermalito to Laurel Ave	95,954	24,739	71,215	36,024	57,834	100,534

7.3.4 Project Performance

As discussed in Section 6.7, project performance for each alternative is identified by the residual index location that has the highest AEP which causes flooding within an EIA. For many alternatives, the with-project AEP may be the same as the without project AEP, even though the annual damages may decrease significantly. For example, the index point which causes flooding within the Yuba City EIA with the

worst AEP is from the Sutter Bypass (S4.0L), even though more significant damages come from a breach on the Feather. Because Alternative SB-2 fixes the stretches of levee on the Feather which cause the worst economic consequence flooding in Yuba City (F4.5R, F5.0R and F6.0R), you see a significant annual benefit from fixing those levees. Although project performance (measured by AEP) has not decreased, the overall consequences of flooding are reduced as levee reaches are fixed. The overall/combined likelihood that the area will get flooded is reduced as levee reaches are fixed. This combined chance of flooding is difficult to quantify, so the representative index point is used.

Project performance statistics for each impact area are displayed by impact area and alternative in the table below.

Table 7-6: Project Performance – With Project Conditions – by EIA

Economic Impact Area	Alternative	Resdiual Breach Location	Annual Exceedance Probability		Long-Term Risk			Assurance by Event			
			Median	Expected	10 Year Period	30 Year Period	50 Year Period	10%	2%	1%	0.20%
Biggs	SB-1: No Action	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-2: Min FIP	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-3: Yuba City Ring	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-4: Little J	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-5: FIP Therm to Star	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-6: FIP ALL	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-7: FIP Sunset to Laurel	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-8: FIP Themalito to Laurel	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
Gridley	SB-1: No Action	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-2: Min FIP	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-3: Yuba City Ring	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-4: Little J	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-5: FIP Therm to Star	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-6: FIP ALL	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-7: FIP Sunset to Laurel	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-8: FIP Themalito to Laurel	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
Live Oak	SB-1: No Action	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-2: Min FIP	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-3: Yuba City Ring	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-4: Little J	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-5: FIP Therm to Star	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-6: FIP ALL	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-7: FIP Sunset to Laurel	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-8: FIP Themalito to Laurel	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
Yuba City	SB-1: No Action	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
	SB-2: Min FIP	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
	SB-3: Yuba City Ring	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-4: Little J	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
	SB-5: FIP Therm to Star	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
	SB-6: FIP ALL	F4_0R-fixed	0.0022	0.0022	2%	7%	11%	99%	99%	99%	55%
	SB-7: FIP Sunset to Laurel	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
	SB-8: FIP Themalito to Laurel	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
Town of Sutter	ALL	None	None	None	None	None	None	None	None	None	None
Rural Butte	SB-1: No Action	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-2: Min FIP	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-3: Yuba City Ring	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-4: Little J	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-5: FIP Therm to Star	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-6: FIP ALL	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
	SB-7: FIP Sunset to Laurel	F9.0R	0.0386	0.0426	35%	73%	89%	89%	60%	56%	19%
	SB-8: FIP Themalito to Laurel	F9.0R-fixed	0.0022	0.0022	2%	6%	10%	99%	99%	100%	55%
Rural Sutter	SB-1: No Action	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
	SB-2: Min FIP	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
	SB-3: Yuba City Ring	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
	SB-4: Little J	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
	SB-5: FIP Therm to Star	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
	SB-6: FIP ALL	F4_0R-fixed	0.0022	0.0022	2%	7%	11%	99%	99%	99%	55%
	SB-7: FIP Sunset to Laurel	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%
	SB-8: FIP Themalito to Laurel	S4.0L	0.2482	0.2954	97%	99%	99%	60%	57%	50%	24%

8 Net Benefit Analysis

With benefits calculations complete, annual costs need to be derived to complete the benefit cost analysis. Economic feasibility and project efficiency are determined through benefit cost analysis. For a project or increment to be feasible, benefits must exceed costs and the most efficient alternative is the one that maximizes net benefits (annual benefits minus annual costs). The National Economic Development Plan (NED) is identified as the plan that reasonable optimizes the net benefits.

8.1 Net benefit and BCR uncertainty and ranges

Table 8-1 below summarizes the Net Benefits and Benefit-to-Cost ratio ranges for each of the draft array of alternatives. The low annual benefit represents the 75% confidence (that benefits will exceed the indicated value), the mid represents the 50% and the high annual benefit represents the 25% confidence level. The low annual cost represents the 20% confidence (that costs will be less than the indicated value), the mid annual cost represents the 50% confidence and the high cost represents the 80% confidence. Net Benefit and BCR mean values and ranges were calculated in a Monte-Carlo simulation using a triangular distribution in the annual benefits and the annual costs. The mean Net Benefit and BCR represent the mean result from this Monte Carlo simulation. The low to high range represent the 90% confident range (5%-95%), given our inputs (less than 90% overall because inputs did not represent the 100% range). In other words, we are most confident that Net Benefits and BCR will exceed the low values and become less confident as you move toward the high values, with the best estimate being the mean values.

More detailed costs estimates will be developed for the final array of alternatives.

Table 8-1: Net Benefits and Benefit-to-Cost Ratios – Draft Array of Alternatives in October 2011 Prices ($Million), 4% Interest Rate

Alternative	Total First Cost[1]			IDC[2]	Annualized Cost + O&M[3]			Annual Benefits[4]			Annual Net Benefits[5]			Benefit to Cost Ratio[5]		
	Low (20%)	Mid (50%)	High (80%)	Mid	Low (20%)	Mid (50%)	High (80%)	Low (75%)	Mid (50%)	High (25%)	Low	Mean	High	Low	Mean	High
SB-1: No Action	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
SB-2: Minimal Fix in Place, Sunset Weir to Star Bend	290	319	361	24	14	16	18	24	38	73	14	29	48	1.9	2.9	4.1
SB-3: Yuba City Ring Levee	411	451	507	53	21	23	26	25	41	71	8	23	40	1.3	2.0	2.7
SB-4: Little J Levee	729	798	899	94	37	40	45	31	46	87	-3	14	36	0.9	1.4	1.9
SB-5: Fix-in-Place, Thermalito to Star Bend	549	608	694	72	28	31	35	29	45	81	4	21	41	1.1	1.7	2.3
SB-6: Fix-in-Place, Feather River, Sutter Bypass and Wadsworth Canal	1,018	1,131	1,297	183	53	59	67	46	73	134	-3	25	58	0.9	1.4	2.0
SB-7: Fix-in-Place, Sunset Weir to Laurel Ave	386	423	479	41	19	21	24	32	51	92	18	37	60	1.8	2.8	3.8
SB-8: Fix-in-Place, Thermalito to Laurel Ave	645	713	812	100	33	36	42	36	58	101	7	28	52	1.2	1.8	2.4

1 Cost Range: Min= 20% Mid=50% Max= 80% (confidence costs are less than given value)

2 IDC based on equal annual spending over the following construction schedules: SB-2 = 3years, SB 3 = 5 years, SB-4 = 5 years, SB-5 = 5 years, SB-6 = 7 years, SB-7=4 years, SB-8=6 years

3 First Costs plus IDC amortized over 50 years at 4% plus annual O&M. Annual O&M costs: SB-2 = $195k, SB-3 = $270k, SB-4 = $477k, SB-5 = $360k, SB-6 = $661k, SB-7 = $350k, SB-8 = $500k

4 Benefit Range: Min=75% Mid=50% Max=25% (confidence benefits are greater than given value)

5 Values are a result of Monte Carlo simulations using triangular distributions of annual benefit and annual cost confidence intervals as inputs. Mean=Mean result from simulation.

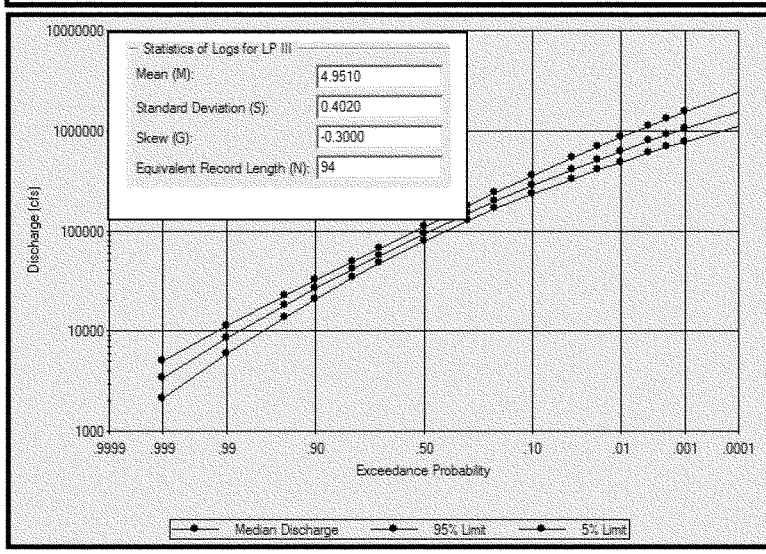
9 Conclusions

The Tentatively Selected Plan will be determined based upon NED and the evaluation of other metrics developed for the Sutter Basin, such as critical infrastructure, life safety and wise use of floodplains. For detailed discussion of these metrics and the identification of the TSP, please refer to the main report.

Enclosure 1 to Attachment 1: Hydrology Inputs

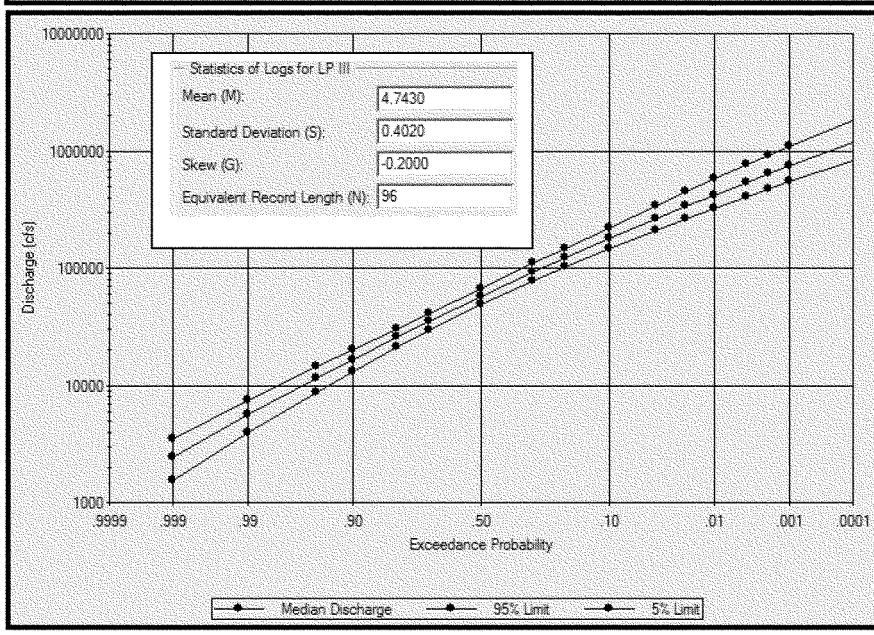
F3.0R, F4.0R, F4.5R (Feather River) – Unregulated Exceedence Probability Curve – Feather River at Shanghai Bend

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs) 95%	75%	25%	5%
0.9990	3,431	2,129	2,860	4,050	5,022
0.9900	8,477	5,893	7,376	9,630	11,374
0.9500	18,084	13,736	16,265	19,950	22,713
0.9000	26,585	21,023	24,270	28,948	32,438
0.8000	41,672	34,292	38,599	44,822	49,513
0.7000	56,968	47,863	53,152	60,922	66,910
0.5000	93,556	79,914	87,721	99,802	109,677
0.3000	149,787	127,290	139,924	160,751	178,969
0.2000	196,719	165,350	182,781	212,541	239,557
0.1000	282,849	232,753	260,236	309,170	355,625
0.0400	408,885	327,533	371,648	453,221	533,887
0.0200	513,588	403,859	462,966	574,653	687,741
0.0100	626,302	484,207	560,320	706,771	858,035
0.0040	786,874	596,129	697,664	897,011	1,107,553
0.0020	918,331	685,967	809,140	1,054,235	1,316,954
0.0010	1,056,818	779,169	925,797	1,221,087	1,541,860
0.0001	1,569,369	1,114,255	1,352,108	1,847,319	2,405,530



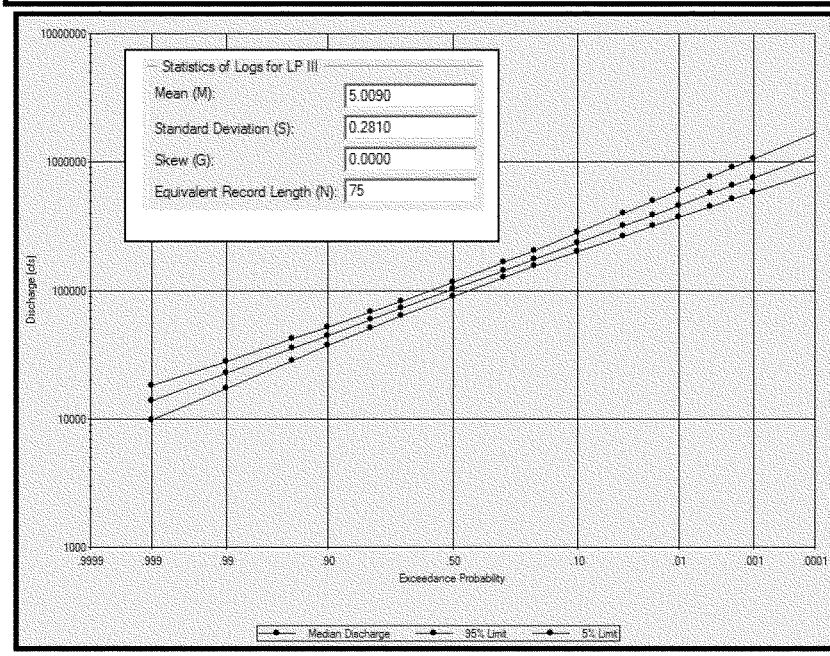
F5.0R, F6.0R, F7.0, F8.0R, F9.0R (Feather River) – Unregulated Exceedence Probability Curve – Feather River at Oroville Dam

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs) 95%	75%	25%	5%
0.9990	2,429	1,542	2,042	2,846	3,497
0.9900	5,612	3,950	4,906	6,351	7,464
0.9500	11,474	8,766	10,342	12,635	14,352
0.9000	16,595	13,168	15,169	18,050	20,198
0.8000	25,654	21,148	23,778	27,577	30,438
0.7000	34,857	29,323	32,539	37,258	40,886
0.5000	57,065	48,817	53,541	60,829	66,765
0.3000	91,859	78,216	85,885	98,489	109,474
0.2000	121,519	102,333	113,001	131,173	147,620
0.1000	177,343	146,095	163,243	193,740	222,641
0.0400	262,032	209,793	238,117	290,510	342,319
0.0200	334,877	262,816	301,612	375,038	449,478
0.0100	415,639	320,212	371,282	469,821	571,867
0.0040	534,779	402,843	472,973	611,282	758,011
0.0020	635,275	471,052	557,947	731,844	919,343
0.0010	744,324	543,817	649,471	863,739	1,098,199
0.0001	1,172,983	820,544	1,004,075	1,390,541	1,831,466



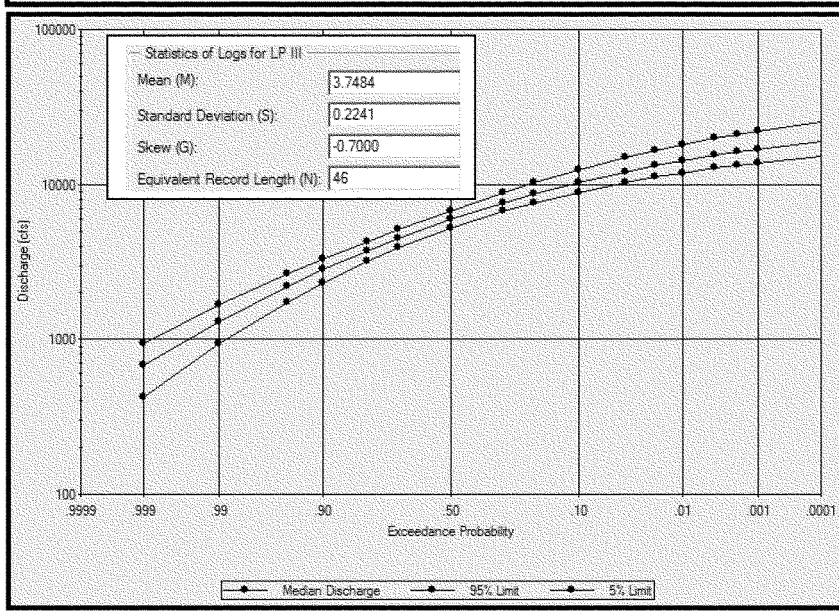
S3.0L, S4.0L, S5.0L (Sutter Bypass) – Unregulated Exceedence Probability Curve – Sacramento River at Ord Ferry

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs) 95%	75%	25%	5%
0.9990	13,824	9,847	12,160	15,524	18,015
0.9900	22,662	17,307	20,456	24,873	28,057
0.9500	35,221	28,497	32,478	37,945	41,839
0.9000	44,554	37,064	41,503	47,584	51,928
0.8000	59,225	50,717	55,746	62,710	67,772
0.7000	72,718	63,290	68,832	76,664	82,501
0.5000	102,094	90,185	97,069	107,379	115,575
0.3000	143,336	126,339	135,960	151,430	164,688
0.2000	175,993	153,799	166,212	186,976	205,516
0.1000	233,946	200,725	219,046	251,140	281,218
0.0400	316,915	265,184	293,362	344,759	395,056
0.0200	385,570	316,837	354,012	423,397	493,019
0.0100	459,942	371,503	419,052	509,531	602,269
0.0040	567,847	448,948	512,442	635,935	765,632
0.0020	657,299	511,795	589,145	741,808	904,794
0.0010	753,973	578,578	671,428	857,171	1,058,498
0.0001	1,132,538	831,447	988,918	1,316,405	1,687,293



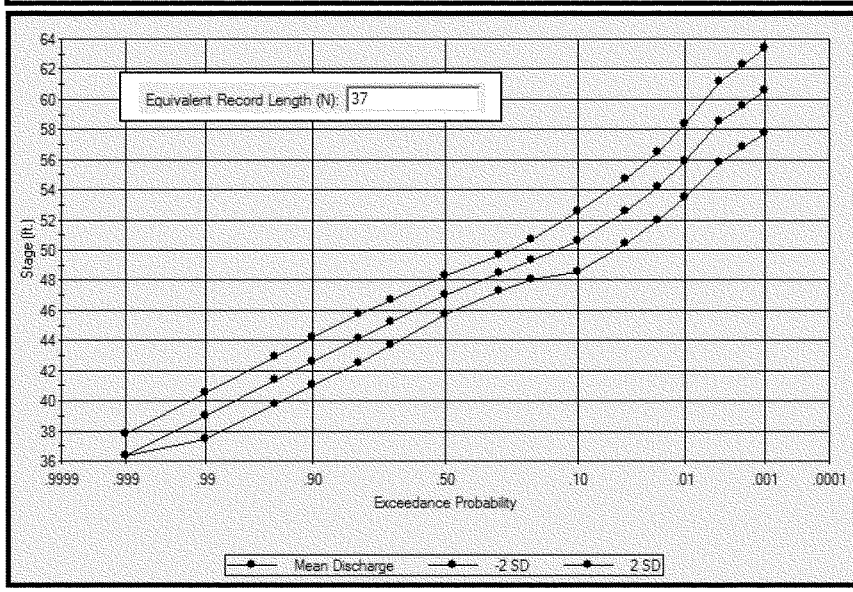
CC.01, CC.02 (Cherokee Canal) – Exceedence Probability Curve – Unregulated Cherokee Canal near Richvale, CA

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs) 95%	75%	25%	5%
0.9990	675	424	570	784	943
0.9900	1,305	934	1,153	1,455	1,667
0.9500	2,192	1,725	2,005	2,374	2,628
0.9000	2,816	2,310	2,614	3,013	3,290
0.8000	3,727	3,179	3,506	3,946	4,261
0.7000	4,491	3,905	4,251	4,734	5,096
0.5000	5,948	5,245	5,650	6,265	6,769
0.3000	7,621	6,699	7,217	8,072	8,836
0.2000	8,719	7,611	8,226	9,282	10,266
0.1000	10,318	8,894	9,675	11,073	12,433
0.0400	12,077	10,258	11,246	13,072	14,913
0.0200	13,217	11,122	12,254	14,381	16,565
0.0100	14,229	11,877	13,143	15,552	18,060
0.0040	15,395	12,737	14,161	16,909	19,812
0.0020	16,195	13,320	14,856	17,845	21,030
0.0010	16,908	13,835	15,474	18,683	22,127
0.0001	18,840	15,215	17,139	20,966	25,149



W2.0L, W2.0R – Graphical Probability-Stage Curve – Wadsworth Canal

Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	36.35	36.35	35.62	37.08	37.80
0.9900	38.99	37.48	38.23	39.74	40.50
0.9500	41.34	39.78	40.56	42.12	42.90
0.9000	42.60	41.00	41.80	43.39	44.19
0.8000	44.11	42.49	43.30	44.93	45.74
0.7000	45.21	43.72	44.47	45.95	46.70
0.5000	47.02	45.74	46.38	47.66	48.30
0.3000	48.47	47.28	47.88	49.07	49.67
0.2000	49.35	48.00	48.68	50.02	50.70
0.1000	50.57	48.59	49.58	51.56	52.55
0.0400	52.58	50.43	51.50	53.66	54.73
0.0200	54.22	51.93	53.07	55.37	56.51
0.0100	55.92	53.48	54.70	57.14	58.36
0.0040	58.50	55.84	57.17	59.82	61.15
0.0020	59.58	56.83	58.21	60.95	62.33
0.0010	60.60	57.76	59.18	62.02	63.43



Regulated Transform-Flow Curves by Reach*

ACE Event	Inflow	Ouflow by Reach		
		F3.0R	F4.0R	F4-5.0R
50%	93,556	54,591	69,312	71,106
10%	282,849	150,135	190,157	191,421
4%	408,885	205,191	252,011	253,367
2%	513,588	226,967	277,249	278,979
1%	626,302	238,438	285,044	287,003
0.40%	786,874	296,829	353,748	355,874
0.20%	918,331	395,730	485,616	500,541

ACE Event	Inflow	Ouflow by Reach				
		F5.0R	F6.0R	F7.0R	F8.0R	F9.0R
50%	57,065	49,008	49,008	49,446	53,058	53,058
10%	177,343	107,588	107,588	107,862	99,999	99,999
4%	262,032	151,060	151,060	151,635	149,997	149,997
2%	334,877	158,391	158,391	160,995	150,000	150,000
1%	415,639	160,000	160,000	161,108	150,001	150,001
0.40%	534,779	163,927	163,927	183,101	172,002	172,002
0.20%	635,275	265,514	265,514	290,432	326,100	326,100

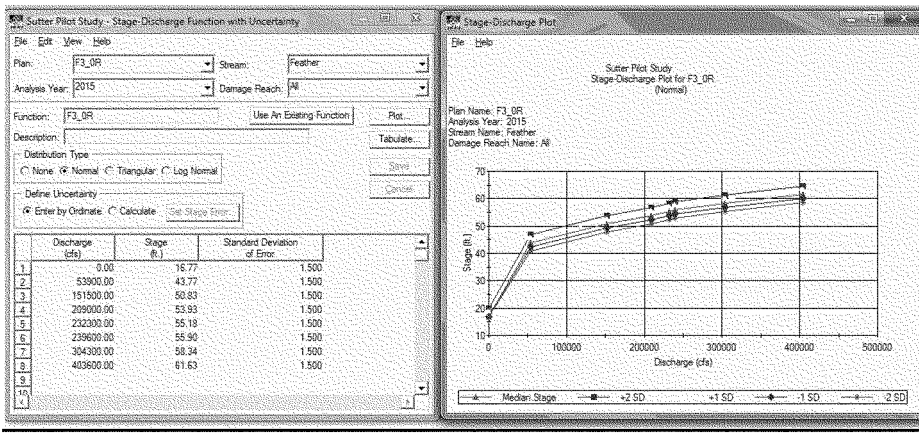
ACE Event	Inflow	Ouflow by Reach		
		S3.0L	S4.0L	S5.0L
50%	102,094	71,238	58,910	57,413
10%	233,946	117,554	103,502	102,011
4%	316,915	141,501	127,476	126,200
2%	385,570	165,863	156,454	155,064
1%	459,942	198,747	185,534	184,198
0.40%	567,847	238,664	228,793	228,195
0.20%	657,299	267,199	251,118	267,153

ACE Event	Inflow	Ouflow by Reach	
		CC.01	CC.02
50%	5,948	5,584	5,584
10%	10,318	9,658	9,658
4%	12,077	11,321	11,321
2%	13,217	12,384	12,384
1%	14,229	13,331	13,331
0.40%	15,395	14,206	14,206
0.20%	16,195	15,286	15,286

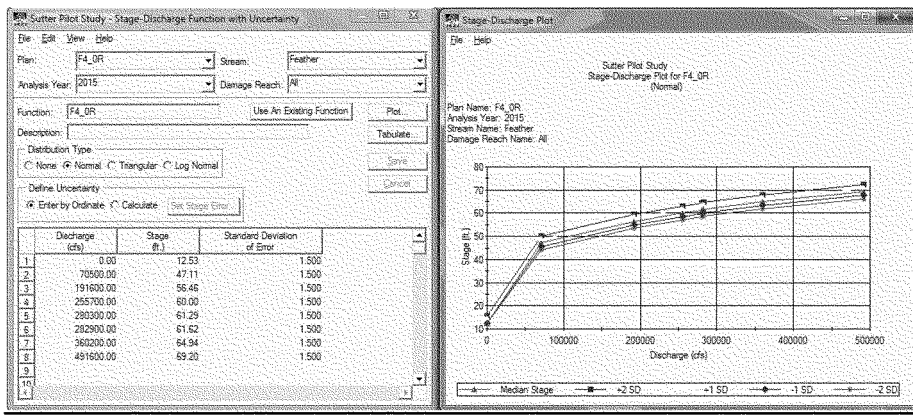
**Note: Inflow values reflect upstream inflows in most cases, while outflows represent the flow at the index location.*

Enclosure 2 to Attachment 1: Hydraulics Inputs

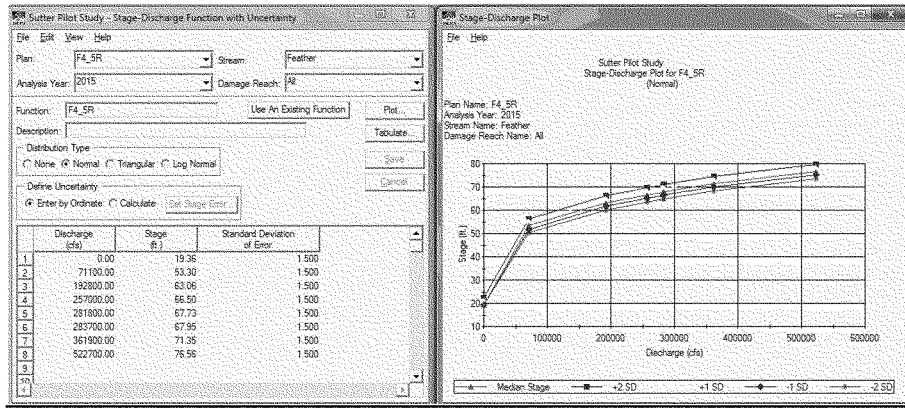
F3.0R



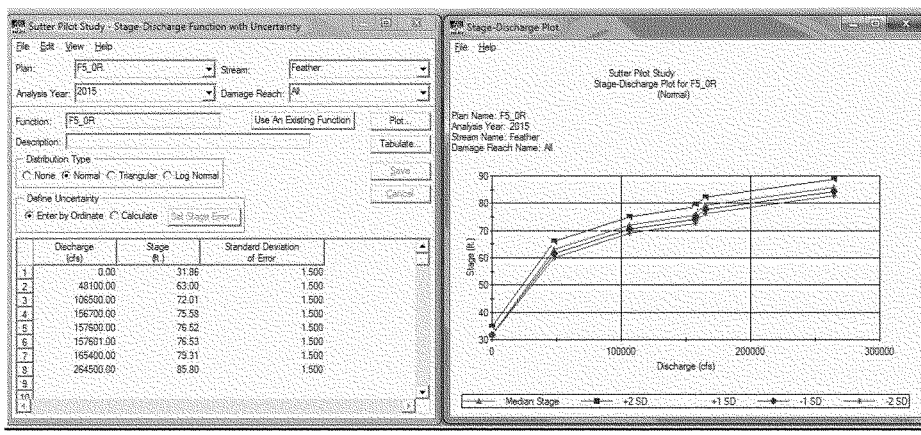
F4.0R



F4.5R


Sutter Pilot Study - Stage-Discharge Function with Uncertainty
File Edit View Help
Plan: F4_5R
Stream: Feather
Analysis Year: 2015
Damage Reach: All
Function: F4_5R
Use An Existing Function
Plot...
Description:
Tabulate...
Distribution Type
None Normal Triangular Log Normal
Save
Cancel
Define Uncertainty
Enter by Ordinate Calculate
Set Stage Error...
Discharge (cfs) | Stage (ft.) | Standard Deviation of Error
1 0.00 19.36 1.500
2 71100.00 53.30 1.500
3 192800.00 63.06 1.500
4 257000.00 66.50 1.500
5 281800.00 67.73 1.500
6 283700.00 67.95 1.500
7 361900.00 71.35 1.500
8 522700.00 76.56 1.500
Stage-Discharge Plot
File Help
Sutter Pilot Study
Stage-Discharge Plot for F4_5R
(Normal)
Plan Name: F4_5R
Analysis Year: 2015
Stream Name: Feather
Damage Reach Name: All
Stage (ft.)
Discharge (cfs)
Median Stage
+2 SD
+1 SD
-1 SD
-2 SD

F5.0R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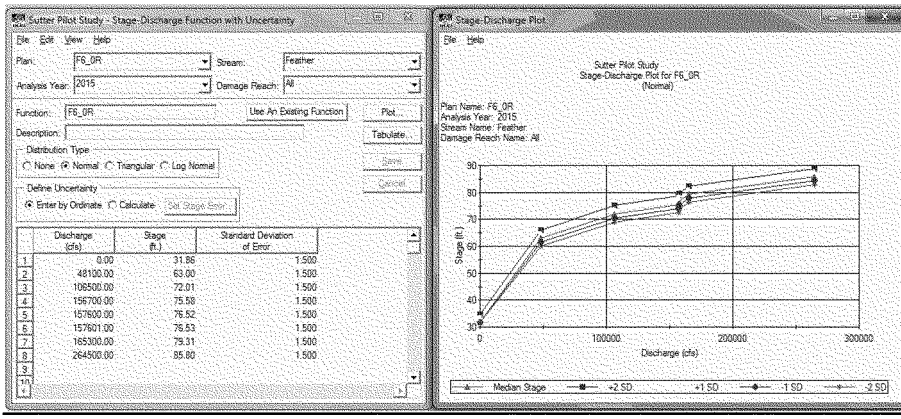
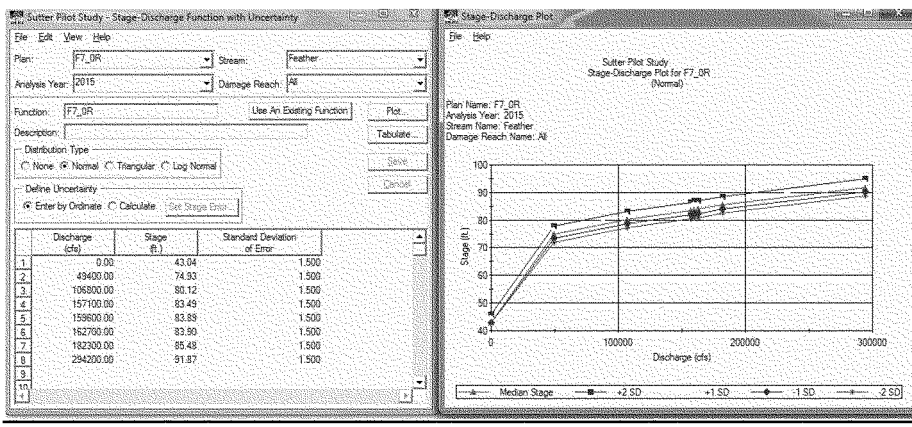
File Edit View Help
Plan: F5_0R
Stream: Feather
Analysis Year: 2015
Damage Reach: All
Function: F5_0R
Use An Existing Function
Plot...
Description:
Tabulate...
Distribution Type
None Normal Triangular Log Normal
Save
Cancel
Define Uncertainty
Enter by Ordinate Calculate
Set Stage Error...
Discharge (cfs) | Stage (ft.) | Standard Deviation of Error
1 0.00 31.86 1.500
2 48100.00 63.00 1.500
3 106500.00 72.01 1.500
4 156700.00 75.58 1.500
5 157500.00 76.52 1.500
6 157601.00 76.53 1.500
7 165400.00 79.31 1.500
8 264500.00 85.80 1.500
Stage-Discharge Plot
File Help
Sutter Pilot Study
Stage-Discharge Plot for F5_0R
(Normal)
Plan Name: F5_0R
Analysis Year: 2015
Stream Name: Feather
Damage Reach Name: All
Stage (ft.)
Discharge (cfs)
Median Stage
+2 SD
+1 SD
-1 SD
-2 SD

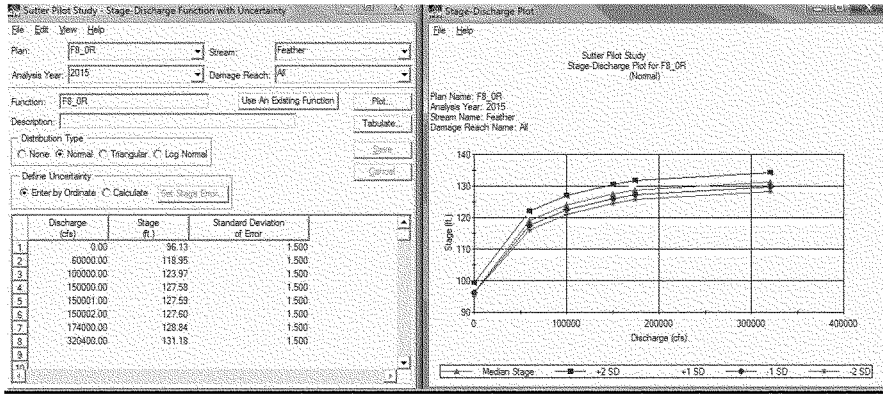
F6.0R


Sutter Pilot Study - Stage-Discharge Function with Uncertainty
File Edit View Help
Plan: F6_0R
Stream: Feather
Analysis Year: 2015
Damage Reach: All
Function: F6_0R
Use An Existing Function
Plot...
Description:
Tabulate...
Distribution Type
None Normal Triangular Log Normal
Save
Cancel
Define Uncertainty
Enter by Ordinate Calculate
Set Stage Error
Discharge (cfs) | Stage (ft.) | Standard Deviation of Error
1 0.00 31.86 1.500
2 48100.00 63.00 1.500
3 106500.00 72.01 1.500
4 156700.00 75.58 1.500
5 157600.00 76.52 1.500
6 157601.00 76.53 1.500
7 165300.00 79.31 1.500
8 264500.00 85.80 1.500
Stage-Discharge Plot
File Help
Sutter Pilot Study
Stage-Discharge Plot for F6_0R
(Normal)
Plan Name: F6_0R
Analysis Year: 2015
Stream Name: Feather
Damage Reach Name: All
Stage (ft.)
90
80
70
60
50
40
30
0
100000
200000
300000
Discharge (cfs)
Median Stage
+2 SD
+1 SD
-1 SD
-2 SD

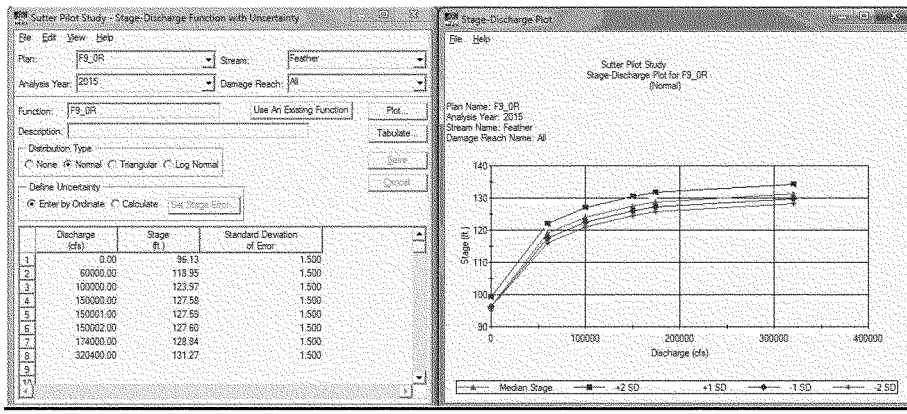
F7.0R


Sutter Pilot Study - Stage-Discharge Function with Uncertainty
File Edit View Help
Plan: F7_0R
Stream: Feather
Analysis Year: 2015
Damage Reach: All
Function: F7_0R
Use An Existing Function
Plot...
Description:
Tabulate...
Distribution Type
None Normal Triangular Log Normal
Save
Cancel
Define Uncertainty
Enter by Ordinate Calculate
Set Stage Error
Discharge (cfs) | Stage (ft.) | Standard Deviation of Error
1 0.00 43.04 1.500
2 49400.00 74.93 1.500
3 106800.00 80.12 1.500
4 157100.00 83.49 1.500
5 159600.00 83.89 1.500
6 162700.00 83.90 1.500
7 182300.00 85.48 1.500
8 294200.00 91.87 1.500
Stage-Discharge Plot
File Help
Sutter Pilot Study
Stage-Discharge Plot for F7_0R
(Normal)
Plan Name: F7_0R
Analysis Year: 2015
Stream Name: Feather
Damage Reach Name: All
Stage (ft.)
100
90
80
70
60
50
40
0
100000
200000
300000
Discharge (cfs)
Median Stage
+2 SD
+1 SD
-1 SD
-2 SD

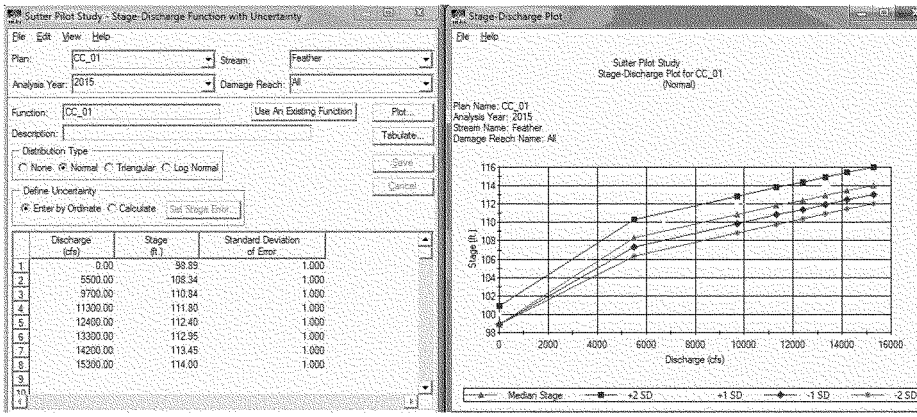
F8.0R


Sutter Pilot Study - Stage-Discharge Function with Uncertainty
File Edit View Help
Plan: F8_0R
Stream: Feather
Analysis Year: 2015
Damage Reach: All
Function: F8_0R
Use An Existing Function
Plot...
Description:
Tabulate...
Distribution Type
None Normal Triangular Log Normal
Save...
Cancel
Define Uncertainty
Enter by Ordinate Calculate
Get Stage Error...
Discharge (cfs)
Stage (ft.)
Standard Deviation of Error
1 0.00 96.13 1.500
2 60000.00 118.95 1.500
3 100000.00 123.97 1.500
4 150000.00 127.58 1.500
5 150001.00 127.59 1.500
6 150002.00 127.60 1.500
7 174000.00 128.84 1.500
8 320400.00 131.18 1.500
Stage-Discharge Plot
File Help
Sutter Pilot Study
Stage-Discharge Plot for F8_0R
(Normal)
Plan Name: F8_0R
Analysis Year: 2015
Stream Name: Feather
Damage Reach Name: All
Stage (ft.)
140
130
120
110
100
90
0
100000
200000
300000
400000
Discharge (cfs)
Median Stage
+2 SD
+1 SD
-1 SD
-2 SD

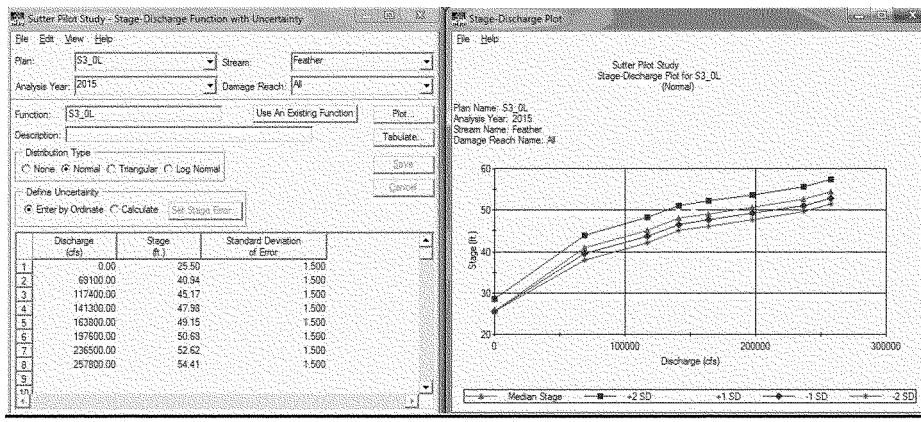
F9.0R


Sutter Pilot Study - Stage-Discharge Function with Uncertainty
File Edit View Help
Plan: F9_0R
Stream: Feather
Analysis Year: 2015
Damage Reach: All
Function: F9_0R
Use An Existing Function
Plot...
Description:
Tabulate...
Distribution Type
None Normal Triangular Log Normal
Save...
Cancel
Define Uncertainty
Enter by Ordinate Calculate
Get Stage Error...
Discharge (cfs)
Stage (ft.)
Standard Deviation of Error
1 0.00 96.13 1.500
2 60000.00 118.95 1.500
3 100000.00 123.97 1.500
4 150000.00 127.58 1.500
5 150001.00 127.59 1.500
6 150002.00 127.60 1.500
7 174000.00 128.84 1.500
8 320400.00 131.27 1.500
Stage-Discharge Plot
File Help
Sutter Pilot Study
Stage-Discharge Plot for F9_0R
(Normal)
Plan Name: F9_0R
Analysis Year: 2015
Stream Name: Feather
Damage Reach Name: All
Stage (ft.)
140
130
120
110
100
90
0
100000
200000
300000
400000
Discharge (cfs)
Median Stage
+2 SD
+1 SD
-1 SD
-2 SD

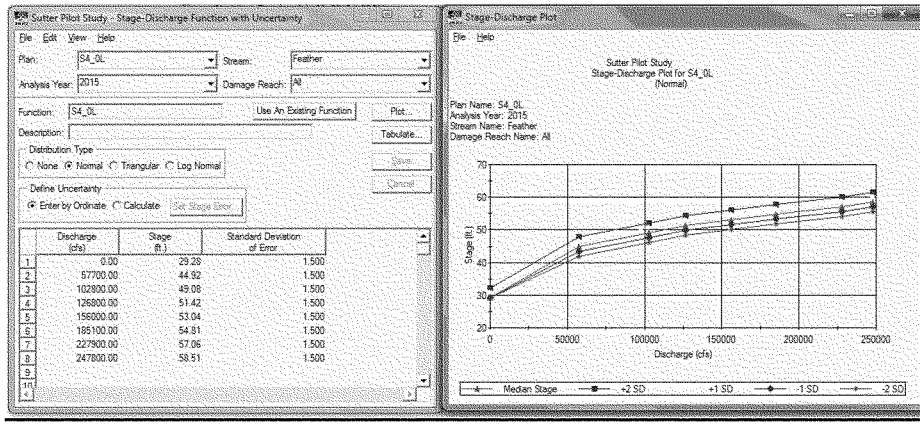
CC.01 & CC.02



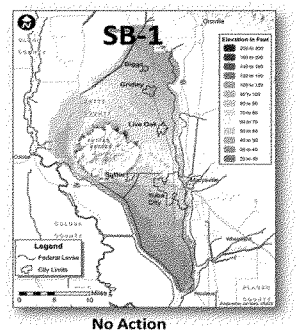
S3.0L



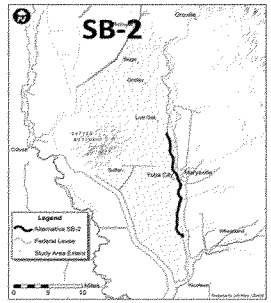
S4.0L


Sutter Pilot Study - Stage-Discharge Function with Uncertainty
File Edit View Help
Plan: S4_0L
Stream: Feather
Analysis Year: 2015
Damage Reach: All
Function: S4_0L
Use An Existing Function
Plot...
Description:
Tabulate...
Distribution Type
None Normal Triangular Log Normal
Save
Cancel
Define Uncertainty
Enter by Ordinate Calculate
Set Stage Error
Discharge (cfs)
Stage (ft.)
Standard Deviation of Error
1 0.00 29.28 1.500
2 57700.00 44.92 1.500
3 102800.00 49.08 1.500
4 126800.00 51.42 1.500
5 156000.00 53.04 1.500
6 185100.00 54.81 1.500
7 227900.00 57.06 1.500
8 247800.00 58.51 1.500
Stage-Discharge Plot
File Help
Sutter Pilot Study
Stage-Discharge Plot for S4_0L
(Normal)
Plan Name: S4_0L
Analysis Year: 2015
Stream Name: Feather
Damage Reach Name: All
Stage (ft.)
70
60
50
40
30
20
0
50000
100000
150000
200000
250000
Discharge (cfs)
Median Stage
+2 SD
+1 SD
-1 SD
-2 SD

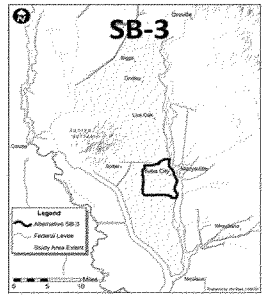
Enclosure 3 to Attachment 1: Draft Array of Alternatives – Maps Showing Project Measures (Levee Reaches)



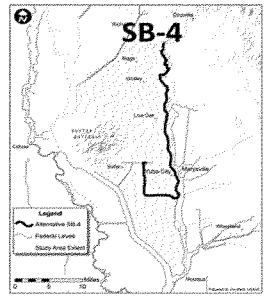
No Action Alternative



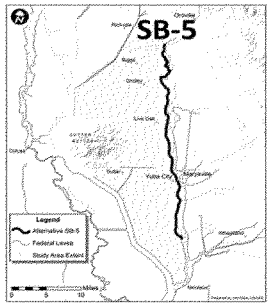
Feather River at Yuba City



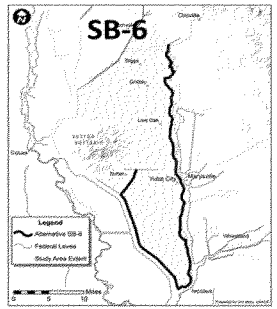
Yuba City Ring Levee



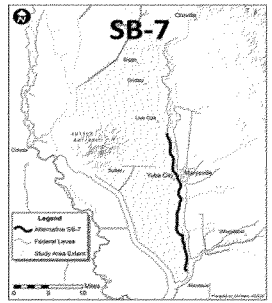
Little "J" Levee



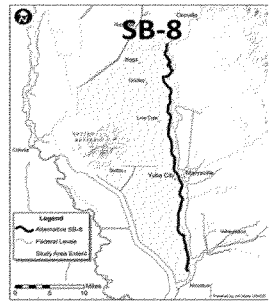
Feather River Thermalito Afterbay to Star Bend



Feather River, Sutter Bypass, and Wadsworth



Feather River Sunset Weir to Laurel Ave



Feather River Thermalito Afterbay to Laurel Ave

Enclosure 4 to Attachment 1: With-Project - Levee Breach & Floodplain Assignments by ACE Event and EIA

Below are the Levee Breach & Floodplain assignments used during HEC-FDA flood damage calculations by Alternative.

SB-1: No Action

EIA	Dominating Index Point (Significant Flooding Starts)	FDA Index Point	Annual Chance Exceedance Event						
			50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Biggs	F9.0R	F9.0R	None	CC.02	F9.0R	F9.0R	F9.0R	F9.0R	F9.0R
Gridley	F9.0R	F9.0R	None	None	F9.0R	F9.0R	F9.0R	F9.0R	F9.0R
Live Oak	F9.0R	F9.0R	None	None	F9.0R	F9.0R	F9.0R	F9.0R	F7.0R
Yuba City	F5.0R	F5.0R	None	S4.0L	F5.0R	F5.0R	F5.0R	F5.0R	F5.0R
Town of Sutter	None	None	None	None	None	None	None	None	None
Rural Butte	F9.0R	F9.0R	None	CC.02	F9.0R	F9.0R	F9.0R	F9.0R	F9.0R
Rural Sutter	S4.0L	S4.0L	None	S4.0L	F5.0R	F5.0R	F5.0R	F6.0R	F6.0R

SB-2: Minimal Fix-in-Place Feather River Levees-Sunset Weir to Star Bend

EIA	Dominating Index Point (Significant Flooding Starts)	FDA Index Point	Annual Chance Exceedance Event						
			50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Biggs	F9.0R	F9.0R	None	CC.02	F9.0R	F9.0R	F9.0R	F9.0R	F9.0R
Gridley	F9.0R	F9.0R	None	None	F9.0R	F9.0R	F9.0R	F9.0R	F9.0R
Live Oak	F9.0R	F9.0R	None	None	F9.0R	F9.0R	F9.0R	F9.0R	F7.0R
Yuba City	F4.0R	F4.0R	None	S4.0L	F4.0R	F4.0R	F4.0R	F4.0R	F5.0R
Rural Butte	F9.0R	F9.0R	None	CC.02	F9.0R	F9.0R	F9.0R	F9.0R	F9.0R
Rural Sutter	S4.0L	S4.0L	None	S4.0L	F4.0R	F4.0R	F4.0R	F4.0R	F6.0R

SB-3: Yuba City Ring Levee

EIA	Dominating Index Point (Significant Flooding Starts)	FDA Index Point	Annual Chance Exceedance Event						
			50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Biggs	F9_0R	F9_0R	None	CC_02	F9_0R	F9_0R	F9_0R	F9_0R	F9_0R
Gridley	F9_0R	F9_0R	None	None	F9_0R	F9_0R	F9_0R	F9_0R	F9_0R
Live Oak	F9_0R	F9_0R	None	None	F9_0R	F9_0R	F9_0R	F9_0R	F7_0R
Yuba City	F5_0R	F5_0R	None	None	None	None	None	None	F5_0R
Rural Butte	F9_0R	F9_0R	None	CC_02	F9_0R	F9_0R	F9_0R	F9_0R	F9_0R
Rural Sutter	S4_0L	S4_0L	None	S4_0L	F5_0R	F5_0R	F5_0R	F6_0R	F6_0R

SB-4: Little J Levee

EIA	Dominating Index Point (Significant Flooding Starts)	FDA Index Point	Annual Chance Exceedance Event						
			50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Biggs	CC_02	F9_0R*	None	CC_02	CC_02	CC_02	CC_02	CC_02	F9_0R
Gridley	F9_0R	F9_0R	None	None	None	None	None	None	F9_0R
Live Oak	F7_0R	F7_0R	None	None	None	None	None	None	F7_0R
Yuba City	F4_0R	F4_0R	None	S4_0L	F4_0R	F4_5R	F4_5R	F4_5R	F5_0R
Rural Butte	CC_02	F9_0R*	None	CC_02	CC_02	CC_02	CC_02	CC_02	F9_0R
Rural Sutter	S4_0L	S4_0L	None	S4_0L	F4_0R	F4_5R	F4_5R	F4_5R	F6_0R

* Fragility curve adjusted to mimic CC_02 Fragility

SB-5: Fix-in-Place Feather River Levees: Thermalito Afterbay to Star Bend

EIA	Dominating Index Point (Significant Flooding Starts)	FDA Index Point	Annual Chance Exceedance Event						
			50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Biggs	CC_02	F9_0R*	None	CC_02	CC_02	CC_02	CC_02	CC_02	F9_0R
Gridley	F9_0R	F9_0R	None	None	None	None	None	None	F9_0R
Live Oak	F7_0R	F7_0R	None	None	None	None	None	None	F7_0R
Yuba City	F3_0R	F3_0R	None	S4_0L	F4.0R	F4.0R	F4.0R	F4.0R	F5_0R
Rural Butte	CC_02	F9_0R*	None	CC_02	CC_02	CC_02	CC_02	CC_02	F9_0R
Rural Sutter	S4_0L	S4_0L	None	S4_0L	F4.0R	F4.0R	F4.0R	F4.0R	F6_0R

* Fragility curve adjusted to mimic CC_02 Fragility

SB-6: Fix-in-Place Feather River, Sutter Bypass, & Wadsworth Canal Levees

EIA	Dominating Index Point (Significant Flooding Starts)	FDA Index Point	Annual Chance Exceedance Event						
			50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Biggs	CC_02	F9_0R*	None	CC_02	CC_02	CC_02	CC_02	CC_02	F9_0R
Gridley	F9_0R	F9_0R	None	None	None	None	None	None	F9_0R
Live Oak	F7_0R	F7_0R	None	None	None	None	None	None	F7_0R
Yuba City	F5_0R	F5_0R	None	None	None	None	None	None	F5_0R
Rural Butte	CC_02	F9_0R*	None	CC_02	CC_02	CC_02	CC_02	CC_02	F9_0R
Rural Sutter	F6_0R	S4_0L	None	None	None	None	None	None	F6_0R

*Fragility adjusted to mimic CC_02 Fragility

SB-7: Fix-in-Place Feather River Levees: Sunset Weir to Laurel Ave.

EIA	Dominating Index Point (Significant Flooding Starts)	FDA Index Point	Annual Chance Exceedance Event						
			50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Biggs	CC_02	F9_0R	None	CC.02	F9.0R	F9.0R	F9.0R	F9.0R	F9.0R
Gridley	F9_0R	F9_0R	None	None	F9.0R	F9.0R	F9.0R	F9.0R	F9.0R
Live Oak	F7_0R	F7_0R	None	None	F9.0R	F9.0R	F9.0R	F9.0R	F7.0R
Yuba City	F5_0R	F5_0R	None	S4.0L	F3.0R	F3.0R	F3.0R	F3.0R	F5.0R
Rural Butte	CC_02	F9_0R	None	CC.02	F9.0R	F9.0R	F9.0R	F9.0R	F9.0R
Rural Sutter	F6_0R	S4_0L	None	S4.0L	F3.0R	F3.0R	F3.0R	F3.0R	F6.0R

SB-8: Fix-in-Place Feather River Levees: Thermalito Afterbay to Laurel Ave.

EIA	Dominating Index Point (Significant Flooding Starts)	FDA Index Point	Annual Chance Exceedance Event						
			50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Biggs	CC_02	F9_0R*	None	CC_02	CC_02	CC_02	CC_02	CC_02	F9_0R
Gridley	F9_0R	F9_0R	None	None	None	None	None	None	F9_0R
Live Oak	F7_0R	F7_0R	None	None	None	None	None	None	F7_0R
Yuba City	F5_0R	F5_0R	None	None	None	None	None	None	F5_0R
Rural Butte	CC_02	F9_0R*	None	CC_02	CC_02	CC_02	CC_02	CC_02	F9_0R
Rural Sutter	F6_0R	S4_0L	None	S4.0L	F3.0R	F3.0R	F3.0R	F3.0R	F6.0R

*Fragility adjusted to mimic CC_02 Fragility

Attachment 2: Agricultural Analysis

SUBJECT: Agricultural Damages for Final Alternative Comparison

1. REFERENCES:

a. Recommendation for Transforming the Current Pre-Authorization Study Process, USACE, January 2011.
b. USACE, 1989. Expected Annual Flood Damage Computation, Users Manual, CPD-30 US Army Corps of Engineers Hydrologic Engineering Center, March 1989.
c. DWR, 2004A Butte County Land use Data, DWR Division of Planning and Local Assistance. Arc GIS 04bu.shp file. July through September 2004.
d. DWR, 2004B Sutter County Land use Data, DWR Division of Planning and Local Assistance. Arc GIS 04su.shp file. July through September 2004.

2. PURPOSE:

The purpose of this memorandum is to describe the method used to calculate Expected Annual Damages (EAD) associated with agricultural land uses for the Sutter Basin Pilot Feasibility Study. A map of the study area showing economic evaluation areas is provided in Plate 1. A map of the landuse types within the study area is provided in Plate 2. The approach was based on the pilot study objective of applying qualitative rather than quantitative analysis during plan selection (Reference a).

The values presented for the final alternatives are based on final hydraulic models, final geotechnical fragility curves, and final depth versus agricultural damage curves. The final values also incorporate estimated residual flooding from interior drainage.

Damages for urban, industrial, urban-landscape, and residential were not included in the estimates. These damages are calculated using the USACE FDA model and are not part of this analysis.

3. BACKGROUND:

The Sutter Basin study area is approximately 300 square miles. The probability of flooding varies by geographical location due to variable hydrologic, hydraulic, and geotechnical conditions.

Expected Annual Damages associated with Agricultural land uses will be used in the comparison of final alternatives for the Sutter Basin Feasibility Study. The final alternatives are presented in Plates 3 through 5. The Recommended Plan will be selected from these refined alternatives.

The USACE Flood Damage Assessment (FDA) computer program was considered for calculating agricultural damages. However, a major limitation of the FDA approach is

evaluation of multiple sources of flooding within a damage area. One of the major limitations of the approach is that damages are aggregated to a single source index point. This limitation was overcome in the urban economic damage calculation by assigning floodplains to damage areas based on probability and consequence from the various levee breaches. This approach resulted in different floodplain assignments for each damage area (see Economic Appendix for more detailed information). However, the method was considered more detailed, costly, and time consuming than necessary for evaluation of the agricultural related damages. A simplified approach was developed based on stage damage curves for land use types within the study area and simplifying calculations by utilizing 1000ft x 1000ft hydraulic model grid elements.

4. APPROACH:

Estimated annual damages were calculated for agricultural land uses using a grid type analysis of the study area. The damage estimates were calculated using stage- damage relationships for the crop type within each grid element, levee breach inundation maps indicating depths within each grid, and levee performance calculations from HEC-FDA which estimate the probability of a levee breach inundating each grid element.

As described in Institute for Water Resources (IWR) Report 87-R-10, dated October, 1987 flood damage to agriculture is computed and categorized as either direct production investment (DPI) loss, or income loss. Analyses of DPI losses per acre and income losses per acre for each major crop type form the basis for determining total expected damages per acre for each crop. Direct production investment costs are cash and non-cash costs needed to bring the product to market and include pre-harvest costs (e.g., land preparation, fertilizer application, equipment costs, labor costs, seed, planting, etc.). Harvest costs are excluded as it assumed that the product is removed from risk once the product is harvested. DPI losses for each crop type are based on typical monthly production costs incurred during the growing season and the probability of experiencing a flood event during a particular month.

Income losses represent loss of anticipated net income that is expected to be generated from the production on the land. Net income losses per acre for each crop type were calculated based on the four-year average yield and price data from Sutter and Sacramento Counties and subtracting the cash and non-cash costs of production as published in UC Davis Agricultural Economics Crop Production Cost Estimation. The costs are adjusted based on the producer cost index for the appropriate level.

5. AGRICULTURAL DEPTH-DAMAGE CURVES

Agricultural stage-damage curves were developed for each agricultural type within the grid elements of the study area. To evaluate the uncertainty in the results, curves were developed for most likely, low, and high confidence limits.

Input data for the analysis was received from a variety of sources. The input data for Sutter Basin Project includes data collected from literature reviews, UC Davis Agricultural

Economic Crop Budget website, Sutter and Sacramento County Agricultural Commissioner's Annual Crop and Livestock Reports and hydrologic and hydraulic data.

a. Non-Flood Scenario. The status quo is the non-flood scenario. This analysis assumes *ceteris paribus*, or all else equal. This means that aspects not discussed in the analysis were assumed to be the same pre-flood and post-flood.

b. Long term conditions. Average long-term conditions were assumed for all aspects not explicitly discussed.

c. Market prices. Market prices and yields for the study area are based on the County which comprises most of the study area.

d. Budget costs. Budget costs associated with individual crops were received from the UC Davis Crop Budget routine located on the UC Davis, California website and are representations of the costs incurred by producers in the study area.

e. Shortages. No shortages of labor or capital are expected. The quantity of labor and capital demanded and consumed by the flood would be small, relative to the national market. The market has many buyers and sellers and no one firm or consumer should be able to affect prices and quantities in the market.

f. Crop Type. Stage-Damage curves were developed only for crops considered as having significant acres devoted to them. The crops include:

Truck and Specialty Crops – including processing tomatoes
Field Crops – including row crops like corn, and winter forage
Orchard – including Walnuts and Almonds
Alfalfa and Irrigated Pasture
Wine grapes
Rice
Other – including lands irrigated and native pasture and lands that are idle, semi-agricultural, and native vegetation

Other crops or lesser acreages are represented by the surrogate crop/crops representing the general land use category. For example, apples, peaches, and pears are recognized as being grown in the study area but contain a relatively small acreage of the total Orchard Land Class, therefore Walnuts and Almonds making up approximately 90 percent of the Orchard acres are used as surrogates for the acreages of apples, peaches, and pears grown in the area.

g. Producer Price Index. The producer prices paid in the Crop Sector from United States Department of Agriculture (Table 1) was used to adjust costs to current dollars.

Prices Paid by Farmers for Production Items, Interest, Taxes, and Wages
1990-92 = 100

Year	Price Index
2005	142
2006	150
2007	161
2008	187
2009	181
2010	185
2011	205
2012	220

Source: http://usda.mannlib.cornell.edu/usda/nass/AgriPric/

h. Seasonality. Computationally, the season of the year that the flood occurs greatly impacts the amount of flood damage to the agricultural crop. If flooding occurs early within the year, the producer may be able to re-prepare the seedbed, plant and realize a return on the efforts. Conversely, a flood of substantial proportion occurring at harvest time will most certainly result in complete loss for the entire year.

The probabilities of flooding by month were estimated from seventy-six years of historical peak annual flows. Monthly realizations of peak annual flows were then computed as a percentage of all peak annual flows. These monthly percentages formed the basis for determining the likelihood of a flood occurring in a particular month.

Due to year-to-year variability, flood occurrences may be as much as 4 weeks early or later than the flood occurrence midpoint. These flood occurrence probabilities for the Sutter Basin Project Study area are provided in Table 1. The table indicates the uncertainty within each month:

Table 1 - Monthly Flood Occurrence Probabilities

Month	Probability of Peak Annual Flood Occurring within Given Month		
	Scenario Midpoint	Scenario Beginning	Scenario Ending
January	0.21	0.17	0.31
February	0.31	0.21	0.17
March	0.17	0.31	0.08
April	0.08	0.17	0.01
May	0.00	0.1	0.00
June	0.00	0.00	0.00
July	0.00	0.00	0.00
August	0.00	0.00	0.00
September	0.00	0.00	0.00
October	0.00	0.00	0.01
November	0.04	0.01	0.17
December	0.17	0.04	0.21

Farm budgets provide costs that are incurred on a monthly production cycle for each respective crop. These monthly costs are used in a spreadsheet and accumulated throughout the production cycle to show the costs of production that is at risk for any particular month of assumed flooding. Multiplying the direct production costs and the value of crop at risk for each month times the monthly probability provided the probable damages expected if a flood event occurred in any particular month.

Farm budgets were obtained from the University of California at Davis and are available at . All crop budgets used in the agricultural model are found on this site. Specific crop budgets are chosen by the analyst based on the proximity to the study area and the irrigation practice that is prevalent. The farm budgets are updated periodically by UC Davis and display a comprehensive library of budget data that is readily used. US Davis economists can be contacted when inquiries pertaining to the budgets are necessary.

The percent of flood damages is also analyzed and reflects the botanical responds that is expected to the crops yield (and associated gross income) if a flood were to occur in the month. Therefore, the flood related damages depend on the crops response to a given flood event occurring in the particular month. During the period of October to December the affects are not as great as later in the production cycle. Although the seedbed has been prepared, planting has not occurred and crop production is limited by possible herbicide, pesticide, fertilizer, and organic waste contamination from adjoining fields.

i. Value of Perennial Crops. Damage caused by long-term duration flooding may result in permanent loss of perennial crops. The damage to perennials susceptible to flooding is

computed based upon the assumption that the crop stands are at various ages, ranging from year 1 throughout their economic useful life. Accordingly, damage caused by long-term duration flooding is computed based upon a stand that is at the mid-point of its economic useful life.

j. Clean-up and Rehabilitation. Clean-up and rehabilitation of farm acreage is a genuine flood loss and is accordingly accounted for in the computation of agricultural flood damages. Erosion and deposition of debris and sediment may be caused by floods of any duration or time of year. Additionally, drainage and irrigation ditches may become clogged with silt and debris. Interviews with cooperative extension agents and local farmers have been conducted over the past several years. The costs are estimated using data received from the UC Davis agricultural budgets and also from local farmers. The clean up reflects the amount of effort that it takes to place the land into a "before flood event" condition. It does not include costs which would be considered as pre-planting costs as they are included in the crop budgets.

The requirement to restore agricultural land after having been inundated by a flood will require the removal of trash and debris that may have accumulated, dealing with sediment deposition, and reworking of fields to incorporate the sediment and re-level the irrigated cropland. The restoration costs are based on estimates of cultural procedures from the University of California, Davis. This cost for this type of flooding range from $0 to $92 for open cropland. This level of restoration requirement is consistent with the post-flood demands identified in other USACE studies. The estimated cost for agricultural land restoration requiring the largest amount of clean-up and restoration effort on a per acre basis is provided in Table 2.

Table 2 – Per Acre Field Cropland Restoration Costs

Operation	$ Cost/per Acre
Debris/Trash Removal	16.00
Chisel Plow (2X)	22.00
Disc and Roll (2X)	16.00
Triplane (2X)	22.00
Repair/Replace Irrigation System	16.00
Total (25% of acres)	92.00

The average cleanup and restoration costs over the entire floodplain are estimated to be $46 per acre. It is noted that the restoration costs include only those costs that re-establish the land to a condition prior to the incurrence of any of the expected annual production costs. Restoration costs do not provide for fertilizing, applying herbicide, or any pre-planting activities that are expected to occur during the normal growing season.

k. Flood Duration. The short and long-term damages were considered in the agricultural damage analysis. Short term damages are defined as those damages incurred as a result of a short duration flood. In many cases the short duration flood will not entirely destroy the crop but may have deleterious effects on the crop yield which results in a change in the gross income garnered from the crop. Long term damages are based on two criteria: the duration of the flood event, and secondly, on the affect on longevity of the perennial crop. Sometimes the duration can be so deleterious that the perennial crops such as orchards, vines, and alfalfa stands do not survive the flood and must be replanted. The loss of this investment is considered in the computation of the effects of long term flood events.

The duration of flooding within the study area was found to be correlated to the depth of flooding. Shallow overland flow areas in the northern part of the study area are expected to drain to the southern portion of the basin within several weeks. However, the deeper floodwaters within the southern portion of the study area would not be able to drain back to the channel until for several months.

Depth-Damage estimates were developed for each crop from either a short term or long term flood event. Damages for depths less than 10 feet were based on the assumption of short duration flooding. Depths greater than 15 feet were based on the assumption of long duration flooding. Damages between 10 feet and 15 feet were linearly interpolated.

l. Uncertainty. The uncertainty of price and yield data were accounted for by using triangular distributions in the estimation of flood related costs. Similarly, planting times and other cultural practice data were also input as triangular distributions to account for variability in seasons of the year. The resulting outputs were primarily the translation of the inputs based on simple linear

mathematical equations. Due to the uncertainty in the spreadsheet inputs presented as triangular distribution values, @Risk simulation techniques are used in the study to generate a range of model outputs for the stage-damage curves.

m. Example Calculation. All crops undergo a consolidation of costs by month to arrive at the cumulative direct production costs that are at risk should a flood event occur. Below is a example presentation of the cash outlays for the processing tomatoes for the year 2007, which is the most current budget provided by UC Davis for the region in question. Table 3 below can be found on page 13 of the UC Davis budget located at . A Summary of Annual Non-Cash Costs Per Acre to Produce Tomatoes is provided in Table 4. A Summary of Monthly Cash Cost Per Acre to Produce Tomatoes is provided in Table 5. The final costs used for the Sutter Feasibility Study are updated to current dollars using the producers paid index provided by the National Agricultural Statistics Service, United States Department of Agriculture.

Table 3

Monthly Cash Cost Per Acre to Produce Tomatoes

2007- Direct Seeded

Beginning SEP 06 Ending SEP 07	SEP 06	OCT 06	NOV 06	DEC 06	JAN 07	FEB 07	MAR 07	APR 07	MAY 07	JUN 07	JUL 07	AUG 07	SEP 07	TOTAL
Preplant:														
Land Prep - Laser Level - 4% of Acreage	7													7
Land Prep - Stubble Disc & Roll	9													9
Land Prep - Subsoil & Roll 2X	44													44
Land Prep - Disc & Roll X	16													16
Land Prep - Triplane 2X	22													22
Land Prep - Apply Gypsum on 20% of Acreage	26													26
Land Prep - List Beds		6												6
Land Prep - Shape & Fertilize		30												30
Weed Control - Roundup & Goal					12									12
Weed Control - Roundup					12									12
Weed Control - Cultivate 2X					22									22
TOTAL PREPLANT COSTS	123	36			47									206
Cultural:														
Power Mulch Beds							10							10
Apply Fumigant - Vapam on 30% of Acreage							22							22
Weed Control - Apply Devrinol on 30% of Acreage							22							22
Decap Vapam Beds							3							3
Plant Seed & Fertilize								220						220
Break Bed Crust								4						4
Weed Control - Apply Matrix 2X								32						32
Replant 10% of Acreage - No Additional Fertilizer								19						19
Insect Control - Sevin Bait on 50% of Acreage								5						5
Fertilize - Sidedress 20% of Acreage								5						5
Weed Control - Cultivate 5X								44			11			55
Weed Control - Thin & Hand Hoe								150						150
Insect Control - Sevin Spray on 10% of Acreage								1						1
Disease Control – Bacterial Speck on 30% of Acreage								5						5
Fertilize - Layby UN-32								82						82
Chisel Furrow								12						12
Weed Control – Treflan (& Dual on 30% of Acreage)								29						29
Irrigate - Sprinklers 3X								114						114
Open Ditches								1			1			2
Irrigate - Furrow 8X								55	55	55	53			218
Disease Control - Late Blight on 5% of Acreage										2				2
Close Ditches											2			2
Mite Control - Sulfur on 70% of Acreage											10			10
Weed Control - Hand Hoe											50			50
Train Vines											21			21
Insect Control - Aphids on 40% of Acreage											7			7
Disease Control - Late Blight on 15% of Acreage													4	4
Insect Control - Worms													26	26
Fruit Ripener - Ethrel on 5% of Acreage													5	5
Pickup Truck Use (2 pickups)	1	1	1	1	1	1	1	1	1	1	1	1	1	18
ATV Use	0	0	0	0	0	0	0	0	0	0	0	0	0	6
TOTAL CULTURAL COSTS	2	2	2	2	2	2	58	781	57	59	156	2	36	1,160
Harvest:														
Open Harvest Lane on 8% of Acreage											2	2	2	5
Harvest											103	103	10	216
In Field Hauling											27	26	6	58
TOTAL HARVEST COSTS											131	130	18	279
Assessment:														
Assessments/Fees													14	14
TOTAL ASSESSMENT COSTS													14	14
Interest on Operating Capital @ 10.00%	1	1	1	1	2	2	2	9	9	10	12	13	14	78
TOTAL OPERATING COSTS/ACRE	126	39	3	3	50	4	60	790	66	68	299	145	82	1,737
OVERHEAD:														
Liability Insurance					0									0
Office Expense	1	1	1	1	1	1	1	1	1	1	1	1	1	17
Field Sanitation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crop Insurance					25									25
Field Supervisor Salaries (2)	5	5	5	5	5	5	5	5	5	5	5	5	5	70
Land Rent @ 12% Of Gross Returns													265	265
Property Taxes						3					3			6
Property Insurance						2					2			5
Investment Repairs	0	0	0	0	0	0	0	0	0	0	0	0		5
TOTAL CASH OVERHEAD COSTS	7	7	7	7	33	13	7	7	7	7	13	7	271	393
TOTAL CASH COSTS/ACRE	134	47	10	10	83	16	67	797	73	76	312	152	353	2,131

Table 4
Summary of Annual Non-Cash Costs Per Acre to Produce Tomatoes
2007- Direct Seeded

NON-CASH OVERHEAD COSTS (CAPITAL RECOVERY):	
Shop Building	2
Storage Building	1
Fuel Tanks & Pumps	1
Shop Tools	0
Booster Pumps	3
Sprinkler Pipe	5
Main Line Pipe - 10"	3
Semi Truck & Lowbed Trailer	1
Implement Carrier	1
Truck-Service - 2 Ton	3
Pipe Trailers	2
Fuel Wagons	0
Closed Mix System	0
Siphon Tubes	0
Generators & Light	1
Equipment	130
TOTAL NON-CASH OVERHEAD COSTS/ACRE	153

Table 5
Summary of Monthly Cash Cost Per Acre to Produce Tomatoes
2007- Direct Seeded

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
TOTAL PREPLANT COSTS [11]	159			47									206
TOTAL CULTURAL COSTS [12]	4	2	2	2	2	58	781	57	59	156	2	36	1,160
TOTAL HARVEST COSTS										131	130	18	279
TOTAL ASSESSMENT COSTS[13]												14	14
INT ON OPERATING CAPITAL	2	1	1	2	2	2	9	9	10	12	13	14	78
TOTAL OPERATING COSTS/ACRE [14]	165	3	3	50	4	60	790	67	69	168	15	64	1,458
TOTAL CASH OVERHEAD COSTS [15]	29	29	29	56	36	29	29	29	29	36	29	33	393
TOTAL ALLOCATED NON-CASH COSTS[16]	13	13	13	13	13	13	13	13	13	13	12	12	153
TOTAL COSTS/ACRE [17]	207	45	45	119	53	102	832	109	111	217	56	109	2,005

[11] Preplant costs include land preparation soil cultivation and weed control.
[12] Cultural costs include seeding, fertilizing, and insect control.
[13] Assessment costs include assessment fees paid for marketing products.
[14] Total Operating Costs include all direct operating cash costs excluding harvest costs.
[15] Cash Overhead Costs include land rent, office expenses, and insurance. Cash overhead costs are allocated on a month-to-month basis as a monthly usage cost.
[16] Non-Cash costs (from Table 4) include capital recovery costs of equipment and tools
[17] Total Costs are the sum total of cash and non-cash costs that are expended to produce the respective crop.

n. Results. A tabulation of mean depth damage curves for land use types in the study area is presented in Table 6. A tabulation of Low and High estimated depth damage curves for land use types in the study area is presented in Table 7 and 8 respectively. The method used to calculate the depth-damage curves is discussed in detail in the economics appendix to the feasibility study report. The values in these tables were used as depth damage curves in the grid analysis used to estimate agricultural annual damages described below.

Table 6
Depth-Damage Curves for Agricultural Land Use Types, Mean Estimate

Land Use Type	Assumption	Damage ($/acre) by Flood Depth	
		Less than 10 feet	Greater Than 15 Feet
Abandoned	No Damage	$0	$0
Burned Over Areas	No Damage	$0	$0
Citrus and Subtropical	Prunes	$546	$5,011
Deciduous Fruits and Nuts	Walnuts	$473	$8,268
Entry Denied	No Damage	$0	$0
Field Crops	Corn	$285	$345
Grain and Hay Crops	Alfalfa	$282	$770
Idle	idle	$46	$46
Barren and Wasteland	No Damage	$0	$0
Native Classes Unsegregated	No Damage	$0	$0
Non-irrigated Idle	idle	$46	$46
Riparian Vegetation	No Damage	$0	$0
Not Surveyed	No Damage	$0	$0
Native Vegetation	idle	$46	$46
Water Surface	No Damage	$0	$0
Pasture	Pasture	$215	$215
Rice	Rice	$577	$803
Semi Agricultural and Incidental to Ag	idle	$46	$46
Truck, Nursery and Berry Crops	Tomatoes	$446	$446
Urban	See FDA model	$0	$0
Commercial	See FDA model	$0	$0
Industrial	See FDA model	$0	$0
Urban Landscape	See FDA model	$0	$0
Residential	See FDA model	$0	$0
Vacant	idle	$46	$46
Vineyards	Grapes	$2,512	$9,126
Outside study limit	No Damage	$0	$0

Table 7
Depth-Damage Curves for Agricultural Land Use Types, Low Estimate

Land Use Type	Assumption	Damage ($/acre) by Flood Depth	
		Less than 10 feet	Greater Than 15 Feet
Abandoned	No Damage	$0	$0
Burned Over Areas	No Damage	$0	$0
Citrus and Subtropical	Prunes	$340	$4,638
Deciduous Fruits and Nuts	Walnuts	$172	$7,278
Entry Denied	No Damage	$0	$0
Field Crops	Corn	$174	$204
Grain and Hay Crops	Alfalfa	$156	$603
Idle	idle	$23	$23
Barren and Wasteland	No Damage	$0	$0
Native Classes Unsegregated	No Damage	$0	$0
Non-irrigated Idle	idle	$23	$23
Riparian Vegetation	No Damage	$0	$0
Not Surveyed	No Damage	$0	$0
Native Vegetation	idle	$23	$23
Water Surface	No Damage	$0	$0
Pasture	Pasture	$98	$98
Rice	Rice	$297	$382
Semi Agricultural and Incidental to Ag	idle	$23	$23
Truck, Nursery and Berry Crops	Tomatoes	$196	$196
Urban	See FDA model	$0	$0
Commercial	See FDA model	$0	$0
Industrial	See FDA model	$0	$0
Urban Landscape	See FDA model	$0	$0
Residential	See FDA model	$0	$0
Vacant	idle	$23	$23
Vineyards	Grapes	$1,343	$7,994
Outside study limit	No Damage	$0	$0

Table 8
Depth-Damage Curves for Agricultural Land Use Types, High Estimate

Land Use Type	Assumption	Damage ($/acre) by Flood Depth	
		Less than 10 feet	Greater Than 15 Feet
Abandoned	No Damage	$0	$0
Burned Over Areas	No Damage	$0	$0
Citrus and Subtropical	Prunes	$792	$5,524
Deciduous Fruits and Nuts	Walnuts	$967	$9,977
Entry Denied	No Damage	$0	$0
Field Crops	Corn	$441	$492
Grain and Hay Crops	Alfalfa	$180	$1,027
Idle	idle	$92	$92
Barren and Wasteland	No Damage	$0	$0
Native Classes Unsegregated	No Damage	$0	$0
Non-irrigated Idle	idle	$92	$92
Riparian Vegetation	No Damage	$0	$0
Not Surveyed	No Damage	$0	$0
Native Vegetation	idle	$92	$92
Water Surface	No Damage	$0	$0
Pasture	Pasture	$408	$408
Rice	Rice	$1,065	$1,386
Semi Agricultural and Incidental to Ag	idle	$92	$92
Truck, Nursery and Berry Crops	Tomatoes	$750	$750
Urban	See FDA model	$0	$0
Commercial	See FDA model	$0	$0
Industrial	See FDA model	$0	$0
Urban Landscape	See FDA model	$0	$0
Residential	See FDA model	$0	$0
Vacant	idle	$92	$92
Vineyards	Grapes	$4,050	$10,303
Outside study limit	No Damage	$0	$0

6. ANNUALIZED DAMAGE S

Estimated annual damages were calculated for each 1000ft x 1000ft grid element within the study area. The first step was to calculate the potential agricultural damage within each grid for each of 16 sources. The potential damage was estimated by comparing the depth from each breach source to the depth-damage curve for the crop type within the grid. Probability weighted damage was then calculated for each of the 16 sources by multiplying the potential damage by the probability a breach would occur (1-assurance). The highest of the 16 probability weighted damage estimates were then selected for each grid. The above process was repeated for each of seven annual chance exceedance events. The next step was to annualize the damage for each grid. The last step was to add the annual damages for all grid cells within the study area.

a. Land Use. Butte and Sutter County Land use data were obtained in Arc GIS format from California Department of Water Resources Division of Planning and Local Assistance. The data were gathered using aerial photography and field visits and represent conditions in July through September 2004. GIS data were provided in variable sized polygons that represented each land use type. Land use within each grid element was determined by sampling at the center of the grid element. A map of land use types within the study area is provided in Plate 2.

b. Interior Drainage. Cherokee Canal, Wadsworth Canal, and the three largest pump stations were included in floodplain models. Interior drainage from the study area is primarily conveyed to the Butte Basin, Feather River, or Sutter Bypass by gravity through Cherokee Canal, Wadsworth Canal, and by 10 pump stations. The effects of the 10 smaller pump stations were assumed to be negligible during levee breach type scenarios.

c. Non Failure Stage Frequency. The stage frequency for each flood source was estimated over a range of flood events from a 50% Annual Chance of Exceedance (ACE) to 0.2% ACE. For each event, the peak stage was estimated using a hydraulic model that assumes flows are contained by the existing levee project (non failure). The ability of levees to sustain overtopping is highly uncertain. Therefore, flood flows were allowed to overtop upstream levees without failure. It should be noted that the probability of overtopping failure is accounted for in the analysis by reviewing the full suite of potential breach locations throughout the study area. Additional details regarding hydraulic model assumptions are described in the hydraulic model documentation.

d. Inundation maps. Inundation depth maps were developed for15 hypothetical breach failure sources and one natural inundation source throughout the study area. Breach locations were selected to reflect a full range of potential inundation patterns within the study area. Inundation maps were developed for a range of flood frequencies from 50% (1/2) ACE to 0.2% (1/500) ACE. Use of each inundation map must incorporate the probability of levee failure (or stage for natural inundation sources) to define flood probability. Each location (grid element) in the study could be inundated by multiple breach locations. All breach inundation maps and associated breach probability must be reviewed to assess flood potential.

e. Performance Assurance. The performance assurance (Conditional Non-exceedance Probability) for each flood source was calculated using an FDA model. FDA was used to combine flow-frequency, stage-discharge, geotechnical fragility, and stage-damage relationships for each flood source. Uncertainty in each relationship is incorporated by assigning uncertainty estimates and applying a Monte Carlo type approach to combine the results.

f. Critical Flood Source and Damages. The critical flood source and damages for each grid element was defined as the source which would result in the highest expected damage for each ACE event. This was determined by calculating the non-assurance probability weighted damage from each flood source and selecting the largest value. Since the probability of inundation and consequence of inundation varies by grid element, the procedure was done separately for each grid element.

The non-assurance probability weighted damage was calculated by multiplying the non-assurance probability of inundation times the consequence of the inundation. The non-assurance probability of inundation was defined by one minus the assurance (1-Conditional Exceedance Probability) computed by FDA. The consequence of inundation was determined by comparing the depth in the grid element for the assumed breach to the depth damage curve. The next step was to calculate a non-assurance weighted damage value by multiplying the potential damage by the non-assurance probability of inundation. This process was completed for each flood source (possible breach location). The last step was to select the source that generated the highest non-assurance probability weighted damage. It was assumed that for an infinitely long flood record, this damage would represent the most likely damages for that grid element for the given ACE event. An example calculation for the 1% ACE event at Grid Element 11243 (in the south portion of the study area) is presented in Table 9.

g. Estimated Annual Damages. Annualized damages were estimated by integrating the frequency vs: damage curve within each grid element. In the integration procedure, the damages were assumed to be negligible for events more frequent than 95% ACE because flood stages are below the natural bank elevation. Damage for the 0.1% ACE event was assumed to be the same as the 0.2% ACE event in the integration of the frequency vs: damage curve. Floodplain stage (and damages) was assumed to be relatively insensitive to flow for extreme events (less than 0.2% ACE) because of the large flood conveyance area once levees have overtopped and failed. The increment of annual damages for events greater than 0.1% ACE was assumed to be negligible because of its extremely rare frequency and small contribution in the integration calculations. An example calculation for Grid Element 11243 (in the south portion of the study area) is presented in Table 10.

h. Alternatives. Alternatives were evaluated by using fragility curves and inundation maps that reflect each alternative being evaluated.

13. RESULTS

The mean agricultural estimated annual damages for each of the final alternatives are presented in Table 12. The low and high estimates are provided in Table 13 and 14. Maps showing the mean agricultural EAD for each refined alternative are provided in Plates 3 through 5.

Table 9
Example Event Damage Calculation, Without Project Conditions
1% ACE Event, Grid Element 11243

Potential Flood Source	Probability of Inundation			Consequence of Inundation		Non-Assurance Probability Weighted Damage ($)
	Geotech Index	Non-Failure Channel Stage (NAVD88-ft)	Non-Assurance Probability (1-CNP)	Flood Depth Assuming Breach (ft)	Damage Assuming Breach ($)	
Butte Basin BB1.0	Natural	65.06	1.0	0	0	0
Interior Drainage	Natural	NA	NA	0	0	
Feather River F3.0R	MA3	55.95	0.16	18.53	18,435	2,863
Feather River F4.0R	LD1-3.99	61.73	0.46	20.83	18,435	8,487
Feather River F4.5R	LD1-9.31	67.95	0.44	21.46	18,435	8,063
Feather River F5.0R	LD9-0.52	76.57	0.40	21.26	18,435	7,383
Feather River F6.0R	LD9-0.52	76.57	0.40	12.53	15,872	6,357
Feather River F7.0R	MA16-0.9	83.85	0.28	0	0	0
Feather River F8.0R	MA7-Ham Bend	127.30	0.42	0	0	0
Feather River F9.0R	MA7-Ham Bend	127.30	0.42	1.05	13,246	5,594
Sutter Bypass S3.0L	Sutter Bypass 11.9	50.17	0.50	15.96	18,434	9,178
Sutter Bypass S4.0L	Sutter Bypass 6.2	54.44	0.78	17.55	18,434	**14,336**
Sutter Bypass S5.0L	SB LM 4.0	55.91	0.70	0	0	0
Cherokee Canal CC01L	Cherokee Canal 9.5	112.95	0.99	0	0	0
Cherokee Canal CC02L	Cherokee Canal 9.5	112.95	0.99	0	0	0
Wadsworth Canal W2.0L	Wadsworth LB 0.84	55.92	0.66	4.12	13,247	8,792
Wadsworth Canal W2.0R	Wadsworth RB 0.50	55.92	0.81	0	0	0
Critical flood damage source = S4.0L based on largest Non-Assurance Probability Weighted Damage of						**14,336**

Note 1: Non-Failure channel stage assumes upstream levee overtopping without failure. As a result, all potential flood sources must be reviewed to evaluate the probability of flood damages within the study area.
Note 2: The Butte Basin flood source is a natural system without levees. To be consistent with the approach, a fragility of 1 is assumed for all flood events.
Note 3: Summed values may vary due to round off error.

Table 10
Agricultural Damage Frequency Integration, Without Project Conditions
Grid Element 11243

Annual Chance Exceedance (Percent)	Exceedance Frequency Events/100yrs	Frequency Interval (Events per Year)	Non-Assurance Probability Weighted Damage ($)	Average Damage For Frequency Interval ($)	Frequency Interval Weighted Damage ($)	Percent of Total EAD
99.99	99.99		0			
		0.0499		0	0	0.0
95	95		0			
		0.45		3,072	1382	23.0
50	50		6,144			
		0.4		8,499	3400	56.6
10	10		10,854			
		0.06		11,512	691	11.5
4	4		12,171			
		0.02		12,578	252	4.2
2	2		12,985			
		0.01		13,661	137	2.3
1	1		14,336			
		0.005		15,104	76	1.3
0.5	0.5		15,871			
		0.003		16,571	50	0.8
0.2	0.2		17,271			
		0.001		17,271	17	0.3
0.1	0.1		17,271			
				Total EAD	6,003	100

Table 11
Agricultural Estimated Annual Damages
Mean Estimate

Economic Evaluation Area	Estimated Annual Agricultural Damages ($1000)		
	SB-1	SB-7	SB-8
	No Action	Fix-In-Place Feather River Sunset Weir to Laurel Ave	Fix-In-Place Feather River Thermalito to Laurel Ave
Town of Sutter	0	0	0
Yuba City Urban	246	65	57
Biggs Urban	4	4	0
Gridley Urban	5	5	0
Live Oak Urban	9	9	1
Sutter County Rural	16227	11802	11452
Butte County Rural	1875	1875	1208
Total	18366	13760	12718
Note: Damages for urban, industrial, urban-landscape, and residential are not included.			

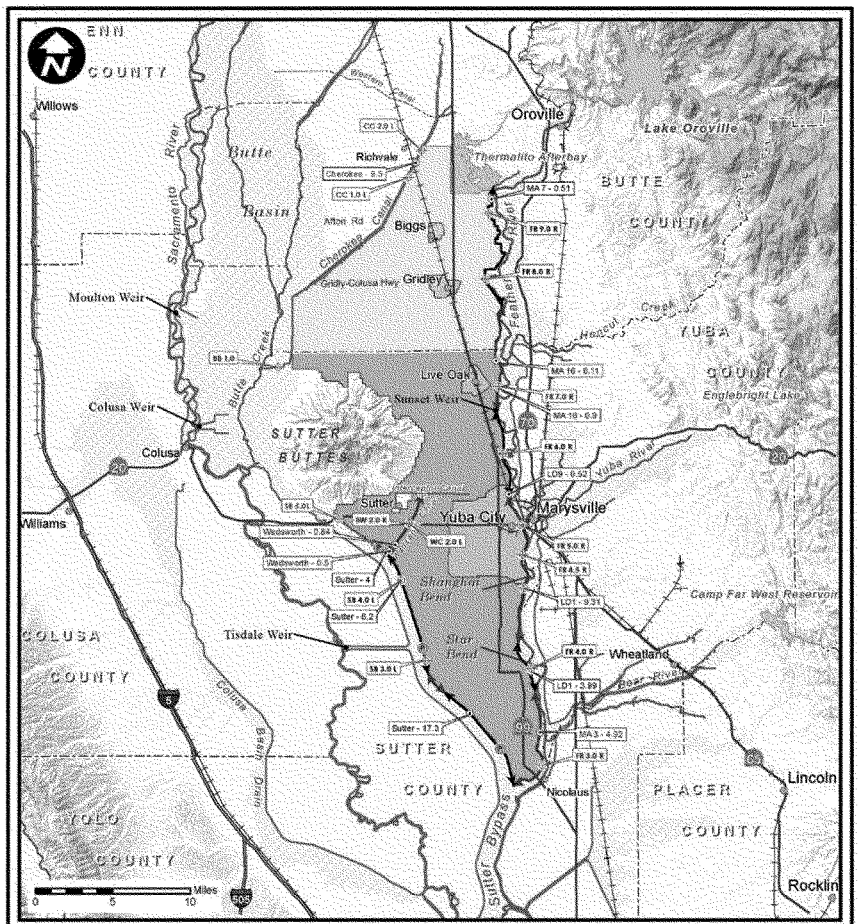
Table 12
Agricultural Estimated Annual Damages
Low Estimate

Economic Evaluation Area	Estimated Annual Agricultural Damages ($1000)		
	SB-1	SB-7	SB-8
	No Action	Fix-In-Place Feather River Sunset Weir to Laurel Ave	Fix-In-Place Feather River Thermalito to Laurel Ave
Town of Sutter	0	0	0
Yuba City Urban	106	28	25
Biggs Urban	2	2	0
Gridley Urban	2	2	0
Live Oak Urban	3	3	0
Sutter County Rural	11006	6766	6610
Butte County Rural	921	921	620
Total	12040	7723	7255
Note: Damages for urban, industrial, urban-landscape, and residential are not included.			

Table 13
Agricultural Estimated Annual Damages
High Estimate

Economic Evaluation Area	Estimated Annual Agricultural Damages ($1000)		
	SB-1	SB-7	SB-8
	No Action	Fix-In-Place Feather River Sunset Weir to Laurel Ave	Fix-In-Place Feather River Thermalito to Laurel Ave
Town of Sutter	0	0	0
Yuba City Urban	470	126	111
Biggs Urban	8	8	1
Gridley Urban	8	8	0
Live Oak Urban	18	18	1
Sutter County Rural	24671	19873	19201
Butte County Rural	3498	3498	2227
Total	28673	23530	21541

Note: Damages for urban, industrial, urban-landscape, and residential are not included.



Legend

Evaluation Area
- Biggs
- Gridley
- Live Oak
- Town of Sutter
- Yuba City
- Rural Butte
- Rural Sutter

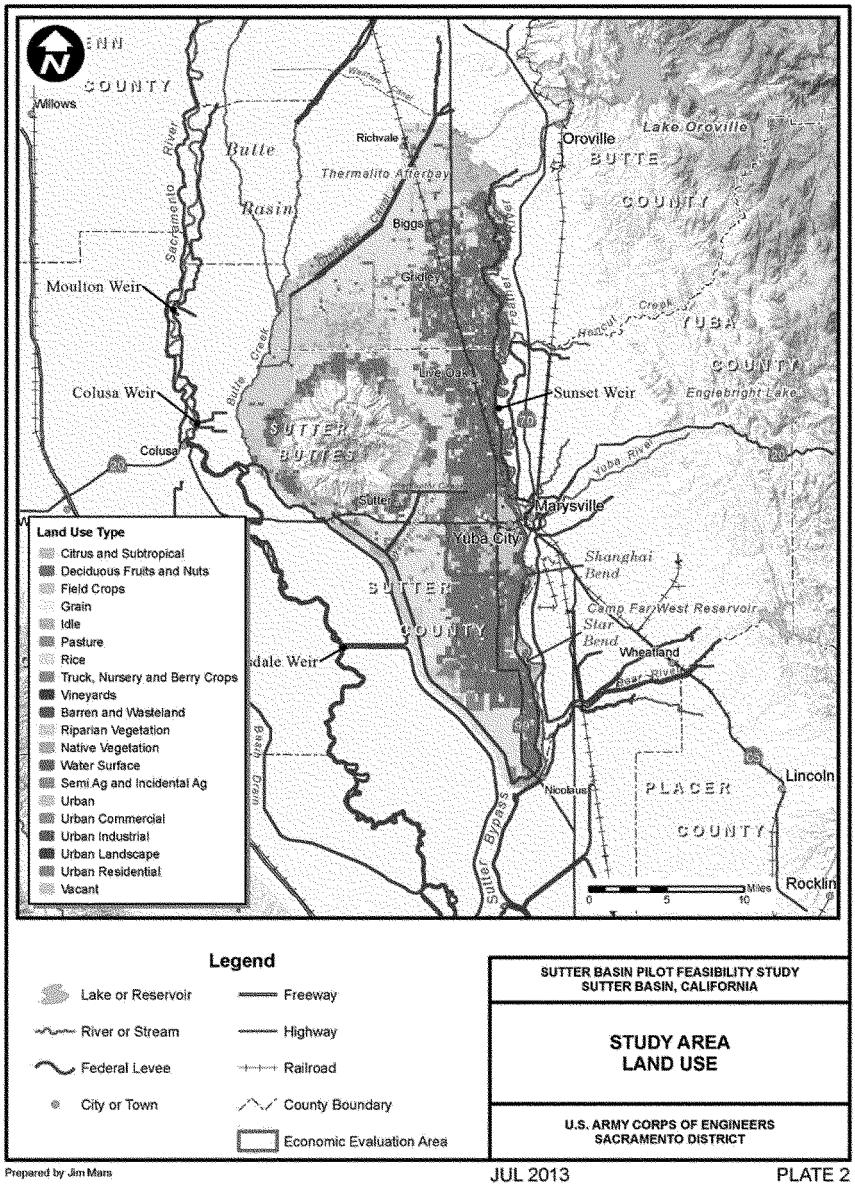
- Geotechnical Levee Reach
- Breach_Locations
- Geotechnical Index Point
- Pump Station

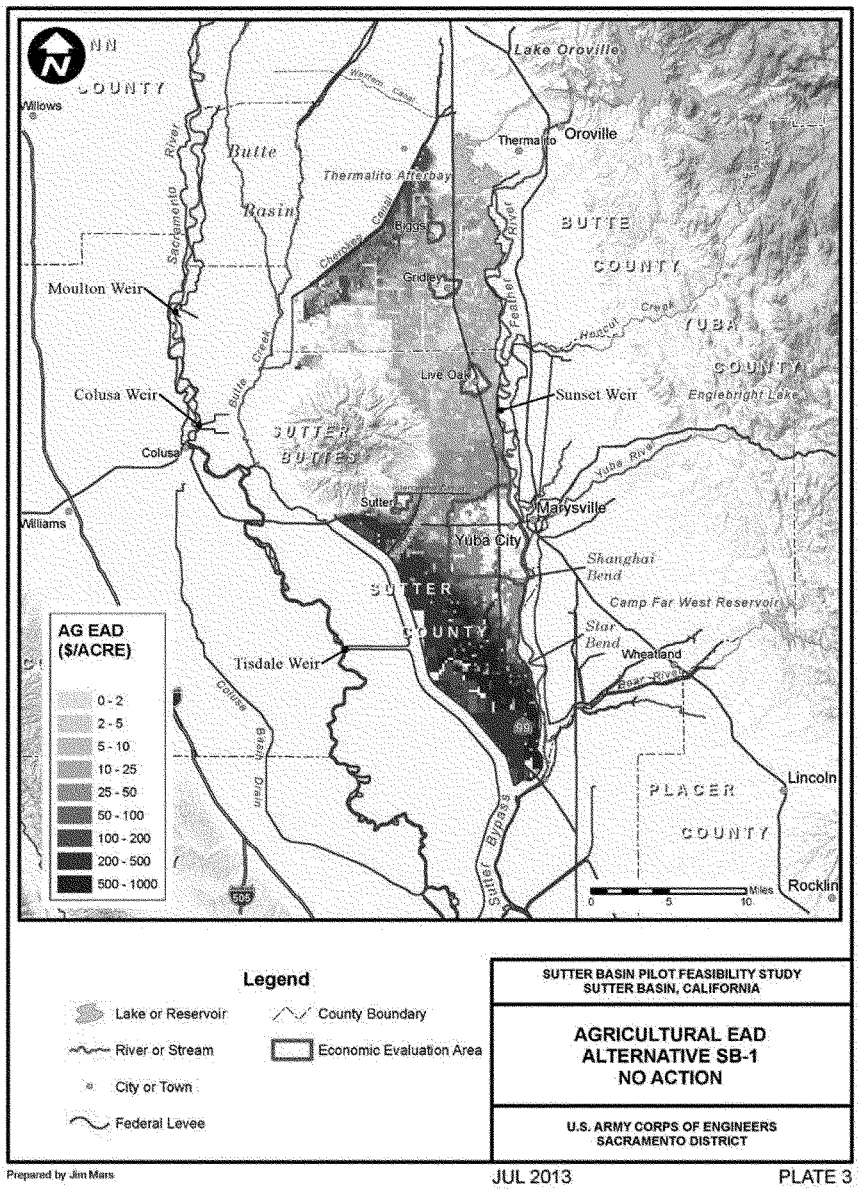
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

ECONOMIC IMPACT AREAS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars JUL 2013 PLATE 1


COUNTY
Willows
Richvale
Butte
Basin
Thermalito Afterbay
Oroville
Lake Oroville
BUTTE
COUNTY
Biggs
Gridley
Moulton Weir
Colusa Weir
Colusa
Live Oak
Sunset Weir
Feather River
Sacramento River
Butte Creek
Yuba River
Yuba City
Marysville
Shanghai Bend
Camp Far West Reservoir
Star Bend
Wheatland
Bear River
Nicolaus
Sutter Bypass
Lincoln
PLACER
COUNTY
Rocklin
Miles
0
5
10
Land Use Type
Citrus and Subtropical
Deciduous Fruits and Nuts
Field Crops
Grain
Idle
Pasture
Rice
Truck, Nursery and Berry Crops
Vineyards
Barren and Wasteland
Riparian Vegetation
Native Vegetation
Water Surface
Semi Ag and Incidental Ag
Urban
Urban Commercial
Urban Industrial
Urban Landscape
Urban Residential
Vacant
Legend
Lake or Reservoir
River or Stream
Federal Levee
City or Town
Freeway
Highway
Railroad
County Boundary
Economic Evaluation Area
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
STUDY AREA
LAND USE
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
Prepared by Jim Mars
JUL 2013
PLATE 2


Lake Oroville
Oroville
Thermalito
Thermalito Afterbay
Butte
Basin
Biggs
Gridley
BUTTE
COUNTY
YUBA
COUNTY
Englebright Lake
Live Oak
Sunset Weir
Moulton Weir
Colusa Weir
Colusa
Williams
Willows
SUTTER
BUTTES
Sutter
Marysville
Yuba City
Yuba River
Shanghai Bend
Camp Far West Reservoir
Star Bend
Wheatland
Bear River
SUTTER
COUNTY
Tisdale Weir
Colusa Basin Drain
Sutter Bypass
PLACER
COUNTY
Lincoln
Rocklin
Miles
0
5
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AG EAD ($/ACRE)
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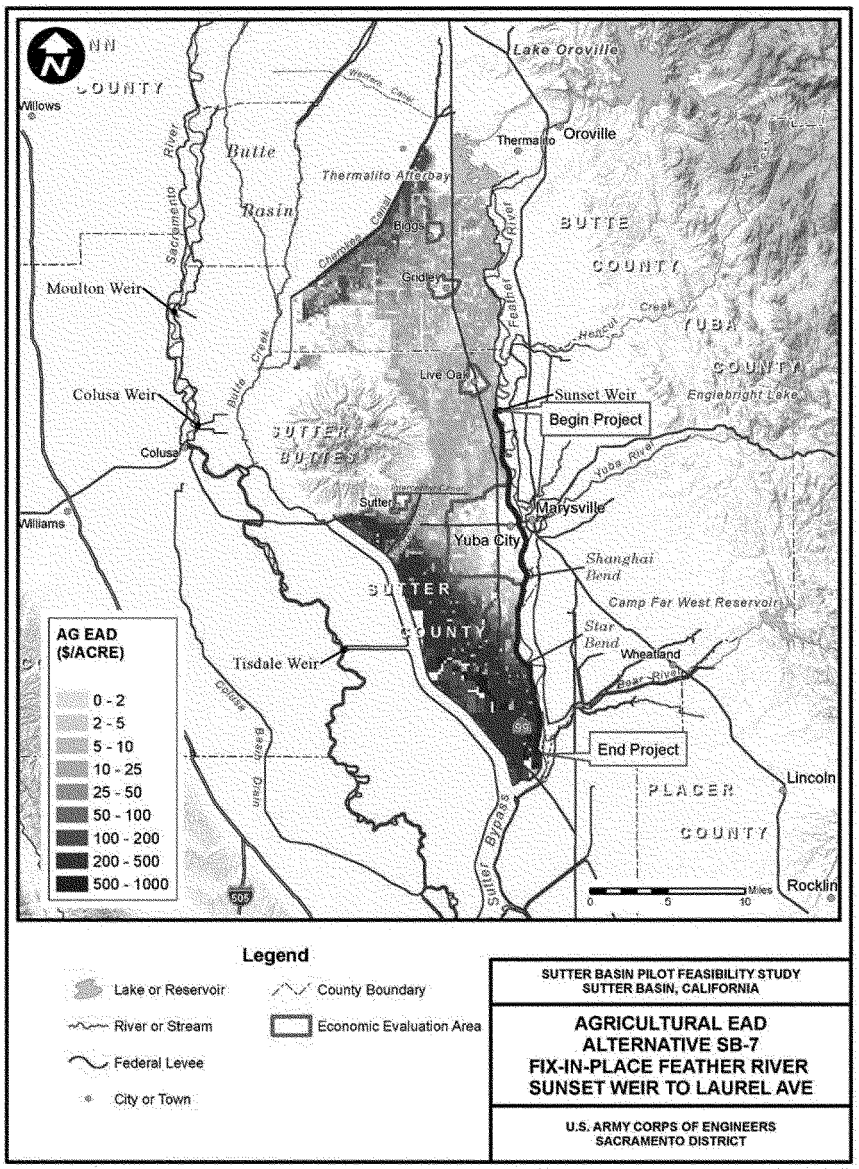
2 - 5
5 - 10
10 - 25
25 - 50
50 - 100
100 - 200
200 - 500
500 - 1000
Legend
Lake or Reservoir
River or Stream
City or Town
Federal Levee
County Boundary
Economic Evaluation Area
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
AGRICULTURAL EAD
ALTERNATIVE SB-1
NO ACTION
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
Prepared by Jim Mars
JUL 2013
PLATE 3


Lake Oroville
Willows
Butte Basin
Thermalito Afterbay
Thermalito
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Biggs
Gridley
BUTTE COUNTY
Moulton Weir
Colusa Weir
Colusa
Live Oak
Sunset Weir
Begin Project
Engiebright Lake
YUBA COUNTY
SUTTER BUTTES
Sutter
Marysville
Yuba City
Williams
Shanghai Bend
Camp Far West Reservoir
SUTTER COUNTY
Star Bend
Wheatland
Tisdale Weir
End Project
Lincoln
PLACER COUNTY
Rocklin
AG EAD ($/ACRE)
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200 - 500
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Miles
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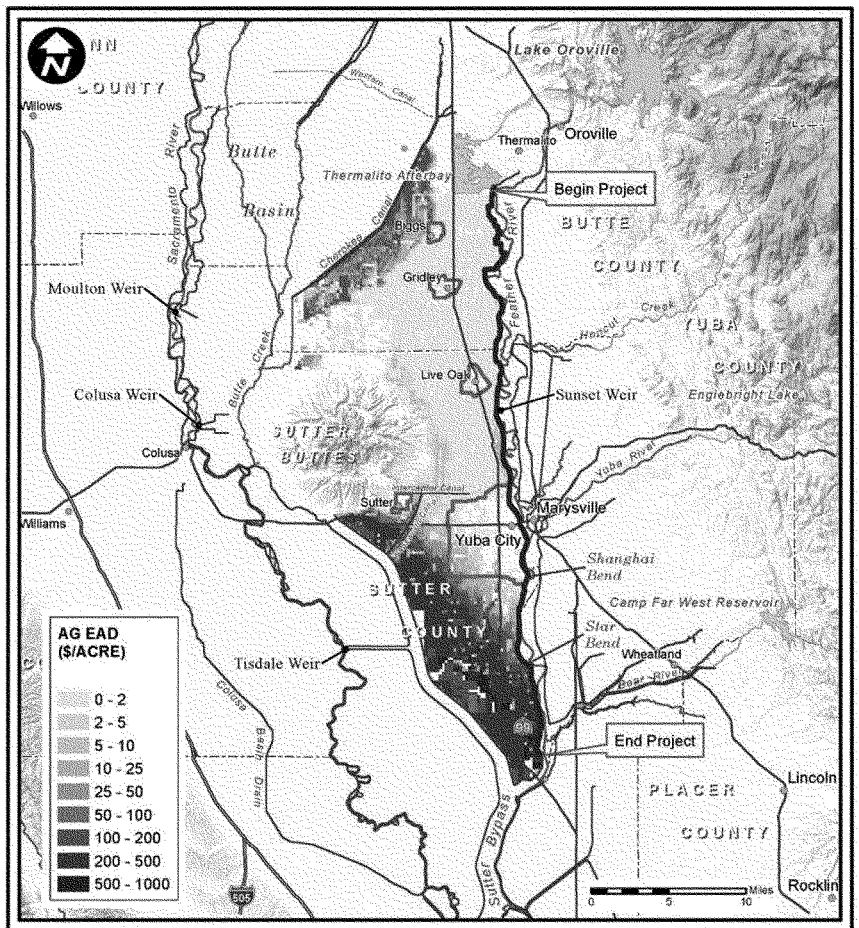
Legend
Lake or Reservoir
River or Stream
Federal Levee
City or Town
County Boundary
Economic Evaluation Area
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
AGRICULTURAL EAD
ALTERNATIVE SB-7
FIX-IN-PLACE FEATHER RIVER
SUNSET WEIR TO LAUREL AVE
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
Prepared by Jim Mars
JUL 2013
PLATE 4


Lake Oroville
Willows
Thermalito
Oroville
Begin Project
Butte
Basin
Thermalito Afterbay
Biggs
Gridley
BUTTE
COUNTY
Moulton Weir
Sacramento River
Butte Creek
Feather River
Honcut Creek
YUBA
COUNTY
Live Oak
Colusa Weir
Sunset Weir
Englebright Lake
SUTTER
BUTTES
Colusa
Yuba River
Sutter
Marysville
Williams
Yuba City
Shanghai Bend
SUTTER
COUNTY
Camp Far West Reservoir
Star Bend
Wheatland
Bear River
Tisdale Weir
Colusa Basin Drain
End Project
Lincoln
PLACER
COUNTY
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Rocklin
AG EAD ($/ACRE)
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Miles
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Legend
Lake or Reservoir
County Boundary
River or Stream
Alternative SB-8
Federal Levee
Economic Evaluation Area
City or Town
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
AGRICULTURAL EAD
ALTERNATIVE SB-8
FIX IN PLACE FEATHER RIVER
THERMALITO TO LAUREL AVE
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
Prepared by Jim Mars
JUL 2013
PLATE 5

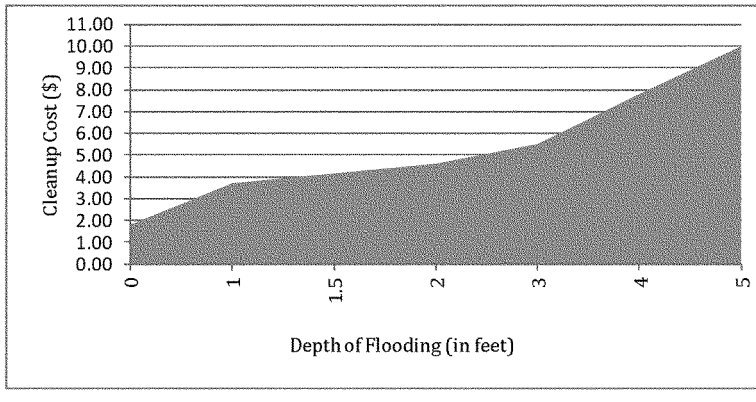
Attachment 3: Cleanup and Emergency Costs

OTHER FLOOD DAMAGE CATEGORIES LINKED TO STRUCTURE DAMAGES

Depreciated structure and structure content damages measure the cost of replacing damaged portions of structures and structure contents with those of similar use and condition. It does not, however, fully account for all the various costs incurred following a damaging flood event. In this report, four additional categories of damages directly related to structure and structure content damages were considered: cleanup costs, temporary housing and relocation assistance costs and other emergency costs. In the sub-sections below, these damage categories are explained and justified as legitimate flood damage reduction benefit categories. Following these explanations, the without-project damages associated with all four categories are summarized

CLEANUP COSTS

Floodwaters leave debris, sediment, salts and the dangers of diseases and mycotoxins throughout flooded structures. The cleaning of these structures is a necessary post-flood activity. Clean-up costs for the extraction of floodwaters, dry-out, and decontamination vary significantly based upon various factors, including depth of flooding. Based upon research and analysis conducted by both Sacramento and New Orleans Districts, a maximum value of ten dollars per square foot was assumed for such costs. This maximum per square foot cost includes the clean-up costs associated with mold and mildew abatement, including costs of paid to professional firms to apply fans, chemicals, etc., to eliminate any mold and prevent mold in inundated areas. This maximum cost was applied for flood depths equal to and exceeding five feet, with damage percentages scaled down for depths between zero and five feet. The figure below displays per square foot cleanup costs as a function of flood depths.



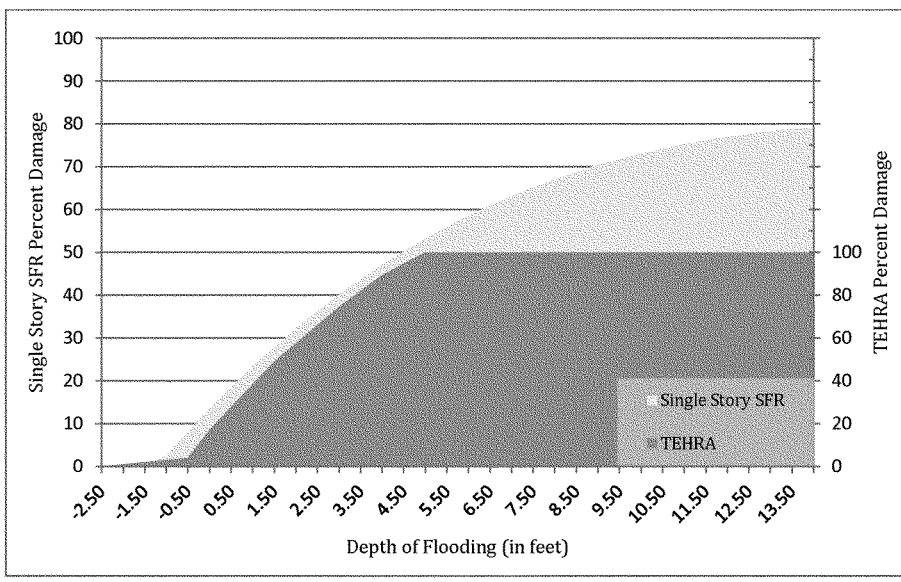
TEMPORARY EVACUATION, RELOCATION AND HOUSING ASSISTANCE COSTS

ER 1105-2-100 states, "Flood damages are classified as physical damages or losses, income losses, and emergency costs." The ER then defines emergency costs as "those expenses resulting from a flood what

would not otherwise be incurred…" The ER further requires that emergency costs should not be estimated by applying an arbitrary percentage to the physical damage estimates.

The Federal Emergency Management Agency (FEMA) provides grants to assist individuals and families to find suitable housing when they are displaced in cases of federally declared disasters. The program assures that people have a safe place to live until their homes can be repaired. This assistance is directly attributable to the disaster, since it is an expenditure that is only undertaken when a disaster occurs. Therefore, it falls under the emergency cost guidance of ER 1105-2-100, and the funds expended by FEMA for temporary evacuation, relocation and housing assistance (TERHA) in the event of flooding are a legitimate NED account flood damage reduction category.

Costs estimates for the relocation and emergency services provided to floodplain residents displaced during peak flood events and post-flood structural renovations were based on FEMA's methodology for evaluating TEHRA costs. This methodology relates TEHRA costs to relocation costs, structure damage percentages and the number of days residents spend displaced from their structures. The maximum TEHRA costs of $9,960 correspond with one year of FEMA evacuation, relocation and/or housing assistance costs. These costs are based on the median price for a two bedroom apartment within the City of Yuba City, posted on the rent.com website. It is applied whenever a structure sustains at least 50 percent damage, with a scaled down cost being computed for less damaging flood events. The figure below shows percent of maximum TEHRA damages as a function of the depth of flooding. This depth-damage relationship for single story single family residences (SFR) is also shown as a point of reference.



OTHER EMERGENCY COSTS

Other emergency costs, in addition to TEHRA costs, incurred in the event of a flood are included in this report's analysis. These additional emergency cost categories account for cash-based assistance disaster survivors receive to pay for uninsured medical care, funeral expenses and living expenses; and public assistance received by local governments and non-profit institutions to repair critical public infrastructure. Both of these assistance programs are administered by FEMA. Special care was taken to ensure temporary evacuation, relocation and housing assistance costs described above were explicitly excluded from this damage category.

A basic methodology for the calculation of other emergency costs was presented in the Centralia Flood Damage Reduction Project - Chehalis River, Washington, General Reevaluation Study. The Chief's Report for the Centralia Flood Damage Reduction Project - Chehalis River, Washington, General Reevaluation Study includes two relevant benefit categories: temporary rental assistance and public assistance. In the Chehalis River study, these benefit categories are based on FEMA disaster report data published between 1997 and 1999. Since 1999, many flooding events have occurred and FEMA damage reports are available.

Several changes have occurred since data was compiled for the Chehalis River study. Foremost, the benefit category of temporary rental assistance underwent a program change. When data was compiled for the Chehalis study, temporary rental assistance was a separate program line item. It has since been rolled into another program, under the name of housing assistance. Since the new housing assistance program can include temporary evacuation, relocation and housing assistance costs, included in the TEHRA section above, special care was taken to explicitly exclude these costs from this analysis. The portion of the new housing assistance program that was included under this flood damage reduction category is referred to as the other needs assistance program. This program provides assistance to applicants who have disaster-related necessary expenses and serious needs not covered by insurance. These needs may include medical, dental and funeral expenses, as well as transportation and other emergency expenses. Seventy five-percent of this aid is contributed by FEMA; the remaining 25 percent is contributed by the state.

The public assistance program, included under this flood damage reduction category, provides supplemental Federal disaster grant assistance for the repair, replacement or restoration of disaster-damaged publicly owned facilities, as well as the facilities of some private non-profit organizations. The Federal share of assistance is not less than 75 percent of the eligible cost for emergency measures and permanent restoration. The state determines how the non-Federal share, of up to 25 percent is split between the applicants.

To be eligible, the work must be required as the result of the disaster, be located within the designated disaster area and be the legal responsibility of an eligible applicant. Work that is eligible for supplemental Federal disaster grant assistance is classified as either emergency work or permanent work.

(1) Emergency Work: Debris removal from public roads and rights-of-way, as well as from private property when determined to be in the public interest, and emergency protective measures performed to eliminate or reduce immediate threats to the public, including search and rescue, warning of hazards and demolition of unsafe structures.

(2) Permanent Work: Work to restore an eligible damaged facility to its pre-disaster design; this work can range from minor repairs to total replacement. Categories of permanent work may include:

a. Repairs to roads, bridges and associated features, such as shoulders, ditches, culverts, lighting and signs
b. Repairs to water control facilities including drainage channels, pumping facilities, and the emergency repair of levees
c. Repairs to utility distribution systems, such as water treatment and delivery systems; power generation facilities and distribution lines; and sewage collection and treatment facilities
d. Repairs to public parks, recreational facilities and other facilities, including playgrounds, swimming pools and cemeteries

The evaluation of other needs assistance and public assistance is based on the disaster reports contained in the archive at FEMA's web site. Unfortunately for this evaluation, FEMA does not have available either a final summary of expenditures by disaster or an annual expenditure report by disaster for analysis. Instead, interim reports by disaster are the only available data sources. To minimize the influences of factors other than flooding, the current analysis excludes from its database: hurricanes, tropical storms, flooding events associated with tornadoes and other non-flood events.

The cost per temporary relocation assistance claim ($1,537) in the Chehalis River study was based on 13 disasters. An updated database of 132 disaster housing grants was obtained for this report. The average dollar amount per application for housing assistance in this sample was $1,550, the median was $1,479 and the standard deviation of the sample is $717. Other needs expenditures average $825 per housing assistance claim, with a standard deviation of $651 and minimum and maximum of $0 and $3,702, respectively.

Public assistance benefits in the Chehalis study were based upon the ratio of public assistance expenditures to disaster housing grants (temporary relocation assistance expenditures). In the Chehalis study, this ratio was based on total expenditures during public assistance and/or disaster housing grant claims, not individual or comparable events. This methodology may have been selected because only six disasters in the Chehalis sample had data for both expenditures. The current database contains 60 events having data for both housing assistance and public assistance claims. The larger sample size permitted the use of a more representative public-to-housing assistance ratio, based on the sample of 60 comparable events. Based on a ratio of 2.83, it was estimated that public assistance grants average $4,387 on a per household basis, following flood events. Therefore, the total other emergency costs of $5,212 estimated on a per household basis, is the sum of this amount and the average other needs assistance claim reported above.

The table below summarizes the without-project damages estimates for the four damage categories discussed above. Since all of these categories are directly linked to the floodplain structure damages, structure and structure content damages are also restated. The table shows that total without-project damages in the cleanup, TEHRA, Other Needs Assistance and Public Assistance.

Annual Damages for Without Project					
Data in $1,000					
EIA	Clean-up Costs	TEHRA	Other Need Assistance	Public Assistance	**TOTAL**
Yuba City	$7,440	$3,622	$409	$2,168	**$13,639**
Biggs	$105	$83	$10	$54	**$252**
Gridley	$254	$143	$19	$104	**$520**
Live Oak	$308	$218	$33	$175	**$734**
Rural Butte	$152	$102	$15	$82	**$351**
Rural Sutter	$4,231	$1,871	$204	$1,078	**$7,384**
TOTAL	**$12,490**	**$6,039**	**$690**	**$3,661**	**$22,880**

For the proposed projects of SB-7 and SB-8, the following tables provide the residual damages and total annual benefits for each of the four damage categories: clean-up costs, TEHRA, Other Need Assistance, and Public Assistance.

Annual Residual Damages and Annual Benefits for Alt SB-7					
Data in $1,000					
	Clean-up Costs	TEHRA	Other Need Assistance	Public Assistance	**TOTAL**
Yuba City	$1,183	$565	$56	$295	**$2,099**
Biggs	$105	$83	$10	$54	**$252**
Gridley	$254	$143	$19	$104	**$520**
Live Oak	$308	$218	$33	$175	**$734**
Rural Butte	$152	$102	$15	$82	**$351**
Rural Sutter	$2,919	$1,268	$145	$766	**$5,098**
TOTAL	**$4,921**	**$2,379**	**$278**	**$1,476**	**$9,054**
Total Annual Benefits	**$7,569**	**$3,660**	**$412**	**$2,185**	**$13,826**

Annual Residual Damages and Annual Benefits for Alt SB-8					
Data in $1,000					
	Clean-up Costs	TEHRA	Other Need Assistance	Public Assistance	**TOTAL**
Yuba City	$1,183	$565	$56	$295	**$2,099**
Biggs	$37	$26	$3	$17	**$83**
Gridley	$47	$28	$4	$20	**$99**
Live Oak	$60	$40	$4	$23	**$127**
Rural Butte	$30	$19	$3	$14	**$66**
Rural Sutter	$2,919	$1,268	$145	$766	**$5,098**
TOTAL	**$4,202**	**$1,914**	**$210**	**$1,116**	**$7,442**
Total Annual Benefits	**$8,288**	**$4,125**	**$480**	**$2,545**	**$15,438**

Attachment 4: Population Growth and Executive Order 11988

Evaluation of Developable Acreage

Prepared by: SBFCA & USACE

INTRODUCTION

The US Army Corps of Engineers (USACE) is currently evaluating several alternatives to provide improved flood protection in the Yuba City Basin of Sutter and Butte Counties. The USACE has identified a set of criteria to use in evaluation of alternatives for the purpose of identifying a Recommended Plan. One of the criteria is "wise use of the floodplain", measured as the potentially developable acreage in the basin under each alternative, where existence of a floodplain is the only barrier to development (Table 1). Under the no-action alternative, the USACE quantifies the developable acreage at approximately 71,800 acres – most of which is located in the vicinity of Yuba City and in the northern portions of the basin, and is subject to shallow (less than 3-feet) flooding in a levee break, with the assumption that development could proceed by elevating structures. Under the action alternatives, more of the basin is protected, and therefore the USACE estimate of developable acreage increases. This is judged to be a negative consequence of providing flood protection under Federal policy (Executive Order 11988).

Development is limited by factors other than just floodplain restrictions, including local land use policies and ordinances, economic and market factors. Proof of success of these forces at controlling growth is in observation of past growth. The cities of Biggs, Gridley, Live Oak, and Yuba City have not historically been mapped within the FEMA 100-year floodplain, and are not currently mapped within the 100-year floodplain. Despite the lack of floodplain development restrictions, development in Biggs, Gridley, Live Oak, and Yuba City has been modest. It is SBFCA's contention, therefore, that past growth trends illustrate the fact that development in the basin is effectively controlled by existing policies, ordinances, economic and market and factors, thereby minimizing the "wise use of floodplain" differences between action alternatives. In short, implementation of flood control improvements will not change any of the drivers responsible for growth in the basin.

The purpose of this Technical Memorandum (TM) is to illustrate that flood control improvements will not change the fundamental drivers of urban growth by evaluating historical and future growth data, summarizing current growth inhibitors, lack of market/economic drivers, and development restrictions in place at the local, state, and federal level, which will continue to control and limit urbanized development, even with the implementation of these improvements. Furthermore, this TM will illustrate that growth in the basin over the next 60 years is projected to be less than the developable acreage under the no-action alternative.

PROJECT ALTERNATIVES

The Sutter Basin Pilot Feasibility Study identified two primary action alternatives, plus the no-action alternative, and estimated the acreage of developable land for each alternative (Table 1). The "wise use of the floodplain" is a criteria used by the USACE which estimates the potentially developable acreage in the basin under each alternative, defined as the total area not subject to flooding depths greater than 3-feet in a 100-year flood, excluding State protected lands.

Table 1 - Sutter Basin Pilot Feasibility Study Developable Acreage

	SB-1 (No-Action)	SB-7 (NED)	SB-8 (Recommended Plan)
Developable Area (Acres)	71,832 acres	88,200 acres	100,200 acres

The acreage in Table 1 is simply the estimate of acreage in the basin not subject to flooding depths greater than 3-feet in a 100-year flood (excluding State protected lands). These values do not consider market demand, land use restrictions, or other encumbrances which govern growth in the basin. An assessment of future growth in the basin needs to be performed to see if demand exists for this developable acreage.

GROWTH PROJECTIONS

In order to put future growth projections into perspective, the growth in the basin over the past 50 years was assessed. Table 2 below presents the population and respective historical growth rates for the cities in the basin in 1960 and 2010. These were also compared to the growth rates of Sutter & Butte County, and the State of California at the request of USACE.

Table 2 – Historical Growth Rates

Jurisdiction	1960 Population[1]	2010 Population[2]	Avg. Annual Growth Rate
Yuba City	11,507	64,925	3.52%
Live Oak	2,276	8,392	2.64%
Biggs	831	1,707	1.45%
Gridley	3,343	6,584	1.36%
Sutter County	33,380	94,737	2.11%
Butte County	82,030	220,000	1.99%
State of California	15,717,204	37,253,956	1.74%

1 – According to the California Department of Finance
2 – According to the 2010 Census

The table above illustrates that growth in the basin has historically been modest, with Yuba City being the fastest growing area. The increased growth rate of Yuba City is largely attributed to its proximity to Sacramento, since residents can live and commute to the metro area. Growth rates have been slower in Biggs and Gridley primarly due to lack of economic drivers in and around these small agricultural communities. Growth in the basin has occurred relatively free from floodplain-related development restrictions. Urban development and growth was centered around the largest urban area in the basin – Yuba City – while the rural towns maintained slower growth rates, consistent with the General Plans for these areas.

Sources for future population estimates range from the General Plans for Sutter and Butte County, the California Department of Finance (CDOF), and the Sacramento Area Council of Governments (SACOG). A summary comparing the various population growth projections in included in Table 3.

Table 3 – Comparison of Future (Year 2030) Projected Growth Rates									
	General Plan/CDOF			BCAG			SACOG		
Jurisdiction	**Low**	**Med**	**High**	**Low**	**Med**	**High**	**Low**	**Med**	**High**
Yuba City	-	2.5%	-	-	-	-	-	2.5%	-
Live Oak	-	2.6%*	-	-	-	-	-	-	-
Biggs	3.3%	3.7%	4.1%	3.3%	3.7%	4.1%	-	5.2%	-
Gridley	-	5.1%	-	3.2%	3.5%	3.9%	-	3.5%	-
Sutter County	-	2.6%*	-	-	-	-	-	1.7%	-
Butte County	0.9%*	1.6%	-	1.4%	1.6%	1.8%	-	1.1%	-
State of California	-	0.7%*	-	-	-	-	-	-	-

*References CDOF Estimates (Year 2060 Horizon)

The projected growth rates are assumed to be accurate beyond 2030 for purposes of estimating the populations in these jurisdictions in 2070. These projections are estimates only, and are subject to change over time.

The table above is presented in order to compare population projections from various sources. For purposes of this TM, the SACOG projections are used in order to address comments received on the Draft report. It should be noted SACOG growth estimates for Biggs and Gridely are projected by SACOG to be significantly higher than historic growth rates. Even though SBFCA contends these growth rates are overstated, these values will be used to estimate the maximum demand for new developable acreage in the basin.

The growth rates referenced by SACOG and the CDOF use a baseline cohort-component method to project population by age, gender, and race/ethnicity. The method uses seven mutually exclusive race/ethnic groups and assumes people have the right to migrate where they choose and no major natural catastrophes or war will befall the state or the nation. The cohort-component method traces people born in a given year through their lives. As each year passes, cohorts change due to the mortality and migration assumptions. Applying the fertility assumptions to the women of childbearing age forms new cohorts.

A comparison of the 2070 population estimates for each jurisdiction noted above is presented in Table 4 below.

Table 4 – Projected Population (Year 2070)		
	SACOG	
Jurisdiction	**Med Growth Rate**	**Est. Population**
Yuba City	2.5%	285,656
Live Oak	2.6%*	39,148
Biggs	5.2%	35,742
Gridley	3.5%	51,869
Sutter County	1.7%	260,482
Butte County	1.1%	424,123

*City of Live Oak Growth Rate used since SACOG estimate was not available for Live Oak

The population figures presented above do not relate directly to demand for developable acreage. In order to compare the USACE's estimate of Developable Area in Table 1 to the demand for developable land necessary to accommodate the projected population presented in Table 4, the Medium Population Growth rates were applied to existing developed acreage in each jurisdiction. The projected urban development within each City's Sphere of Influence (SOI) as shown in each General Plan is shown in the Tables 5 & 6.

Table 5 - Projected Sutter County Developed Area			
Sutter County Growth Areas[1]	**Existing Developed Acreage[2]**	**Projected New Urban Acreage from 2010-2030[3]**	**Projected New Urban Acreage from 2010-2070[4]**
Yuba City SOI & Employment Corridor	8,965	12,019	30,479
Live Oak SOI	1,165	6,511	11,667[5]
Other (Sutter & Tudor)	2,037	2,939	7,465
Subtotal Sutter County	**12,167**	**21,469**	**49,611**

1 – As indicated in the Sutter County General Plan Draft EIR
2 – Acreage within the City limits are assumed to be fully developed
3 – As indicated in the Sutter County General Plan Draft EIR. Does not subtract out existing development in the SOI
4 – Assumes population projected growth rate of 2.6% also applies to urbanized development
5 – Growth rate of 2.6% applied to new acreage in 2030 (6,511 acres)

Table 6 - Projected Butte County Developed Area			
Butte County Growth Areas	**Existing Developed Acreage**	**Projected New Urban Acreage from 2010-2030[3]**	**Projected New Urban Acreage from 2010-2070[4]**
Biggs SOI	414[2]	541[2]	8,524
Gridley SOI	1,300[3]	2,900[3]	8,941
Subtotal Butte County	**5,155**	**3,441**	**17,465**
Total for Sutter & Butte County	**17,322**	**24,910**	**67,076**

1 – Does not subtract out existing development in the SOI
2 – As indicated in the City of Biggs General Plan
3 – Acreage values not included – gross acreage scaled off map in Gridley General Plan
4 – Assumes projected growth rate of 5.2% and 3.5% for Biggs and Gridley, respectively, also applies to urbanized development

The data presented in Tables 5 & 6 indicates that only about 67,000 new acres are projected to be developed by 2070 within the basin, assuming SACOG projected growth rates are maintained beyond 2030. Furthermore, Yuba City accounts for about half of the demand for developable acreage (approx. 30,000 acres). This estimated projected new urban acreage is far less than the Developable Area under the No Action, SB-7, and SB-8 alternatives. Therefore, this data indicates the estimated demand by 2070 for approximately 60,000 acres of developable land – far less than the 71,800 acres projected to be available in the basin under the no-action alternative.

Furthermore, it is worthy to note that the Developable Acreage shown in Table 1 is primary located in the northern basin where current flooding depths are relatively shallow. Land located in the deep floodplain in the southern portion of the basin is not removed from the floodplain under either alternative, and is therefore not included in the acreage estimates noted in Table 1.

ECONOMIC AND MARKET DRIVERS

Development does not occur in the absence of demand. Land use in the basin is primarily dominated by agricultural uses. This type of land use does not support rapid, urbanized growth. Furthermore, the necessary public infrastructure (i.e. roadways, water/sewer systems, utilities, etc) do not exist, and would require a substantial investment from the State, County, and development community. This type of investment is not and likely will not be warranted due to the lack of demand from consumers to develop land outside the Yuba City.

The projected growth rates from CDOF and BCAG are reasonable based on historical growth data in the basin, and are further supported by forward-looking statements in each County's General Plan:

Sutter County's General Plan states "A majority of the County has historically been set aside for agriculture and other resource uses, with rural development focused within the County's unincorporated communities. Urban growth has largely been directed to the incorporated cities, Yuba City and Live Oak. The 2030 General

Plan supports a broad continuation of the current land use pattern, while affording new opportunities for growth and change. It balances the County's vision to maintain and enhance its high quality rural lifestyle, agricultural heritage, and natural resources, with a commitment to promoting a vibrant and sustainable economy that attracts diverse jobs and services. It does so by advocating managed growth that is comprehensively planned, efficient, and compatible with adjacent uses and valued resources".

Similarly, Butte County's vision statement in the General Plan indicates that "Agriculture and open space will continue to dominate Butte County's landscape and be an important part of the County's culture and economy."

As further discussed below, the visions in these General Plans provide the long-term vision to maintain the rural character of both Sutter and Butte Counties. These General Plans dictate where and what type of land uses are permitted; deviating from the General Plans involves a lengthy process, which would have to be funded by a developer.

DEVELOPMENT RESTRICTIONS

Various development restrictions are in place at the local, state, and federal levels as summarized below (Source: "Summary of Discretionary Approvals Requisite for Development in California" prepared by Downey Brand for SBFCA)

Local-Level Development Restrictions

State law requires that every city adopt a "general plan" that incorporates a long term framework for the physical development of the city itself, and any outlying land that is necessarily related to the city's land use planning. (Cal. Gov't Code § 65300.) While a city may add optional elements, each general plan must include seven mandatory elements; land use, circulation, housing, conservation, open space, noise, and safety. (Cal. Gov't Code § 65302.)

The general plan is considered the "constitution for all future development." (Lesher Communications, Inc. v. City of Walnut Creek, 52 Cal.3d 531, 540 (1990).) Furthermore, zoning ordinances are used to establish land uses included in a General Plan. Therefore, no development may occur within a given California city unless such development is consistent with the zoning and land use elements codified in a valid general plan. In the case where approving a land use decision would require amending the general plan, the city must follow a complicated procedure involving comment by numerous agencies and public hearings before the planning commission and city council. (Cal. Gov't Code § 65350 et seq.)

California's State Zoning Law gives all general law cities and counties the authority to divide land within a given entity's jurisdiction into use districts. (Cal. Gov't Code § 65800 et seq.) In addition, zoning laws allow a city or county to regulate the size and shape of physical structures. (See O'Loane v. O'Rourke, 231 Cal.App.2d 774, 780 (1965).) Zoning ordinances typically classify use districts into four different types: residential; commercial; industrial; and agricultural. Within each use category, the city may impose a different set of restrictions to regulate both the use to which a landowner may dedicate property and the size and placement of physical structures on the property. (See O'Loane, 231 Cal.App.2d at 780.) City and county zoning ordinances receive an extreme degree of deference from the courts, as they need only be "reasonably related" to the promotion of the public welfare. (See City of Del Mar v. City of San Diego, 133 Cal.App.3d 401, 409 (1982).)

Federal-Level Development Restrictions

Cities and counties participating in the National Flood Insurance Program (NFIP) must conform to Federal Emergency Management Agency regulations regarding approval of development and/or the type of development that may occur. These regulations have severe growth limiting measures for areas that are mapped in the 100-year floodplain. FEMA also incentivizes cities and counties (through reduced NFIP insurance rates) to limit or regulate development in the floodplain. Virtually all cities and counties in the State participate in the NFIP.

OTHER DEVELOPMENT RESTRICTIONS

WILLIAMSON ACT CONTRACTS

Sutter and Butte County participate in the Williamson Act agricultural land preservation program. The Williamson Act aims to preserve agricultural and open space lands by discouraging premature and unnecessary conversion to urban uses. In exchange for agreeing to maintain Williamson Act compatible land uses, landowners receive the benefit of reduced property tax rates from the County. Williamson Act contracts are voluntarily established between a landowner and the County and are automatically renewed every ten years, unless a notice of non-renewal is filed by the landowner.

A Williamson Act contract influences a landowner's ability to use, subdivide or separately sell any parcel of land under an existing contract. Compatible uses under the Williamson Act generally consist of agricultural (i.e. farming, ranching, grazing, timber) and related uses such as processing facilities. One single-family home and agricultural housing is also allowed under the Williamson Act. Subdividing, selling, or using property in a manner not compatible with the Williamson Act can have serious consequences.

There are three ways a landowner can terminate a Williamson Act contract: non-renewal, cancellation, and breach of contract.

Non-renewal is the preferred method of terminating a contract. On each anniversary date of a Williamson Act contract, the original ten year term of the contract is automatically renewed unless notice is given by the landowner. When notice is provided on or before September 30th, the contract shall expire nine years from December 31st of the year that notice was provided. Upon notice of non-renewal, tax rates are incrementally increased over the nine year period up to the fair market valuation assessment. While the tax rate changes during this period, the land use restriction maintain in effect until the contract expires.

A landowner may also terminate a contract by petitioning the County for immediate cancellation of a contract for all or a portion of the property. These requests are only granted under extraordinary circumstances and must be consistent with Williamson Act principles, or be shown to have significant public benefit. To invoke this method of contract termination, the local government is required to make specific statutory findings that the termination is consistent with the Williamson Act requirements and/or that the cancellation has significant public benefit. A cancellation penalty equal to 12 ½% of the unrestricted fair market value is assessed to the landowner if the petition is granted.

If property subject to the Williamson Act is developed, divided, or sold, it could be considered a material breach of the contract. This could result in contract non-renewal and related increase in the property tax rate. Additionally, a material breach of contract can result in a monetary penalty up to 25% of the unrestricted fair market value of the land, plus 25% of the value of any incompatible building and related improvements on the contracted land.

The local government may allow a lesser monetary penalty to be negotiated. Negotiating a lesser penalty involves the local government, the department and the landowner and could result in the monetary penalty being reduced to no less than 12½ percent of the unrestricted fair market value of the land and related improvements. The monetary penalty assessed is secured by a lien payable to the county treasurer. Simple interest of 10 percent per year will be assessed against any unpaid penalty after 60 days. Upon full payment of the lien, the local government will record a termination of contract by breach for the affected portion of land.

Table 7 – Williamson Act Contracts in Sutter Basin			
	Approx. Number of Parcels under Williamson Act Contracts	**Approx. Acreage under Williamson Act Contracts**	**Approx. Average Annual Tax Benefit ($/ac)***
Butte County	190	16,800	$1,650
Sutter County	80	10,700	$1,650
Total	**270**	**27,500**	

*The average annual tax benefits can vary based on prime/non-prime land, and crop type.

In summary, the Williamson Act is intended to preserve the agricultural and open space resources in rural California. These contracts are typically renewed in ten year increments and offer participating landowners tax breaks on the assessed land value. While the consequences can have monetary impacts, there are several options available for landowners to terminate or non-renew these contracts.

AGRICULTURAL/CONSERVATION EASEMENTS

There are numerous agricultural and conservation easements within the Sutter Basin. These easements differ from the Williamson Act parcels in that the majority of the conservation easements are legal agreements between a landowner and a land trust that conserve agricultural or open space resources by permanently limiting future development. Conservation easements are tailor made to meet the needs of an individual landowner and can cover an entire parcel or portions of a property. Tax benefits and/or financial compensation are often available for grantors of conservation easements.

Conservation easements typically restrict development and subdivision to the degree that is necessary to protect the significant conservation values of that particular property. Some conservation easements include "home sites," or areas known as "exclusions" where development is allowed. Generally, home sites or exclusions are small in size (1-2 acres) and located on areas low in conservation value. Landowners and land trusts work together to draft conservation easements that reflect both the landowner's desires and the need to protect conservation values. The majority of the agricultural & conservation easements in the Sutter Basin are held by US Fish and Wildlife Service or Wetlands America Trust (Ducks Unlimited).

Ag & conservation easements within the Sutter Basin were obtained from numerous sources. The California Department of Conservation (CDC) and the National Conservation Easement Database (NCED) provided GIS shapefiles for known easements within Sutter and Butte County. Sutter County also provided information on conservation easements within the County. Butte County was contacted but does not maintain GIS information on conservation easements within the County. Additionally, information requests were sent to: The Nature Conservancy, the Northern California Regional Land Trust, and Sutter & Butte County Resource Conservation Districts to obtain as much information as possible regarding existing easements in the Sutter Basin.

The conservation easement shapefile provided by Sutter County was compared against the data provided by the CDC and NCED to identify overlapping datasets. In general, the CDC shapefile did not specifically outline easements; rather it illustrated different types of farming in each county. The NCED shapefile had nearly all the same conservation easements as the file provided by Sutter County. The primary difference was that the NCED separated easements by permanent and temporary duration. All but one NCED conservation easement in the Sutter Basin is permanent. Furthermore, the National Conservation Easement Database website notes that their easements are generally permanent preservation easements. According to discussions with the Wildlife Conservation Board, Department of Fish & Game, and US Fish & Wildlife Service, the average fee paid to a landowner for an easement is approximately $1,000 - $2,000/acre, and varies depending on land use, location, and extent of the easement.

Table 8 – Ag/Conservation Easements in Sutter Basin								
	NCED Easements (Permanent)		NCED Easements (Temporary)		NCED Easements (Unknown)		Other Conservation Easements Provided by County (Unknown Duration)	
	No. Parcels	Approx. Acreage	No. Parcels	Approx. Acreage	No. Parcels	Approx. Acreage	No. Parcels	Approx. Acreage
Butte County	13	2900	0	0	0	0	0	0
Sutter County	35	3500	0	0	1	45	21	2500
Total	**48**	**6400**	**0**	**0**	**1**	**45**	**21**	**2500**

As noted above, these easements were generally found to be permanently attached to the specific parcels of land. Therefore, it is unlikely these parcels will be developed in the future, regardless of flood control improvements completed with the Sutter Basin.

CONCLUSION

The project alternatives proposed by the USACE indicate an increase in developable area ranging from approximately 88,000 acres to 100,000 acres. However, population and growth projections, as well as current zoning ordinances and land use practices in Sutter and Butte County's General Plan indicate more restrictive policies which will limit future development to approximately 60,000 acres – significantly less than the 71,800 acres projected to be available under the no-action alternative. This analysis has resulted in two primary conclusions:

1. These policies, combined with federal regulations, will limit the developable land to approximately 60,000 acres by 2070 under all alternatives, not within a range of 88,000 to 100,000 as shown in Table 1.
2. Historical growth and future projects indicate that economic and market drivers will continue to direct growth around existing urban centers (i.e. Yuba City).

Attachment 5: Project Costs and IDC Calculations

Detailed project costs and IDC Calculations for SB-7 (NED) and SB-8 (Recommended Plan) at 3.5% and 7% can be found beginning on the next page.

****TOTAL PROJECT COST SUMMARY****

10/10/2013

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE DRAFT FEASIBILITY REPORT, ALT. SB-7
PROJECT: Sutter Basin TPCS
LOCATION: CALIFORNIA

U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT
P.O.C.: JEREMIAH A. FROST, CHIEF, COST ENGINEERING SECTION

Current MCACES Estimate Prepared: 25-Jul-2013
Effective Price Level (EPL): 1-Oct-2013

WB NO.	Civil Works FEATURE DESCRIPTION	ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	PROGRAM YEAR(BUDGET EC) 2014 EFF. PRICE LEVEL DATE:1-Oct-2013 PROJECT FIRST COST ESC. (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	TOTAL PROJECT COST (FULLY FUNDED) SPENT THRU: 1-Oct-2013 COST ($K)	ESC. MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
	Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.													
		Contingency Applied To Remaining Cost Only												
	FEDERAL COSTS													
6	FISH & WILDLIFE FACILITIES	5,032	1,006	20	6,038	0.00	5,032	1,006	6,038	0	12	5,611	1,122	6,733
11	LEVEES & FLOODWALLS	176,205	63,717	36	239,922	0.00	176,205	63,717	239,922	0	11	196,085	70,906	266,991
18	CULT. RESRC. PRESERV. (1	1,655	598		2,253		1,655	598	2,253	0		1,841	665	2,506
	Data Recovery	1,200	433		1,633	0.00	1,200	433	1,633	0		1,334	482	1,816
	Inventory/Evaluation/Mitigation Costs	455	165	36	620	0.00	455	165	620	0	11	507	183	690
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	182,892	65,321		248,213		182,892	65,321	248,213	0		203,537	72,693	276,230
1	LANDS & DAMAGES, Admin (2	6,952	348	5	7,300	0.00	6,952	348	7,300	0	17	8,168	408	8,576
30	PLAN/ENGINEERING/DESIGN	32,622	11,797	36	44,419	0.00	32,622	11,797	44,419	0	18	38,534	13,934	52,468
31	CONSTRUCTION MANAGE'MT	15,406	5,570	36	20,976	0.00	15,406	5,570	20,976	0	23	18,943	6,849	25,792
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	237,872	83,036		320,908		237,872	83,036	320,908	0		269,182	93,884	363,066
	NON-FEDERAL CONTRIBUTION (-)	-48,533	-17,105		-65,638		-48,533	-17,105	-65,638	0		-56,289	-19,847	-76,136
	TOTAL FEDERAL COSTS	**$189,339**	**$65,931**		**$255,270**		**$189,339**	**$65,931**	**$255,270**	**$0**		**$212,893**	**$74,037**	**$286,930**
	NON-FEDERAL COSTS													
1	LANDS AND DAMAGES	31,811	10,579	33	42,390	0.00	31,811	10,579	42,390	0	8.5	34,523	11,481	46,004
2	RELOCATIONS	20,962	7,580		28,542		20,962	7,580	28,542	0		23,105	8,355	31,460
	Relocations Construction Cost	16,376	5,922	36	22,298	0.00	16,376	5,922	22,298	0	10	18,074	6,536	24,610
	Plan/Engineering/Design	2,948	1,066	36	4,014	0.00	2,948	1,066	4,014	0	8.8	3,209	1,160	4,369
	Construction Mangement	1,638	592	36	2,230	0.00	1,638	592	2,230	0	11	1,822	659	2,481
	SUBTOTAL NON-FEDERAL	52,773	18,159		70,932		52,773	18,159	70,932	0		57,628	19,836	77,464
	NON-FEDERAL CONTRIBUTION (+)	48,533	17,105		65,638		48,533	17,105	65,638	0		56,289	19,847	76,136
	TOTAL NON-FEDERAL COSTS	**$101,306**	**$35,264**		**$136,570**		**$101,306**	**$35,264**	**$136,570**	**$0**		**$113,917**	**$39,683**	**$153,600**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**$290,645**	**$101,195**		**$391,840**		**$290,645**	**$101,195**	**$391,840**	**$0**		**$326,810**	**$113,720**	**$440,530**

GENERAL NOTES

(1 Cultural Resources Preservation costs was provided by Cultural Resources Archaeologist.
(2 Federal administrative costs for non-Federal land acquisition.
(3 The Fully Funded cost estimate was prepared in compliance with Indexes used from CWCCIS reflecting OMB future rates Mar. 31, 2013
(4 01 Account for Land and Damages cost are from Real Estates.
(5 06 Account Fish and Wildlife Cost was provided by SPK Environmental Planning.
(6 30 Account Planning, Engineering and Design and 31 Account Construction Management cost was provided by its respective organizations.

CONTINGENCY RATIONALE

(A CONTINGENCIES USED WAS DERIVED BY THE COST RISK ANALYSIS PROCESS AND IS BASED ON A 80% CONFIDENCE LEVEL

_____ **CHIEF, COST ENGINEERING**

_____ **PROJECT MANAGER**

_____ **CHIEF, REAL ESTATE**

TOTAL FEDERAL COSTS	**$286,930**
TOTAL NON-FEDERAL COSTS	**$153,600**
THE MAXIMUM PROJECT COSTS	**$440,530**

****TOTAL PROJECT COST SUMMARY****

10/10/2013

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE DRAFT FEASIBILITY REPORT, ALT. SB-8
PROJECT: Sutter Basin TPCS
LOCATION: CALIFORNIA

U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT
P.O.C.: JEREMIAH A. FROST, CHIEF, COST ENGINEERING SECTION

Current MCACES Estimate Prepared: 25-Jul-2013
Effective Price Level (EPL): 1-Oct-2013

PROGRAM YEAR(BUDGET EC) 2014
EFF. PRICE LEVEL DATE:1-Oct-2013

TOTAL PROJECT COST (FULLY FUNDED)
SPENT THRU: 1-Oct-2013

WB NO.	Civil Works FEATURE DESCRIPTION		ESTIMATED COST COST ($K)	CNTG CNTG (%)	TOTAL ($K)	ESC. (%)	PROJECT FIRST COST COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	ESC. MIDPT(%)		COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
	Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.														
			Contingency Applied To Remaining Cost Only												
	FEDERAL COSTS														
6	FISH & WILDLIFE FACILITIES		6,330	1,265	20	7,595	0.00	6,330	1,265	7,595	0	14	7,226	1,445	8,671
11	LEVEES & FLOODWALLS		306,367	106,488	35	412,855	0.00	306,367	106,488	412,855	0	13	347,604	120,821	468,425
18	CULT. RESRC. PRESERV. (1		3,030	1,076		4,106		3,030	1,076	4,106			3,399	1,207	4,606
	Federal Obligations from NED Cost.		1,655	598		2,253		1,655	598	2,253			1,841	665	2,506
	Data Recovery		1,200	433		1,633		1,200	433	1,633	0		1,334	482	1,816
	Inventory/Evaluation/Mitigation Costs		455	165		620		455	165	620	0		507	183	690
	Cost Beyond NED Cost		1,375	478		1,853		1,375	478	1,853	0		1,558	542	2,100
	Data Recovery	18	1,000	348	35	1,348	0.00	1,000	348	1,348	0	13	1,134	394	1,528
	Inventory/Evaluation/Mitigation Costs	18	375	130	35	505	0.00	375	130	505	0	13	424	148	572
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		315,727	108,829		424,556		315,727	108,829	424,556	0		358,229	123,473	481,702
1	LANDS & DAMAGES, Admin (2		11,143	557	5	11,700	0.00	11,143	557	11,700	0	22	13,549	677	14,226
30	PLAN/ENGINEERING/DESIGN		56,285	19,565	35	75,850	0.00	56,285	19,565	75,850	0	22	68,804	23,916	92,720
31	CONSTRUCTION MANAGE'MT		26,580	9,239	35	35,819	0.00	26,580	9,239	35,819	0	27	33,791	11,746	45,537
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION		409,735	138,190		547,925		409,735	138,190	547,925	0		474,373	159,812	634,185
	NON-FEDERAL CONTRIBUTION(-)		-220,396	-72,259		-292,655		-220,396	-72,259	-292,655	0		-261,480	-85,775	-347,255
	TOTAL FEDERAL NED COSTS		**$189,339**	**$65,931**		**$255,270**		**$189,339**	**$65,931**	**$255,270**	**$0**		**$212,893**	**$74,037**	**$286,930**
	NON-FEDERAL COSTS														
1	LANDS AND DAMAGES		41,795	11,751	28	53,546	0.00	41,795	11,751	53,546	0	11	46,222	12,995	59,217
2	RELOCATIONS		64,900	22,559		87,459		64,900	22,559	87,459	0		73,143	25,425	98,568
	Relocations Construction Cost		50,703	17,624	35	68,327	0.00	50,703	17,624	68,327	0	13	57,271	19,907	77,178
	Plan/Engineering/Design		9,127	3,172	35	12,299	0.00	9,127	3,172	12,299	0	11	10,123	3,519	13,642
	Construction Management		5,070	1,763	35	6,833	0.00	5,070	1,763	6,833	0	13	5,749	1,999	7,748
	SUBTOTAL NON-FEDERAL		106,695	34,310		141,005		106,695	34,310	141,005	0		119,365	38,420	157,785
	NON-FEDERAL CONTRIBUTION (+)		220,396	72,259		292,655		220,396	72,259	292,655	0		261,480	85,775	347,255
	Non-Federal Contribution - NED		48,533	17,105		65,638		48,533	17,105	65,638	0		56,289	19,847	76,136
	Additional Cost Above NED		171,863	55,154		227,017		171,863	55,154	227,017	0		205,191	65,928	271,119
	TOTAL NON-FEDERAL COSTS		**$327,091**	**$106,569**		**$433,660**		**$327,091**	**$106,569**	**$433,660**	**$0**		**$380,845**	**$124,195**	**$505,040**
	TOTAL FEDERAL AND NON-FEDERAL COSTS		**$516,430**	**$172,500**		**$688,930**		**$516,430**	**$172,500**	**$688,930**	**$0**		**$593,738**	**$198,232**	**$791,970**

GENERAL NOTES

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(3 The Fully Funded cost estimate was prepared in compliance with Indexes used from CWCCIS reflecting OMB future rates Mar. 31, 2013
(4 01 Account for Land and Damages cost are from Real Estates.
(5 06 Account Fish and Wildlife Cost was provided by SPK Environmental Planning.
(6 30 Account Planning, Engineering and Design and 31 Account Construction Management cost was provided by its respective organizations.

(A CONTINGENCIES USED WAS DERIVED BY THE COST RISK ANALYSIS PROCESS AND IS BASED ON A 80% CONFIDENCE LEVEL

	DOLLAR(K)
TOTAL FEDERAL COSTS	$288,930
TOTAL NON-FEDERAL COSTS	$505,040
THE MAXIMUM PROJECT COSTS	$791,970

_____ CHIEF, COST ENGINEERING

_____ PROJECT MANAGER

_____ CHIEF, REAL ESTATE

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION

PROJECT: Sutter Basin_NED (Alt SB7)
LOCATION: CALIFORNIA
INTEREST RATE: 3.500%

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2013					
	FEDERAL COSTS					
1	LANDS AND DAMAGES, Administration	7,300,000				985,728
		7,300,000	3-Feb-2016	4-Feb-2020	Oct-21	985,728
6	FISH & WILDLIFE FACILITIES	6,038,000				488,264
3--	WILDLIFE FACILITIES & SANCTUARIES					
	Contract A (Reach 2-5)	2,012,000	4-Feb-2020	15-Sep-2021	Oct-21	59,915
	Contract Star Bend FIP (Reach 6)	24,000	5-Feb-2019	13-Jun-2020	Oct-21	1,691
	Contract B (Reach 7-12)	1,633,000	5-Feb-2019	14-Sep-2020	Oct-21	107,484
	Contract C1 (Reach 13-18)	1,590,000	3-Feb-2017	24-Oct-2018	Oct-21	222,227
	Contract C2 (Reach 19-21)	779,000	5-Feb-2018	3-Aug-2018	Oct-21	96,947
11	LEVEES AND FLOODWALLS	239,922,000				20,353,675
	Contract A (Reach 2-5)	66,563,000	4-Feb-2020	15-Sep-2021	Oct-21	1,982,168
	Contract Star Bend FIP (Reach 6)	9,010,000	5-Feb-2019	13-Jun-2020	Oct-21	634,857
	Contract B (Reach 7-12)	64,199,000	5-Feb-2019	14-Sep-2020	Oct-21	4,225,588
	Contract C1 (Reach 13-18)	68,388,000	3-Feb-2017	24-Oct-2018	Oct-21	9,558,261
	Contract C2 (Reach 19-21)	31,762,000	5-Feb-2018	3-Aug-2018	Oct-21	3,952,801
18	CULTURAL RESOURCE PRES. (NO IDC)	1,633,000				
18	CULTURAL RESOURCE PRES.	620,000				52,926
	COST SUBJECT TO (IDC)	620,000	3-Feb-2017	15-Sep-2021	Oct-21	52,926
30	PLANNING, ENGR. & DESIGN	44,419,000				5,807,164
		44,419,000	1-Oct-2014	1-Oct-2021	Oct-21	5,807,164
31	CONSTRUCTION MANAGEMENT	20,976,000				1,773,890
		20,976,000	3-Feb-2017	1-Oct-2021	Oct-21	1,773,890
	CASH CONTRIBUTION (-)	65,638,000	Feb-17		Oct-21	5,550,847
	TOTAL FEDERAL COST	**$255,270,000**				**$23,910,800**
	NON-FEDERAL COSTS					
1	LANDS AND DAMAGES	42,390,000				5,723,976
		42,390,000	3-Feb-2016	4-Feb-2020	Oct-21	5,723,976
2	RELOCATIONS	22,298,000				2,256,149
	Constr. Activities	22,298,000				2,256,149
1--	ROADS					
	Contract B (Reach 7-12)	422,000	5-Feb-2019	14-Sep-2020	Oct-21	27,776
	Contract C1 (Reach 13-18)	2,003,000	3-Feb-2017	24-Oct-2018	Oct-21	279,950
3--	CEMETERIES, UTILITIES, & STRUCTURES					
	Contract A (Reach 2-5)	3,977,000	4-Feb-2020	15-Sep-2021	Oct-21	118,430
	Contract Star Bend FIP (Reach 6)	1,732,000	5-Feb-2019	13-Jun-2020	Oct-21	122,039
	Contract B (Reach 7-12)	2,366,000	5-Feb-2019	14-Sep-2020	Oct-21	155,730
	Contract C1 (Reach 13-18)	5,482,000	3-Feb-2017	24-Oct-2018	Oct-21	766,193
	Contract C2 (Reach 19-21)	5,780,000	5-Feb-2018	3-Aug-2018	Oct-21	719,325
	Contract C2 (Reach 19-21)	536,000	5-Feb-2018	3-Aug-2018	Oct-21	66,706
30	PLANNING, ENGR. & DESIGN	4,014,000				524,774
		4,014,000	1-Oct-2014	1-Oct-2021	Oct-21	524,774
31	CONSTRUCTION MANAGEMENT	2,230,000				188,586
		2,230,000	3-Feb-2017	Oct-21	Oct-21	188,586
	CASH CONTRIBUTION (+)	65,638,000	3-Feb-2017		Oct-21	5,550,847
	TOTAL NON-FEDERAL	**$136,570,000**				**$14,244,332**
	TOTAL	**$391,840,000**				**$38,155,132**

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION

PROJECT: Sutter Basin_NED (Alt SB7)
LOCATION: CALIFORNIA
INTEREST RATE: 7.000%

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2013					
	FEDERAL COSTS					
1	LANDS AND DAMAGES, Administration	7,300,000				2,078,228
		7,300,000	3-Feb-2016	4-Feb-2020	Oct-21	2,078,228
6	FISH & WILDLIFE FACILITIES	6,038,000				1,010,731
3--	WILDLIFE FACILITIES & SANCTUARIES					
	Contract A (Reach 2-5)	2,012,000	4-Feb-2020	15-Sep-2021	Oct-21	119,853
	Contract Star Bend FIP (Reach 6)	24,000	5-Feb-2019	13-Jun-2020	Oct-21	3,441
	Contract B (Reach 7-12)	1,633,000	5-Feb-2019	14-Sep-2020	Oct-21	218,390
	Contract C1 (Reach 13-18)	1,590,000	3-Feb-2017	24-Oct-2018	Oct-21	466,923
	Contract C2 (Reach 19-21)	779,000	5-Feb-2018	3-Aug-2018	Oct-21	202,124
11	LEVEES AND FLOODWALLS	239,922,000				42,166,801
	Contract A (Reach 2-5)	66,563,000	4-Feb-2020	15-Sep-2021	Oct-21	3,965,107
	Contract Star Bend FIP (Reach 6)	9,010,000	5-Feb-2019	13-Jun-2020	Oct-21	1,291,896
	Contract B (Reach 7-12)	64,199,000	5-Feb-2019	14-Sep-2020	Oct-21	8,585,670
	Contract C1 (Reach 13-18)	68,388,000	3-Feb-2017	24-Oct-2018	Oct-21	20,082,965
	Contract C2 (Reach 19-21)	31,762,000	5-Feb-2018	3-Aug-2018	Oct-21	8,241,163
18	CULTURAL RESOURCE PRES. (NO IDC)	1,633,000				
18	CULTURAL RESOURCE PRES.	620,000				109,769
	COST SUBJECT TO (IDC)	620,000	3-Feb-2017	15-Sep-2021	Oct-21	109,769
30	PLANNING, ENGR. & DESIGN	44,419,000				12,396,577
		44,419,000	1-Oct-2014	1-Oct-2021	Oct-21	12,396,577
31	CONSTRUCTION MANAGEMENT	20,976,000				3,679,032
		20,976,000	3-Feb-2017	1-Oct-2021	Oct-21	3,679,032
	CASH CONTRIBUTION (-)	65,638,000	Feb-17		Oct-21	11,512,409
	TOTAL FEDERAL COST	**$255,270,000**				**$49,928,729**
	NON-FEDERAL COSTS					
1	LANDS AND DAMAGES	42,390,000				12,067,957
		42,390,000	3-Feb-2016	4-Feb-2020	Oct-21	12,067,957
2	RELOCATIONS	22,298,000				4,694,952
	Constr. Activities	22,298,000				4,694,952
1--	ROADS					
	Contract B (Reach 7-12)	422,000	5-Feb-2019	14-Sep-2020	Oct-21	56,436
	Contract C1 (Reach 13-18)	2,003,000	3-Feb-2017	24-Oct-2018	Oct-21	588,205
3--	CEMETERIES, UTILITIES, & STRUCTURES					
	Contract A (Reach 2-5)	3,977,000	4-Feb-2020	15-Sep-2021	Oct-21	236,907
	Contract Star Bend FIP (Reach 6)	1,732,000	5-Feb-2019	13-Jun-2020	Oct-21	248,342
	Contract B (Reach 7-12)	2,366,000	5-Feb-2019	14-Sep-2020	Oct-21	316,418
	Contract C1 (Reach 13-18)	5,482,000	3-Feb-2017	24-Oct-2018	Oct-21	1,609,856
	Contract C2 (Reach 19-21)	5,780,000	5-Feb-2018	3-Aug-2018	Oct-21	1,499,714
	Contract C2 (Reach 19-21)	536,000	5-Feb-2018	3-Aug-2018	Oct-21	139,074
30	PLANNING, ENGR. & DESIGN	4,014,000				1,120,238
		4,014,000	1-Oct-2014	1-Oct-2021	Oct-21	1,120,238
31	CONSTRUCTION MANAGEMENT	2,230,000				391,125
		2,230,000	3-Feb-2017	Oct-21	Oct-21	391,125
	CASH CONTRIBUTION (+)	65,638,000	3-Feb-2017		Oct-21	11,512,409
	TOTAL NON-FEDERAL	**$136,570,000**				**$29,786,681**
	TOTAL	**$391,840,000**				**$79,715,410**

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION

PROJECT: Sutter Basin_LPP (Alt SB8)
LOCATION: CALIFORNIA
INTEREST RATE: 3.500%

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2013					
	FEDERAL COSTS					
1	LANDS AND DAMAGES, Administration	11,700,000				2,057,605
		11,700,000	3-Feb-2016	4-Feb-2022	Oct-23	2,057,605
6	FISH & WILDLIFE FACILITIES	7,595,000				845,220
3--	WILDLIFE FACILITIES & SANCTUARIES					
	Contract A (Reach 2-5)	2,012,000	4-Feb-2022	15-Sep-2023	Oct-23	59,816
	Contract Star Bend FIP (Reach 6)	24,000	5-Feb-2021	14-Jun-2022	Oct-23	1,689
	Contract B (Reach 7-12)	1,633,000	5-Feb-2021	14-Sep-2022	Oct-23	107,402
	Contract C1 (Reach 13-18)	1,590,000	3-Feb-2017	24-Oct-2018	Oct-23	351,302
	Contract C2 (Reach 19-25)	779,000	2-Feb-2018	8-Nov-2019	Oct-23	139,353
	Contract D1 (Reach 26-33)	649,000	4-Feb-2019	26-Oct-2020	Oct-23	90,569
	Contract D2 (Reach 34-41)	908,000	3-Feb-2020	16-Aug-2021	Oct-23	95,089
	Contract C2 (Reach 19-25)	0	2-Feb-2018	8-Nov-2019	Oct-23	0
11	LEVEES AND FLOODWALLS	412,855,000				50,784,138
	Contract A (Reach 2-5)	65,879,000	4-Feb-2022	15-Sep-2023	Oct-23	1,958,572
	Contract Star Bend FIP (Reach 6)	8,917,000	5-Feb-2021	14-Jun-2022	Oct-23	627,405
	Contract B (Reach 7-12)	63,539,000	5-Feb-2021	14-Sep-2022	Oct-23	4,178,926
	Contract C1 (Reach 13-18)	66,594,000	3-Feb-2017	24-Oct-2018	Oct-23	14,713,608
	Contract C2 (Reach 19-25)	61,300,000	2-Feb-2018	8-Nov-2019	Oct-23	10,965,805
	Contract D1 (Reach 26-33)	85,696,000	4-Feb-2019	26-Oct-2020	Oct-23	11,958,996
	Contract D2 (Reach 34-41)	60,930,000	3-Feb-2020	16-Aug-2021	Oct-23	6,380,826
18	CULTURAL RESOURCE PRES. (NO IDC)	1,633,000				
18	CULTURAL RESOURCE PRES.	2,473,000				402,281
	COST SUBJECT TO (IDC)	2,473,000	3-Feb-2017	15-Sep-2021	Oct-23	402,281
30	PLANNING, ENGR. & DESIGN	75,850,000				13,058,248
		75,850,000	1-Oct-2014	1-Oct-2023	Oct-23	13,058,248
31	CONSTRUCTION MANAGEMENT	35,819,000				5,796,084
		35,819,000	3-Feb-2017	1-Oct-2021	Oct-23	5,796,084
	CASH CONTRIBUTION (-)	292,655,000	Feb-17		Oct-23	36,225,004
	TOTAL FEDERAL COST	**$255,270,000**				**$36,718,572**
	NON-FEDERAL COSTS					
1	LANDS AND DAMAGES	53,546,000				9,416,796
		53,546,000	3-Feb-2016	4-Feb-2022	Oct-23	9,416,796
2	RELOCATIONS	68,327,000				8,945,230
	Constr. Activities	68,327,000				8,945,230
1--	ROADS					
	Contract B (Reach 7-12)	418,000	5-Feb-2021	14-Sep-2022	Oct-23	27,492
	Contract C1 (Reach 13-18)	1,982,000	3-Feb-2017	24-Oct-2018	Oct-23	437,913
	Contract C2 (Reach 19-25)	445,000	2-Feb-2018	8-Nov-2019	Oct-23	79,605
	Contract D1 (Reach 26-33)	168,000	4-Feb-2019	26-Oct-2020	Oct-23	23,445
	Contract D2 (Reach 34-41)	383,000	3-Feb-2020	16-Aug-2021	Oct-23	40,109
3--	CEMETERIES, UTILITIES, & STRUCTURES					
	Contract A (Reach 2-5)	3,936,000	4-Feb-2022	15-Sep-2023	Oct-23	117,017
	Contract Star Bend FIP (Reach 6)	1,714,000	5-Feb-2021	14-Jun-2022	Oct-23	120,598
	Contract B (Reach 7-12)	2,342,000	5-Feb-2021	14-Sep-2022	Oct-23	154,032
	Contract C1 (Reach 13-18)	5,425,000	3-Feb-2017	24-Oct-2018	Oct-23	1,198,626
	Contract C2 (Reach 19-25)	6,283,000	2-Feb-2018	8-Nov-2019	Oct-23	1,123,950
	Contract D1 (Reach 26-33)	22,321,000	4-Feb-2019	26-Oct-2020	Oct-23	3,114,927
	Contract D2 (Reach 34-41)	20,397,000	3-Feb-2020	16-Aug-2021	Oct-23	2,136,053
	Contract C2 (Reach 19-25)	528,000	2-Feb-2018	8-Nov-2019	Oct-23	94,453
	Contract D1 (Reach 26-33)	1,985,000	4-Feb-2019	26-Oct-2020	Oct-23	277,010
30	PLANNING, ENGR. & DESIGN	12,299,000				2,117,382
		12,299,000	1-Oct-2014	1-Oct-2023	Oct-23	2,117,382
31	CONSTRUCTION MANAGEMENT	6,833,000				845,793
		6,833,000	3-Feb-2017	Oct-23	Oct-23	845,793
	CASH CONTRIBUTION (+)	292,655,000	3-Feb-2017		Oct-23	36,225,004

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
		Effective Price Level (EPL): 1-Oct-2013				
TOTAL NON-FEDERAL		$433,660,000				$57,550,205
TOTAL		$688,930,000				$94,268,777

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION

PROJECT: Sutter Basin_LPP (Alt SB8)
LOCATION: CALIFORNIA
INTEREST RATE: 7.000%

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2013					
	FEDERAL COSTS					
1	LANDS AND DAMAGES, Administration	11,700,000				4,443,038
		11,700,000	3-Feb-2016	4-Feb-2022	Oct-23	4,443,038
6	FISH & WILDLIFE FACILITIES	7,595,000				1,791,104
3--	WILDLIFE FACILITIES & SANCTUARIES					
	Contract A (Reach 2-5)	2,012,000	4-Feb-2022	15-Sep-2023	Oct-23	119,652
	Contract Star Bend FIP (Reach 6)	24,000	5-Feb-2021	14-Jun-2022	Oct-23	3,436
	Contract B (Reach 7-12)	1,633,000	5-Feb-2021	14-Sep-2022	Oct-23	218,215
	Contract C1 (Reach 13-18)	1,590,000	3-Feb-2017	24-Oct-2018	Oct-23	764,971
	Contract C2 (Reach 19-25)	779,000	2-Feb-2018	8-Nov-2019	Oct-23	297,939
	Contract D1 (Reach 26-33)	649,000	4-Feb-2019	26-Oct-2020	Oct-23	190,279
	Contract D2 (Reach 34-41)	908,000	3-Feb-2020	16-Aug-2021	Oct-23	196,612
	Contract C2 (Reach 19-25)	0	2-Feb-2018	8-Nov-2019	Oct-23	0
11	LEVEES AND FLOODWALLS	412,855,000				107,487,670
	Contract A (Reach 2-5)	65,879,000	4-Feb-2022	15-Sep-2023	Oct-23	3,917,774
	Contract Star Bend FIP (Reach 6)	8,917,000	5-Feb-2021	14-Jun-2022	Oct-23	1,276,671
	Contract B (Reach 7-12)	63,539,000	5-Feb-2021	14-Sep-2022	Oct-23	8,490,607
	Contract C1 (Reach 13-18)	66,594,000	3-Feb-2017	24-Oct-2018	Oct-23	32,039,290
	Contract C2 (Reach 19-25)	61,300,000	2-Feb-2018	8-Nov-2019	Oct-23	23,444,990
	Contract D1 (Reach 26-33)	85,696,000	4-Feb-2019	26-Oct-2020	Oct-23	25,124,971
	Contract D2 (Reach 34-41)	60,930,000	3-Feb-2020	16-Aug-2021	Oct-23	13,193,367
18	CULTURAL RESOURCE PRES. (NO IDC)	1,633,000				
18	CULTURAL RESOURCE PRES.	2,473,000				859,615
	COST SUBJECT TO (IDC)	2,473,000	3-Feb-2017	15-Sep-2021	Oct-23	859,615
30	PLANNING, ENGR. & DESIGN	75,850,000				28,592,558
		75,850,000	1-Oct-2014	1-Oct-2023	Oct-23	28,592,558
31	CONSTRUCTION MANAGEMENT	35,819,000				12,382,872
		35,819,000	3-Feb-2017	1-Oct-2021	Oct-23	12,382,872
	CASH CONTRIBUTION (-)	292,655,000	Feb-17		Oct-23	76,997,295
	TOTAL FEDERAL COST	**$255,270,000**				**$78,559,562**
	NON-FEDERAL COSTS					
1	LANDS AND DAMAGES	53,546,000				20,333,926
		53,546,000	3-Feb-2016	4-Feb-2022	Oct-23	20,333,926
2	RELOCATIONS	68,327,000				18,862,069
	Constr. Activities	68,327,000				18,862,069
1--	ROADS					
	Contract B (Reach 7-12)	418,000	5-Feb-2021	14-Sep-2022	Oct-23	55,857
	Contract C1 (Reach 13-18)	1,982,000	3-Feb-2017	24-Oct-2018	Oct-23	953,567
	Contract C2 (Reach 19-25)	445,000	2-Feb-2018	8-Nov-2019	Oct-23	170,196
	Contract D1 (Reach 26-33)	168,000	4-Feb-2019	26-Oct-2020	Oct-23	49,255
	Contract D2 (Reach 34-41)	383,000	3-Feb-2020	16-Aug-2021	Oct-23	82,932
3--	CEMETERIES, UTILITIES, & STRUCTURES					
	Contract A (Reach 2-5)	3,936,000	4-Feb-2022	15-Sep-2023	Oct-23	234,071
	Contract Star Bend FIP (Reach 6)	1,714,000	5-Feb-2021	14-Jun-2022	Oct-23	245,398
	Contract B (Reach 7-12)	2,342,000	5-Feb-2021	14-Sep-2022	Oct-23	312,957
	Contract C1 (Reach 13-18)	5,425,000	3-Feb-2017	24-Oct-2018	Oct-23	2,610,042
	Contract C2 (Reach 19-25)	6,283,000	2-Feb-2018	8-Nov-2019	Oct-23	2,403,016
	Contract D1 (Reach 26-33)	22,321,000	4-Feb-2019	26-Oct-2020	Oct-23	6,544,232
	Contract D2 (Reach 34-41)	20,397,000	3-Feb-2020	16-Aug-2021	Oct-23	4,416,628
	Contract C2 (Reach 19-25)	528,000	2-Feb-2018	8-Nov-2019	Oct-23	201,941
	Contract D1 (Reach 26-33)	1,985,000	4-Feb-2019	26-Oct-2020	Oct-23	581,977
30	PLANNING, ENGR. & DESIGN	12,299,000				4,636,254
		12,299,000	1-Oct-2014	1-Oct-2023	Oct-23	4,636,254
31	CONSTRUCTION MANAGEMENT	6,833,000				1,797,757
		6,833,000	3-Feb-2017	Oct-23	Oct-23	1,797,757
	CASH CONTRIBUTION (+)	292,655,000	3-Feb-2017		Oct-23	76,997,295

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2013					
TOTAL NON-FEDERAL		$433,660,000				$122,627,301
TOTAL		$688,930,000				$201,186,863

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

18 FEB '11

CECW-P

MEMORANDUM FOR MAJOR SUBORDINATE COMMANDS

SUBJECT: Civil Works Program - National Pilot Program: Initial Pilot Study Selection

CORPS,

1. Reference memorandum dated 3 February 2011, subject: Civil Works Program - Pilot Study Implementation. The Pilot Program is intended to validate concepts of a new pre-authorization (planning) study paradigm that shortens the timeframe for completion of a planning study, while maintaining the quality and integrity of the analyses. The purpose of this memorandum is to announce the selection of the initial pilot studies for the National Pilot Program.

2. In the referenced memorandum input on three potential pilot studies was requested: Central Everglades, FL; Jordan Creek (Springfield), MO; and Sutter Basin, CA. The intent was to select two pilot studies on 10 February 2011 from these three studies unless more suitable studies were brought forward prior to 8 February 2011. Additional pilot studies will be selected from the nominations due by 23 February 2011.

3. No additional pilot studies were proposed by the close of business 7 February 2011 due date, so the selection panel proceeded with the three potential pilot studies outlined in the 3 February 2011 memorandum. The selected pilot studies are Jordan Creek (Springfield), MO and Sutter Basin, CA. Central Everglades, FL will remain under consideration for future selection as a pilot study.

- Jordan Creek (Springfield), MO has available Federal and non-Federal funds necessary to complete the study. The Feasibility Scoping Meeting (FSM) is currently scheduled for March 2011, and strong engagement and support of the sponsor, as well as existing vertical team engagement makes this project ideal for initial selection. Southwestern Division supports the study for inclusion as a pilot.

- Sutter Basin, CA is in the FY 2011 and 2012 President's Budget at an adequate level to complete the study. While the FSM for the study has been held, information discovered during planning has resulted in integration and consideration of new data and an expanded study area. The study has the strong support of South Pacific Division and the study sponsor for inclusion in the National Pilot Program.

4. Congratulations to these project delivery teams on their selection as the first representatives of the National Pilot Program. The National Pilot Program studies will proceed with vertical team coordination, a kick-off webinar, and pilot project activity scoping, including refinement and

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CECW-P
SUBJECT: Civil Works Program - National Pilot Program: Initial Pilot Study Selection

communication of expectations, development of the path forward, and further definition of outcomes and indicators of success. The webinar will provide additional information and direction on the pilot program and will be held prior to 28 February 2011. Pilot Program project delivery teams will be contacted no later than 18 February 2011 to coordinate dates for the scoping meetings. The scoping meeting will be the official start of the National Pilot Program and will be held in early to mid-March.

5. We look forward to receipt of your additional nominations and appreciate your responsiveness and commitment to this important Civil Works initiative.

FOR THE COMMANDER:

Encls Thanks for your support!

WILLIAM T. GRISOLI
Major General, USA
Deputy Commanding General
for Civil and Emergency Operations

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CHIEF, CEMP-CR
DIRECTOR, IWR

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

MAY - 7 2013

MEMORANDUM FOR DIRECTOR OF CIVIL WORKS

SUBJECT: Sutter Basin, California – Deviation from the National Economic Development Plan

I am responding to the Army Corps of Engineers (Corps) memorandum dated March 18, 2013, which requests an exception to the policy that requires decision documents to recommend the National Economic Development (NED) Plan. The exception would allow the subject draft feasibility report and draft environmental impact statement to tentatively recommend a Locally Preferred Plan (LPP) for flood risk management improvements. The request indicates that the Sutter Butte Flood Control Agency and the Central Valley Flood Protection Board, as the non-Federal sponsors, support the LPP in lieu of the NED Plan in order to comply with California Government Code requirements for a 200-year level of protection for urban and urbanizing areas by 2025.

Based on the materials provided, the LPP would reduce the vulnerability of a larger population and additional critical infrastructure, reduce economic flood risks to a greater extent, and provide more evacuation routes relative to the NED Plan. The LPP would cost about $290,000,000 more than the NED Plan. As proposed, the non-Federal sponsors would be responsible for the entire extra cost, which would increase the non-Federal cost share from about $148,000,000 for the NED Plan to about $438,000,000 for the LPP. The Federal cost share of initial construction, estimated at $275,000,000, would remain the same for the NED Plan and the LPP.

In addition to the request for an exception, the Corps provided responses on April 17, 2013, to questions my staff raised about the study and the two plans. The responses resolved all but three of those concerns. First, significant population growth during the 50-year period of analysis appears likely and must be explicitly considered in evaluating the public safety aspects of the final alternatives and measures for managing the respective residual risks. Second, the effect of induced development on the public safety aspects of the final alternatives and the residual risks must be assessed. If a reasonable estimate of induced development cannot be achieved, then the analyses should assume full development of areas designated as potentially developable. Areas with temporary restrictions on development should be considered potentially developable unless the Corps can demonstrate that the temporary restrictions would become permanent. Third, the effects of alternatives and their respective induced development and population growth on natural floodplain functions, including the ecological and hydrologic functions, must be assessed.

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After reviewing the materials provided, I have decided to grant the requested policy exception, subject to the Corps incorporating the information discussed above into the final decision documents. The documents should be explicit about compliance with EO 11988, particularly the determination of practicable alternatives. The draft feasibility report and draft environmental impact statement may tentatively select the LPP and be released for public review. I concur that the added cost of the LPP relative to the NED Plan, currently estimated at $290,000,000, would be a 100 percent non-Federal cost, with the remainder of the first cost shared 65 percent Federal, 35 percent non-Federal consistent with current policy.

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

Value Engineering Study/ Planning Charette Report

Sutter Basin Pilot Study

January 2012

Prepared by

Value Management Strategies, Inc.

VMS
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"Value Leadership"

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Date: January 25, 2012

Mary Diel
U.S. Army Corps of Engineers – Sacramento District
CESPK-ED-SC
1325 J Street
Sacramento, CA 95814-2922

Subject: Value Engineering Study/Planning Charette Report
Sutter Basin Pilot Study

Dear Mary:

Value Management Strategies, Inc. is pleased to transmit an electronic copy of the Final Value Engineering Study / Planning Charette Report.

This report summarizes the results and events of the workshop conducted October 31 – November 4, 2011 at the U.S. Army Corps of Engineers, Sacramento District offices.

We enjoyed working with you and are looking forward to continuing efforts to assist you and the Sacramento District in its value engineering efforts.

Sincerely,

VALUE MANAGEMENT STRATEGIES, INC.
Mark Watson, PE, CVS, PMP
VE Study Team Leader

VALUE MANAGEMENT STRATEGIES, INC.
Ronald J. Tanenbaum, PhD, PE, CVS
VE Study Team Leader

CC: Laura Whitney, Project Manager, USACE – Sacramento District

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

FINAL

A combined Value Engineering (VE) study and Planning Charette, sponsored by the US Army Corps of Engineers (USACE), Sacramento District and facilitated by Value Management Strategies, Inc., was conducted on the Sutter Basin Pilot Study. The study was conducted in Sacramento, California October 31 – November 4, 2011. The VE study involved the USACE Sacramento District Project Development Team (PDT) working with designated representatives from USACE South Pacific Division, the California Department of Water Resources (DWR), and Sutter Butte Flood Control Agency (SBFCA).

PROJECT SUMMARY

USACE and SBFCA, in coordination with DWR and the California Central Valley Flood Protection Board are undertaking efforts to study flood risk management measures in Sutter and Butte Counties. The Sutter Basin, California Feasibility Study will investigate flood damage reduction, ecosystem restoration and recreation within the project's study area.

The Sutter Basin Feasibility Study was selected for inclusion in the National Pilot Program in February 2011. The pilot initiative provides an opportunity to test principles that have been outlined in the U.S. Army Corps of Engineers (USACE) Recommendations for Transforming the Current Pre-Authorization Study Process (January 2011), which was drafted by a workgroup of planning and policy experts from USACE and the Office of the Assistant Secretary of the Army for Civil Works referred to as the 17+1 Team. Based on these principles, the Sutter Pilot Study plan formulation strategy focuses on a qualitative analysis that will be increasingly detailed at each Decision Point or In-Progress Review, and early elimination of plans with little probability of implementation.

WORKSHOP TIMING

The VE study/Planning Charette was conducted early in Project Development prior to the Feasibility Report being prepared by USACE Sacramento District.

VE STUDY/PLANNING CHARETTE OBJECTIVES

The objectives of the VE study as identified in the scope of work were to:

- **Validate, Refine, and Optimize Alternatives** – Integrate VE principles, tools and techniques into the project's early decision making processes to validate, refine, and optimize preliminary alternatives and ensure a robust final array of alternatives.
- **Facilitate Communication** – Utilize the VE process to facilitate and encourage the understanding, consideration, and integration of the needs of the PDT members, project sponsors, partners, and other stakeholders.
- **Improve Value** – Identify VE Concepts that improve the project's ability to meet its objectives through increased performance and/or reduced cost.

- **Improve Planning Process** – Combine the VE methodology (5-step job plan) with USACE's 6-step planning process in order to meet both the project and pilot study objectives.

BASELINE CONCEPTUAL ALTERNATIVES AND MEASURES

Prior to the workshop, the PDT in conjunction with the local sponsors, identified a wide array of potential Flood Risk Management (FRM) structural and nonstructural measures, Ecosystem Restoration (ER) measures (in conjunction with FRM), and recreation measures.

The measures were then grouped into one or more conceptual alternatives. Measures listed under each conceptual alternative were designated as either required measures or optional measures that could be incrementally added to the alternative. The measures were formed into nine preliminary alternatives which are summarized in the Project Information section of this report. Since the measures to be included in the nonstructural alternative have not yet been well defined, this alternative was not rated during the VE Study. By policy, a primarily nonstructural alternative will be included in the final array.

WORKSHOP RESULTS

The VE team undertook the task assignment using the VE work plan and methodology. Given that this study was conducted at an early stage of design development, the VE team considered a "top down" approach where the team identified and discussed the general objectives of the project as they relate to the project's purpose and need.

The most notable result of this workshop was the use of the VE methodology at an early stage of design. Traditionally, VE studies are performed later in the design process with the intent to identify cost savings and value improvement suggestions on an existing design. For this study, the VE team used the tools and techniques of the VE methodology to accomplish the stated objectives. The VE study completed the following activities:

- Discuss and concur on the project's mission (purpose and need)
- Identify and prioritize the performance criteria for the project
- Evaluate the Baseline Conceptual Alternatives per the performance criteria and relative costs
- Revise Conceptual Alternatives and identify Final Alternative Array
- Evaluate Final Alternative Array per the performance criteria and relative costs

EVALUATION OF BASELINE CONCEPTUAL ALTERNATIVES

During the course of the workshop, a number of analytical tools and techniques were applied to develop a better understanding of the Baseline Alternative Concepts and begin the process of identifying a final array of alternatives. A major component of this analysis was Value Metrics which seeks to assess cost and performance as they relate to project value. These elements required a deeper level of analysis, the results of which are detailed in this report. Key performance attributes identified for the project are listed in the table, "Performance Attributes."

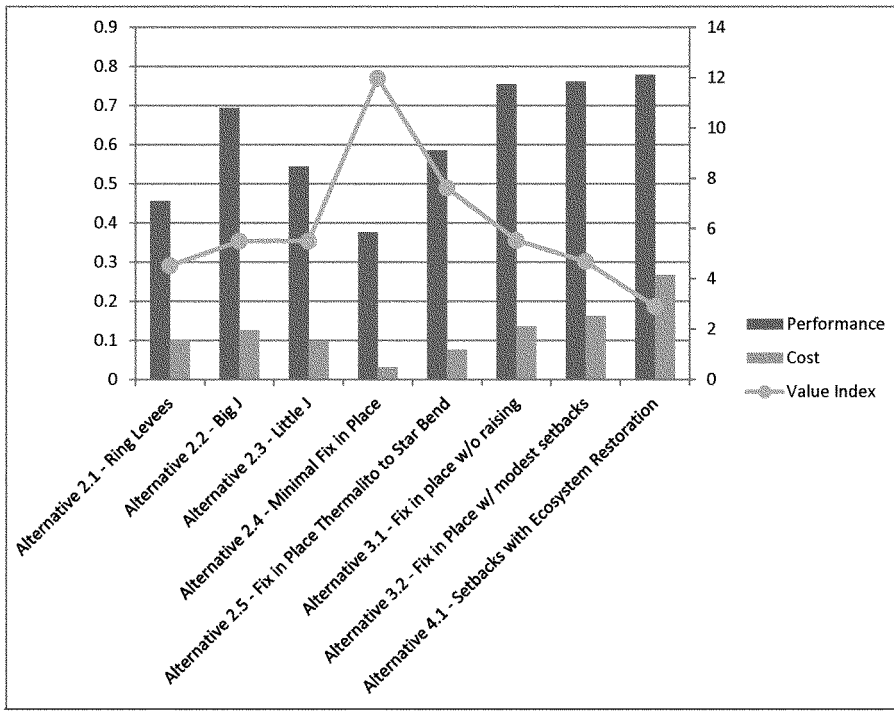
Performance Attributes
Flood Risk Management
Residual Risks
Sustainability
Ecosystem Functionality
Minimize Environmental Impacts

The *Comparison of Value* chart presented below was prepared to summarize the comparison of the Baseline Conceptual Alternatives. The performance scores calculated from the summation of the weighted priority of a performance attribute times an alternative's rating score for the attribute were divided by the total cost scores for each alternative to derive a value index.

The basic equation for value is:

$$Value = \frac{Performance}{Cost + Time}$$

Comparison of Value – Baseline Concepts



Below is a summary of the major observations and conclusions identified during the value analysis of the Baseline Conceptual Alternatives:

- USACE policy requires a predominantly non-structural alternative, however, a stand-alone non-structural alternative (*Alternative 1.1 – Non-Structural Measures*) does not significantly address project objectives due to residual risk. Non-structural measures would enhance all project alternatives in achieving objectives and should be considered in combination with other alternatives.

- *Alternative 4.1 – Setbacks with Ecosystem Restoration* has significantly higher costs than the other alternatives with only slightly added performance. This alternative was eliminated from further consideration because the additional cost of this alternative compared to combined alternatives 3.1 and 3.2 exceeds the additional restoration benefits. The ecosystem benefits from setbacks can be evaluated as standalone additions to other alternatives.

- The performance and costs of *Alternative 3.1 – Fix in Place without Raising* and *Alternative 3.2 – Primarily Fix in Place, Including Modest Setbacks* are relatively the same. The alternatives differ primarily in the optional setbacks they include. The setbacks can be evaluated as standalone additions to the combined alternative.
- Early economic benefit analysis leads to preliminary conclusion that smaller rings around the communities of Biggs, Gridley and Live Oak would not be economically justified, however, the Yuba City ring levee may be justified.
- *Alternative 2.4 – Minimal Fix in Place* provides flood risk reduction to a significant portion of the economic development of the study area for a relatively low construction cost.

VE CONCEPTS SUMMARY

The VE portion of the workshop identified 18 concepts, which are intended to assist the project development team in refining plans to carry forward into the next phase of project development. The concepts could potentially add value to the project, either through enhancing project functionality and alignment with project objectives, performance improvements, risk reduction, or any combination thereof. The alternatives are organized by category based on the project issue or project aspect they address. A summary list and developed content of all of the VE Concepts is included in the *VE Concepts* section of this report.

FINAL ALTERNATIVE ARRAY

Using the results of the previous exercises, the VE team developed a suggested Final Alternative Array. The alternatives are summarized below. Additional information, assumptions, and the performance assessment for each alternative are included in the *Value Analysis of Final Alternatives Array* section of this report.

- **Primarily Nonstructural with Minimal Levee Improvement Reaches**
  This alternative is a combination of minimal levee improvements to Feather River Levees with the implementation of non-structural measures focused on reducing risk to loss of life.

- **Yuba City Ring Levee**
  This alternative consists of constructing a ring levee around Yuba City only with the implementation of non-structural measures focused on reducing risk to loss of life in areas not provided with new or improved levees.

- **Little "J" Levee**
  This alternative consists of improving the Feather River levees from Thermalito to Shanghai Bend and constructing a new levee to the south and west of Yuba City.

- **Fix in Place Feather River Thermalito to Star Bend**
  This alternative consists of improving the Feather River levees from Thermalito to Star Bend. The alternative also includes the Star Bend setback levee.

- **Fix in Place Feather River, Sutter Bypass, and Wadsworth Canal with select setbacks for ecosystem restoration**
  This alternative is a combination of Alternatives 3.1 and 3.2 as originally identified with the Star Bend setback levee and the Northern Feather River setback levees included. The alternative will consider economic and flood risk reduction justification for other setback levee alignments and isolated weak spots as supplemental options where feasible.

CONCLUSION

This study accomplished each of its objectives as summarized below.

Validate, Refine, and Optimize Alternatives – The VE Study/Planning Charette resulted in narrowing the alternative array to a select number of alternatives. The study further provides information on the performance of each alternative as it relates to the purpose and need of the project. Given that this project is at an early stage in project development, no specific alternative or concepts were selected by the VE team as a "most preferred" solution. However, as the feasibility study process continues, it is recommended that the results documented in this report be utilized to aid in the decision-making process.

Facilitate Communication – The VE team incorporated the project objectives and discussions on the project's purpose and need into a mission statement that succinctly summarizes the project's scope. The VE team then utilized function analysis techniques to translate the project's purpose and need into functions in order to further understand how the project is accomplishing its objectives.

Improve Value – The VE team identified 15 VE Concepts that focus primarily on optimization of the Baseline Conceptual Alternatives array through either incorporating additional flood risk reduction measures and/or modifying the Conceptual Alternatives per lessons learned during the previous workshop exercises (Function Analysis and Value Metrics). The VE team also identified suggested revisions to the Baseline Conceptual Alternative array through the combination of certain alternatives or the elimination of alternatives from further consideration.

Integration with Planning Process – The following comments and lessons learned were generated by the participants at the conclusion of the workshop:

- The VE study allowed decisions to be made based on logical, repeatable, and defendable means without the need for significant data generation. The Value Metrics process utilized multi-criteria decision making without the need for full development of all the alternatives in order to reach preliminary screening decisions. This will result in time and effort savings as the planning process continues.

- The Performance Attributes as identified, defined, and prioritized by the Value Metrics process need to be reviewed to ensure that they reflect current USACE policies. Challenge ahead is to get more quantification of the information for rating the alternatives per the attributes identified.

- The VE Process as it has been adapted for this workshop is a complimentary method to USACE's traditional planning process and allowed issues to be brought up and discussed in an open forum and then resolved through creative and consensus-building activities. This collaborative approach allows more to happen in a reduced timeframe than the traditional report/comment/revision methods.
- This was the right time to incorporate VE into the project development process. Validated the effort to this point is in the right direction without requiring significant re-work. Using internal team at this point in the process is essential for good evaluation of the project and taking advantage of the institutional knowledge of the project and alternatives.

PROJECT INFORMATION

PROJECT INFORMATION

BACKGROUND

The U.S. Army Corps of Engineers and the Sutter Butte Flood Control Agency, in coordination with the California Department of Water Resources and the California Central Valley Flood Protection Board are investigating flood risk management in Sutter and Butte Counties. The purpose of the investigation is to address deficiencies in the existing levee system along the Feather River and Sutter Bypass that may lead to flood damage.

This project was one of two projects selected for a new pilot program to shorten the Corps' current study process target of three years. The pilot program is intended to test and confirm ideas for shortening the Corps' planning study process to as few as 18 months, as part of a broader Corps effort to respond to the nation's needs by moving more quickly from studying a problem to fixing it. One method for fast-tracking the Corps' planning process is to screen potential alternatives using logical, transparent, and policy-compliant methods based more on expert judgment rather than detailed quantitative analysis.

PROJECT DESCRIPTION

The Sutter Basin, California Feasibility Study is investigating flood risk management, ecosystem restoration and recreation within the study area. The study is considering improvement of the existing levees, as well as construction of new levees and other structural and non-structural measures for flood damage reduction. The ecosystem restoration and recreation objectives would be secondary to the flood damage reduction objective.

There exists a high risk of flooding from levee failure which threatens the public safety of approximately 80,000 people, as well as property and critical infrastructure throughout the study area. In addition, existing levees have isolated the floodplains from waterways, which eliminated significant floodplain habitats for native species, including federally listed species and other special status species.

Project Objectives

Based upon the information and discussions generated prior to the workshop, the following are the project objectives:

- Reduce the risk to life, health, and public safety due to flooding
- Reduce the risk of property damage due to flooding
- Reduce the risk of damage to critical infrastructure due to flooding
- Encourage wise use of the floodplain
- In conjunction with FRM, restore floodplain connectivity and associated dynamic riverine processes

- In conjunction with FRM, restore aquatic, wetland, riparian, and terrestrial habitats for special status and other native species
- In conjunction with FRM and ER, improve the public's access to and use of outdoor recreational opportunities in the study area

Project Mission Statement

The VE team incorporated the project objectives and discussions on the project's purpose and need into the following mission statement:

> *The Sutter Basin Flood Risk Management project is a multi-purpose approach to fix an unacceptable risk (probability and consequences) to life safety, public safety, critical infrastructure and property from flooding in the project area through structural and non-structural measures, incorporating ecosystem restoration and recreation opportunities, where appropriate.*

BASELINE CONCEPTUAL ALTERNATIVES

Prior to the VE Study/Planning Charette, the project team evaluated potential flood risk reduction, ecosystem restoration and recreation measures with respect to the study objectives and constraints. The result of a Critical Thinking Charette was an array of 33 measures. These measures were formed into eight preliminary alternatives as follows:

- **Alternative 1.1 – Non-Structural Measures**
  Since the measures to be included in the nonstructural alternative have not yet been well defined, this alternative was not evaluated during the combined VE Study/Charette. By policy, a primarily nonstructural alternative will be included in the final array.

- **Alternative 2.1 – Ring Levees**
  This alternative consists of ring levees around the communities of Biggs, Gridley, Live Oak, and Yuba City. The heights of the Biggs, Gridley, and Live Oak ring levees were estimated based on the 1/500 AEP levee breach inundation depths and an assumed additional height to provide 90% reliability. The height of the Yuba City ring levee was estimated based on the 1/200 AEP levee breach floodplain and additional height to provide 90% reliability. The eastern flank of the Yuba City ring levee would utilize the existing Feather River levee. The existing levee would be strengthened in place to its existing authorized height with no raising and would meet current USACE design standards. The higher level of performance for the Biggs, Gridley, and Live Oak ring levees was utilized because the flood depths are relatively shallow and do not vary significantly between flood frequencies. Each ring levee was assumed to require a pump station to address interior drainage. The capacity of the pump station was based on the rational method.

- **Alternative 2.2 – Big J**
  This alternative includes strengthening the Feather River levees from Thermalito to Star Bend, constructing a new cross-levee from Star Bend to Gilsizer Slough, strengthening the Sutter Bypass levee from Gilsizer slough to Wadsworth canal, and strengthening the south levee of the Wadsworth canal. All fix in place levees would meet current USACE design standards and

would be strengthened to the existing authorized height with no raising. The new levee reach was assumed to be a straight line profile from the Feather River levee to the Sutter Bypass levee. The levee footprint follows the approximate drainage divide to the two existing DWR pumping plants. Therefore, additional pumping plants would not be required. This alternative also includes the Star Bend setback levee.

- **Alternative 2.3 – Little J**
  This alternative includes strengthening in place Feather River levees from Thermalito to Shanghai Bend and constructing a new levee to the south and west of Yuba City. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising. The "J" levee was assumed to require a pump station to address interior drainage. The capacity of the pump station was based on the rational method.

- **Alternative 2.4 – Minimal Fix in Place**
  This alternative consists of strengthening in place the Feather River levees from Sunset Weir to Star Bend. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising.

- **Alternative 2.5 – Fix in Place Thermalito to Star Bend**
  This alternative consists of fixing in place Feather River levees from Thermalito to Star Bend and corresponds to the Feather River West Levee Project. The alternative also includes the Star Bend setback levee. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising.

- **Alternative 3.1 – Fix in Place without Raising**
  This alternative consists of fixing in place the Feather River levees from Thermalito to the confluence with the Sutter Bypass and improving the east levees of the Sutter Bypass in the southern basin. Levees along the south side of Wadsworth Canal would also be improved. The alternative also includes the Star Bend setback levee. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising.

- **Alternative 3.2 – Primarily Fix in Place, Including Modest Setbacks with Ecosystem Restoration**
  This alternative is similar to Alternative 3.1. However, in lieu of fixing in place the existing levees, new setback levees would be constructed at Northern Feather River and at the Sutter Bypass and Feather River confluence. The alternative also includes the Star Bend setback levee.

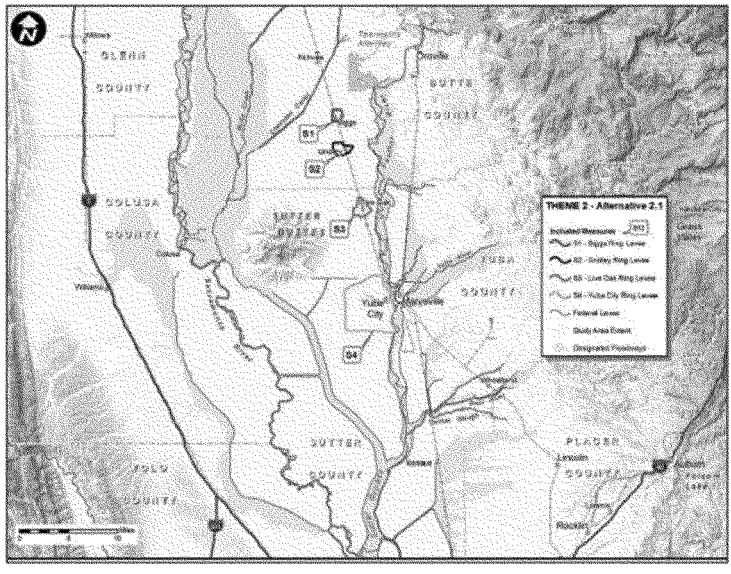
- **Alternative 4.1 – Setbacks with Ecosystem Restoration**
  This alternative is similar to Alternative 3.2. However, in lieu of improving the existing Sutter Bypass levee, a new setback levee would be constructed along the Sutter Bypass.

BASELINE CONCEPTUAL ALTERNATIVE SKETCHES

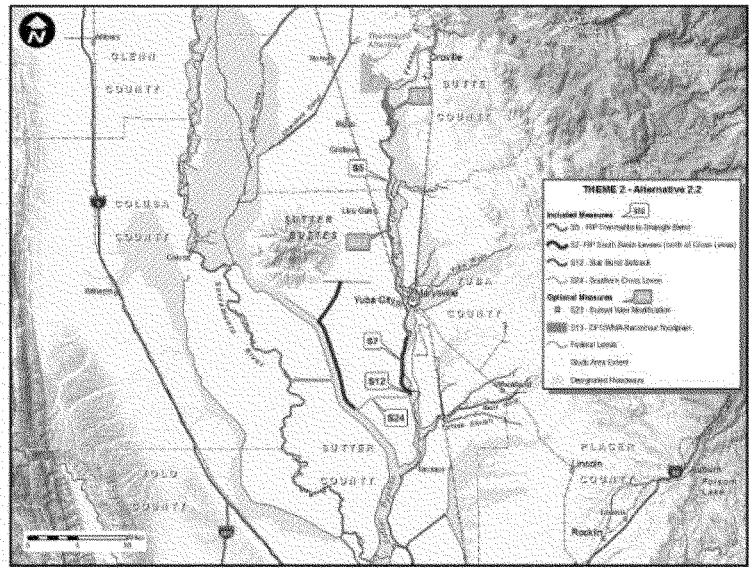
Conceptual illustrations of the Baseline Alternatives are included below and on the following pages.

BASELINE CONCEPTUAL ALTERNATIVES AND MEASURES

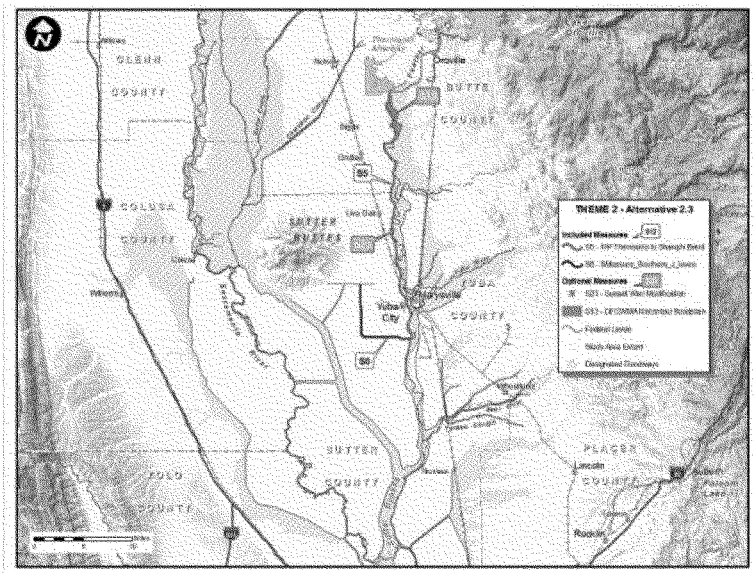
A table summarizing the potential flood risk reduction measures and the measures that comprise the Baseline Conceptual Alternatives is included at the end of this section.



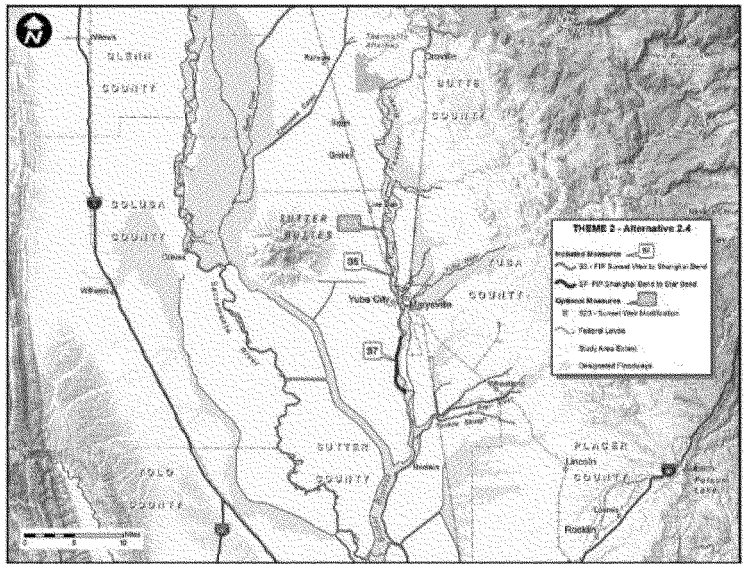
Alternative 2.1 – Ring Levees



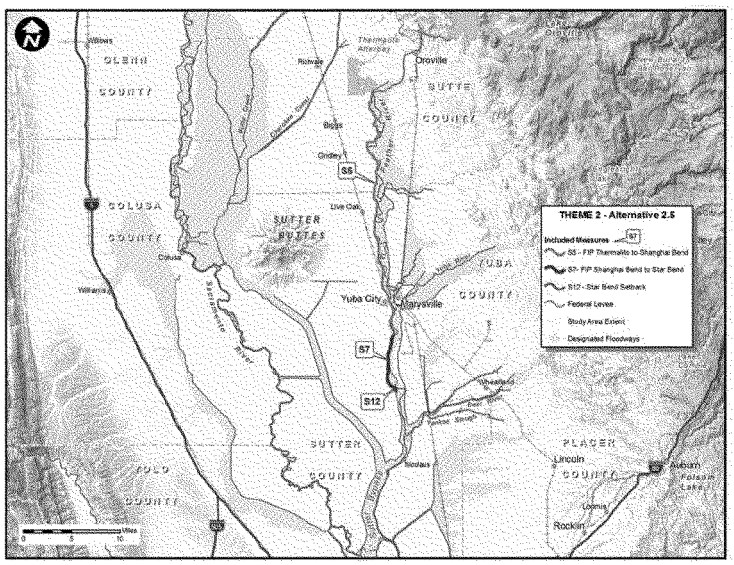
Alternative 2.2 – Big J



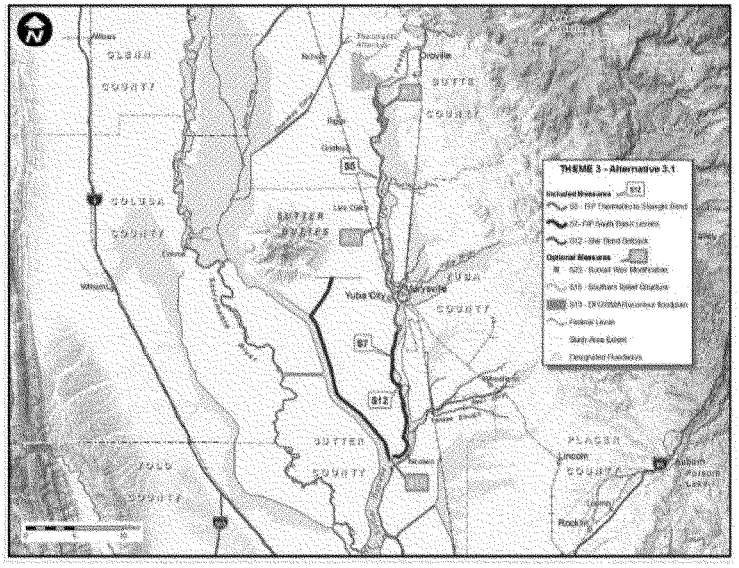
Alternative 2.3 – Little J

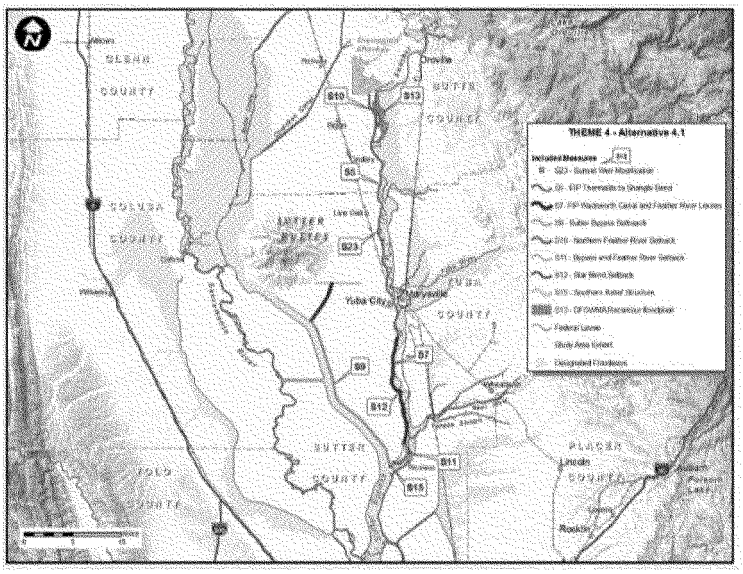


Alternative 2.4 – Minimal Fix in Place



Alternative 2.5 – Fix in Place Thermalito to Star Bend


THEME 3 - Alternative 3.1
Included Measures
S12
S5 - RP Thermalito to Shanghi Bend
S7 - RP South Basin Levees
S12 - Star Bend Setback
Optional Measures
W - S23 - Sunset Weir Modification
S15 - Southern Relief Structure
S13 - DFG/SRA Riverbend Floodplain
Federal Levee
Study Area Extent
Designated Floodways
Yuba City
Marysville
Oroville
Rocklin
Lincoln
Auburn
Folsom Lake
SUTTER BUTTES
Sutter
Live Oak
Colusa
Wilkins
Colusa
Yolo
Sacramento River
Feather River
Bear River
Yuba River
Sacramento River
Sutter Bypass
Butte Creek
Sacramento Weir
Tisdale Weir
Sacramento Weir
Tisdale Weir
Sacramento Weir
Tisdale Weir



Alternative 4.1 – Setbacks with Ecosystem Restoration

Conceptual Alternatives and Measures

ID	Management Measures	Theme 1 Consequence Management focused on Public Safety	Alternative 1.1: Nonstructural	Theme 2 Urban FRM Focus	Alternative 2.1: Ring Levees	Alternative 2.2: Big J	Alternative 2.3: Little J	Alternative 2.4: Minimal Fix in Place	Alternative 2.5: Fix in Place Thermalito to Star Bend	Theme 3 Maximize Existing System with FRM Emphasis	Alternative 3.1: Fix in place w/o raising	Alternative 3.2: Primarily Fix in Place including modest setbacks	Theme 4 Ecosystem Emphasis	Alternative 4.1: Setbacks with Ecosystem Restoration
S1	Biggs Ring Levee			*	X									
S2	Gridley Ring Levee			*	X									
S3	Live Oak Ring Levee			*	X									
S4	Yuba City Ring Levee			*	X									
S5	Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend			*		X	X	X-SBFCA segment 4 and 5 only (Sunset Weir to Shanghai Bend)	X	*	X-may include sub reaches	X	*	X
S6	Southern Portion of J-Levee			*			X							
S7	Fix-In-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee			***- south to star bend only**		X-Feather River North of Star bend and SB north of Gilsizer slough		X- Shanghai Bend to Star Bend	X- Shanghai Bend to Star Bend	*	X- may include sub reaches	X	***-w/o Sutter bypass fix in place**	X-w/o Sutter bypass fix in place
S9	Sutter Bypass Setback Levee									*		O	*	X
S10	Northern Feather River Setback Levee			*						*		O	*	X
S11	Sutter Bypass and Feather River Confluence Setback Levee									*		X	*	X
S12	Star Bend Setback Levee			*		X			X	*	X	X	*	X
S13	Oroville DFG Wildlife Management Area – Degrade Land Surface and Restore Wetlands					O	O				O	O	*	X
S15	Southern Relief Feature	*	O	*						*	O	O	*	X
S23	Sunset Weir Modification			*		O	O	O		*	O	O	*	X
S24	Gilsizer Cross Levee with flap gates	*		*		X								
S25	Wadsworth Canal Tributary Drainage			*		O	O			*	O	O		

ID	Management Measures	Theme 1 Consequence Management focused on Public Safety	Conceptual Alternative 1.1: Nonstructural	Theme 2 Urban FRM Focus	Conceptual Alternative 2.1: Ring Levees	Conceptual Alternative 2.2: Big J	Conceptual Alternative 2.3: Little J	Conceptual Alternative 2.4: Minimal Fix in Place	Conceptual Alternative 2.5: Local Early Implementation Plan Project #1	Theme 3 Maximize Existing System with FRM Emphasis	Conceptual Alternative 3.1: Fix in place w/o raising	Conceptual Alternative 3.2: Primarily Fix in Place including modest setbacks	Theme 4 Ecosystem Emphasis	Conceptual Alternative 4.1: Setbacks with Ecosystem Restoration
S26	Managed overtopping (levee superiority) on Feather River and Sutter Bypass. (e.g. selective levee raising)			*		O	O	O		*	O	O		
S27	Improve upstream fish passage in Sutter Bypass. (Remove fish passage barriers). Dependent on S9												*	X
NS1	Strategic relocation of structures and critical infrastructure in floodplain	*	O	*	O	O	O	O	O		O	O	*	O
NS2	Floodproof at isolated locations	*	O	*	O	O	O	O	O	*	O	O	*	O
NS3	Elevate structures and transportation infrastructure	*	O	*	O	O	O	O	O	*	O	O	*	O
NS4	Establish flood-resistant housing	*	O	*	O	O	O	O	O		O	O	*	O
NS5	Secure large floatable objects	*	O	*	O	O	O	O	O	*	O	O	*	O
NS6	Flood-warning system	*	X	*	X	X	X	X	X	*	X	X	*	X
NS7	Evacuation plan	*	X	*	X	X	X	X	X	*	X	X	*	X
NS8	Construct ring levees at isolated locations.	*	O	*	O	O	O	O	O		O	O	*	O
R1	Multi-Use Trails	*	O	*	O	O	O	O	O	*	O	O	*	O
R2	Bicycle Trails	*	O	*	O	O	O	O	O	*	O	O	*	O
R3	Equestrian Trails	*	O	*	O	O	O	O	O	*	O	O	*	O
R4	Day Use Area	*	O	*	O	O	O	O	O	*	O	O	*	O
R5	River Access	*	O	*	O	O	O	O	O	*	O	O	*	O
R6	Scenic Overlook	*	O	*	O	O	O	O	O	*	O	O	*	O
R7	Recreational parkway	*	O	*	O	O	O	O	O	*	O	O	*	O

* Included in theme
X Included in alternative
O Optional to alternative

FUNCTION ANALYSIS

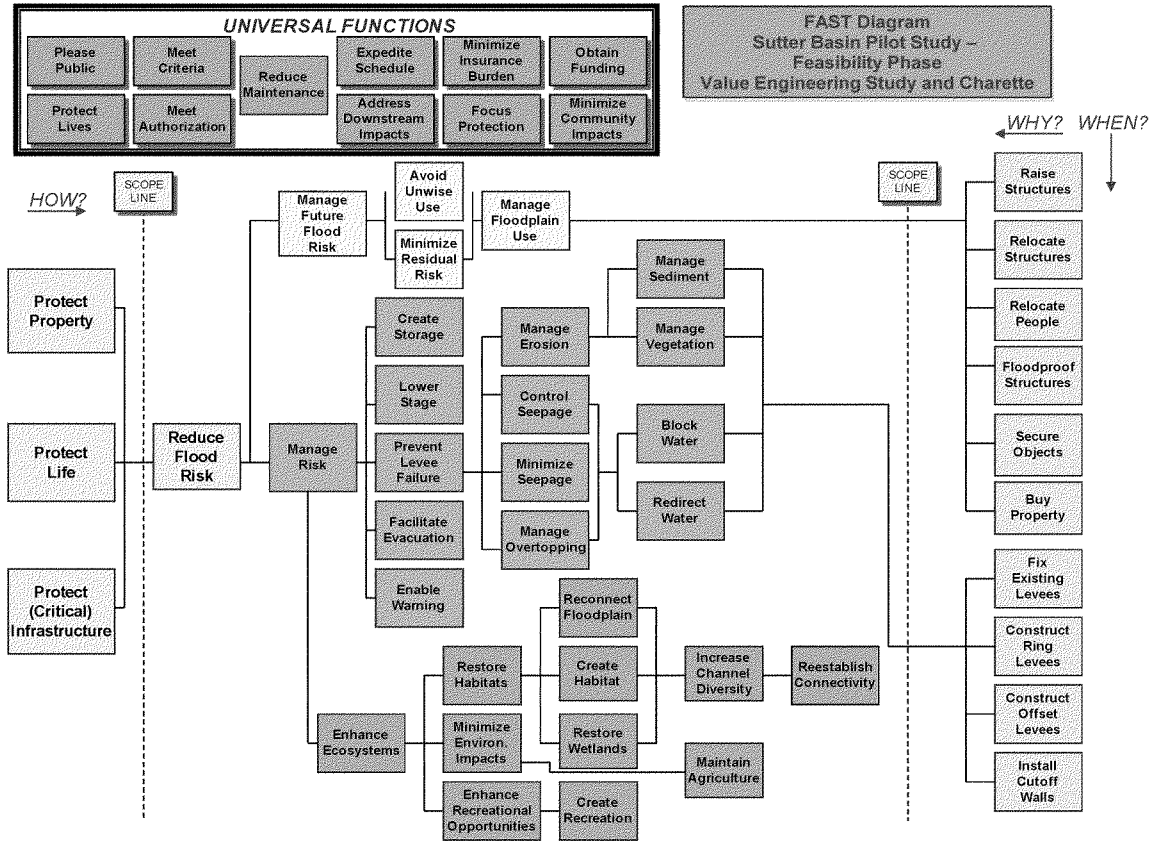
Function analysis was performed and a Function Analysis System Technique (FAST) Diagram was produced, which revealed the key functional relationships for the project. This analysis provided a greater understanding of the total project and how the project's performance, cost, time, and risk characteristics are related to the various functions identified.

The FAST diagram arranges the functions in logical order so that when read from left to right, the functions answer the question, "How?" If the diagram is read from right to left, the functions answer the question, "Why?" Functions connected with a vertical line are those that happen at the same time as, or are caused by, the function at the top of the column (a "When?" relationship).

Random Function Determination

Function	Function
Protect Life	Reconnect Floodplain
Reduce Flood Risk	Create Habitat
Protect Property	Restore Wetlands
Protect Infrastructure	Lower Stage
Enhance Ecosystems	Manage Floodplain Use
Restore Habitats	Create Recreation
Enhance Recreational Opportunities	Reestablish Connectivity
Fix Existing Levees	Maintain Agriculture
Construct Offset Levees	Meet Criteria
Minimize Environmental Impacts	Avoid Unwise Use
Relocate People	Manage Future Flood Risk
Raise Structures	Manage Vegetation
Relocate Structures	Protect Critical Infrastructure
Floodproof Structures	Create Storage
Control Seepage	Obtain Funding
Minimize Seepage	Minimize Community Impacts
Secure Objects	Increase Channel Diversity
Improve Access	Minimize Residual Risk
Facilitate Evacuation	Reduce Maintenance
Manage Overtopping	Address Downstream Impacts
Provide Warning	Manage Sediment
Block Water	Manage Erosion
Construct Ring Levees	Expedite Schedule

FAST Diagram



VALUE ANALYSIS OF BASELINE CONCEPTS

VALUE ANALYSIS OF BASELINE CONCEPTS

SUMMARY OF ANALYSIS

Value Metrics was used as an analysis tool to evaluate the Baseline Alternative Concepts that were identified prior to the workshop.

VALUE METRICS

Value Methodology (VM) has traditionally been perceived as an effective means for reducing project costs. This paradigm only addresses one part of the value equation, oftentimes at the expense of the role that VM can play with regard to improving project performance. Project costs are fairly easy to quantify and compare; performance is not.

Project performance must be properly defined and agreed to by the stakeholders at the beginning of the VE study/Planning Charette. The performance requirements and attributes developed are then used throughout the study to identify, evaluate, and document alternatives. This process, Value Metrics, emphasizes the interrelationship between the elements of performance, cost, and time and can be quantified and compared in terms of how they contribute to overall value. The basic equation for value is:

$$Value = \frac{Performance}{Cost + Time}$$

Value Metrics provides a standardized means of identifying, defining, evaluating, and measuring performance. Once this has been achieved and costs for all VE alternatives have been developed, measuring value is very straightforward.

The following pages describe the steps in the Value Metrics process.

Define Performance Requirements

Performance requirements represent essential, non-discretionary aspects of project performance. Any concept that fails to meet the project's performance requirements, regardless of whether it was developed during the project's design process or during the course of the VE study, cannot be considered as a viable solution. Concepts that do not meet a performance requirement cannot be considered further unless such shortcomings are addressed through the VE study process in the form of VE alternatives. It should be noted that in some cases, a performance requirement may also represent the minimum acceptable level of a performance attribute. The following performance requirements were selected for this project.

Performance Requirement	Definition
Meet Applicable Environmental Regulatory Standards and Policies	Project must meet the environmental regulatory standards and policies applicable to the respective project development stage. Examples include the National Environmental Policy Act, Endangered Species Act, Fish and Wildlife Coordination Act, Clean Water Act, Clean Air Act, and the National Historic Preservation Act. Meet State of California policies and regulatory standards.
Maintain Existing Flood Protection	The level of protection provided by floodwalls and levees must not be reduced.
Distinctiveness	Alternative measures should be unique and identifiable to allow distinguishing amongst the final array of alternatives.
Complete and Independent Project	This requirement is a determination of whether or not the plan includes all elements necessary to achieve the objectives of the plan. It is an indication of the degree that the outputs of the plan are dependent upon the actions of others. Plans that depend upon the actions of others to achieve the desired output do not meet this requirement.
COE authorization guidelines	The federal government has specific guidelines on the types of projects that USACE has authorization to fund. Project must meet the defined project type guidelines as well as meet applicable economic justification criteria for USACE participation.
Levee Design Standards	All levee designs must meet COE standards.

Define Performance Attributes

Performance attributes represent those aspects of a project's scope that may possess a range of potential values. For example, an attribute called "Environmental Impacts" may have a range of acceptable values for a project ranging from 1 acre to 20 acres of wetlands mitigation. It is clear that a concept that offered 15 acres of mitigation would perform at a higher level than one that offered 5 acres, but both would meet the project's need and purpose, and their values (i.e., the relationship between performance and cost) could be rationally compared. Please note that the values assigned to attribute performance were relative to the other alternatives. They were not based on absolute values. The following performance attributes were selected for this project.

Life Safety

This criterion focuses on the potential for life safety risk including the potential for the loss of human life and immediate health impacts that result from flood conditions as well as to facilities such as medical—hospitals, critical care units, helipads for medical; concentrated overnight places– nursing homes, motels; administrative coordination and assistance facilities. It also includes an assessment of the ability to maintain evacuation routes such as road systems leaving major population centers during flood events. Levees with lower geotechnical performance (higher probability of failure prior

to overtopping) were considered to have higher life safety risk due to unexpected failure. A qualitative assessment of life safety was also conducted during the VE study.

Property Damages

This criterion focuses on flood damage benefits which account for the reduction of flood damages to property. Property includes, for example, buildings, economic assets, and loss of standing crops and livestock in agriculture. Each alternative was qualitatively rated based on the geographic distribution of damageable property and the estimated 1/100, 1/200, and 1/500 AEP residual floodplains for the alternative. The analysis was based on a conceptual level of detail.

Critical Infrastructure Damages

This criterion focuses on the potential for impacts to critical infrastructure such as power plants; transportation– road, rail, and air; power– energy supply and distribution systems, including oil; communications– telecommunications network including; public health services– regional healthcare facilities; and water supply and treatment facilities.

Design Capacity Exceedance

Design capacity exceedance measures the remaining flood risks after project measures are constructed that are above and beyond those risks being addressed by the project. This criterion also considers the issue of levee superiority to manage residual risk of catastrophic failures and measures the consequences to life and property if a given alternative's design is exceeded.

Minimize Growth Inducement (Wise Use of Floodplain)

This criterion considers the characteristics of the alternative which could encourage or facilitate growth in the floodplain in an unwise manner. Each alternative was qualitatively rated based on the degree to which the alternative would discourage development in the most high risk areas of the floodplain.

Sustainability

This criterion is a measure of the extent to which future funds and effort will be required to sustain the project measures provided. It is defined as developing and protecting the constructed measures in a manner that enables people to meet current needs and provides that future generations can also meet future needs, from the joint perspective of environmental, economic and community objectives.

Ecosystem Functionality

Ecosystem functionality is a measure of the project's ability to maintain or enhance the natural environment to support a functioning ecosystem. This criterion includes an assessment of the opportunities for riparian and wetland habitat preservation and restoration as well as the efforts to minimize impacts to environmentally sensitive areas adjacent to floodplain such as the riparian forest, oak woodland, and giant garter snake habitats . The criterion also considers the restoration or preservation of natural riverine processes in the floodplain. A wider river channel would also

contribute to improvements in fish habitat. Alternatives should restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities.

Minimize Environmental Impacts

This criterion focuses on the project's temporary and permanent impacts to the environment. It includes the preservation of the existing floodplain and avoiding adverse effects on air quality, water quality, and other resources. Land disturbance outside the existing levee footprint should be minimized. The criterion also considers the loss of farmland and impacts to existing structures.

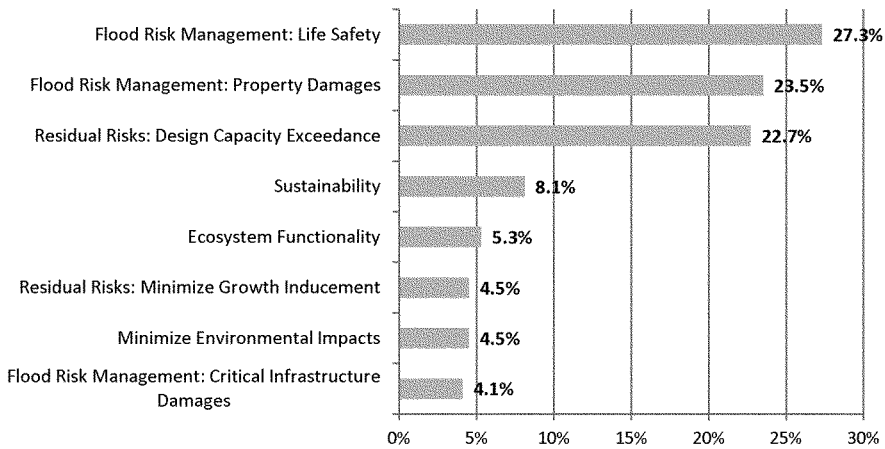
Prioritize Performance Attributes

The performance attributes of a project are seldom of equal importance. Therefore, a systematic approach must be utilized in order to determine their relative importance in meeting the project's need and purpose.

Once the performance attributes were defined and their scales developed, the Project Team and stakeholders prioritized them based on their relative importance to the project. The Analytic Hierarchy Process (AHP) was utilized in the prioritization process. The performance attributes were systematically compared in pairs, asking the question: "An improvement to which attribute will provide the greatest benefit relative to the project's need and purpose?" Participants were then asked to indicate their priorities and the relative intensities of their preferences. The following chart provides the results of this analysis and includes the complete breakdown of the priorities, expressed as a percentage of the whole.

It is important to note that this section describes discussion during the VE study and may not reflect SBFCA, State of California, or USACE policy.

Performance Attribute Prioritization



Performance Attributes Prioritization Rationale

The following information was captured during the performance attribute prioritization process as a means of documenting why a particular attribute was chosen over another and the rationale of the VE Study participants for the priorities indicated above.

Flood Risk Management vs. Residual Risks

Priority is in favor of Flood Risk Management.

Flood risk management is the primary purpose of the project. All alternatives assume a certain level of long-term residual risks, to one level or another. The more that is done under flood risk management, the lower the residual flood risks (but possibly more growth inducement). State floodplain management plans should address growth inducement. The priority still needs to be "fix what is there now". The selected alternative cannot protect people/property outside the project area, and there will be events that will exceed the design that will affect people/property present now. The selected project could provide a lower level of flood risk protection in order to discourage unintended use of land in the future. There is an interest in preserving the rural economy, but this is not fully addressed in the plan where protection of urbanized areas takes priority. By not fixing the levees, for example, one may be unintentionally inducing growth and development in floodplain areas outside the project boundaries.

Flood Risk Management vs. Ecosystem Functionality

Priority is in favor of Flood Risk Management.

Flood risk management is the primary purpose of the project and that ecosystem functionality is a secondary purpose/function. As it relates to life safety, flood risk management takes full priority over ecosystem restoration.

Flood Risk Management vs. Sustainability

Priority is in favor of Flood Risk Management.

Flood risk management is the primary purpose of the project. However, to optimize flood risk management, sustainability must be considered a component of the plan and design. If the alternative does not meet the goal of flood risk management, it does not matter if it is sustainable.

Flood Risk Management vs. Minimize Environmental Impacts

Priority is in favor of Flood Risk Management.

Flood risk management is the primary purpose of the project. Large easements for new or setback levees could be a significant impact to the environment, but would not impede the selection of this approach, if appropriate. In some cases, the socioeconomic impacts need to be considered.

Residual Risks vs. Minimize Environmental Impacts

Priority is in favor of Residual Risks.

All alternatives assume a certain level of long-term residual risks, to one level or another. Each alternative has a very different type and level of residual risks that need to be considered in the alternative selection process. Environmental impacts can be mitigated, especially if unavoidable. Likewise, some residual risks are unavoidable. Economic evaluations of alternatives take into account property damages, etc., but do not account for life loss, which could be significant when associated with the residual risks. Wise use of the floodplain is a basic requirement of the decision making process. This should be addressed by the State Floodplain Management Plan.

Residual Risks vs. Ecosystem Functionality

Priority is in favor of Residual Risks.

The long-term residual risk conditions needs to be of greater importance since the ecosystem is currently performing well. Since the project driver is flood risk management, long-term conditions is a component of such management and should be weighted greater than ecosystem functionality which is supported in conjunction with risk management.

Residual Risks vs. Sustainability

Priority is in favor of Residual Risks.

All alternatives assume a certain level of long-term residual risks, to one level or another. An increase in sustainability should correspond to a reduction in residual risks. In many cases, the project does not have control of residual risks whereas there is control of sustainability. In theory, all levees fail eventually, and there is some control over what will be the residual impact when this event occurs. Additional design components added to a concept could reduce the residual risks, but at additional cost. Also, if an area is outside the protection of the system, it is considered outside of the evaluation of this project. Residual risks relative to property damage are considered in the economic analysis of without project, but not the residual risks associated with life loss.

Ecosystem Functionality vs. Sustainability

Priority is in favor of Sustainability.

Need to have ecosystem functionality in order to have sustainability for future generations. The longevity of the system from an operational point of view, and the need to keep the system operational, is important.

Ecosystem Functionality vs. Minimize Environmental Impacts

Priority is in favor of Ecosystem Functionality.

In general, there is a close balance between the two attributes, where there may be some disturbance of the environment, there would be some benefits to the attributes. But it is better to

minimize damages rather than take aspects from an alternative – that is "do no harm" (which would benefit the ecosystem restoration). There was some opinion that minimizing environmental impacts were really cost issues.

Sustainability vs. Minimize Environmental Impacts

Priority is in favor of Sustainability.

Significant and unavoidable impacts still exist. The level of effort to keep the project operational is paramount, regardless of the impacts to the environment. If the project cannot be sustained, the environmental impacts could be very large.

Sub-attributes under Flood Risk Management

Property Damages vs. Life Safety

Priority between Property Damages and Life Safety is nearly equal, but leans toward Life Safety.

The Corps makes its decision based on the economics of damages. The project must be economically justified. Life safety has not displaced economic considerations. In a post-Katrina world, more emphasis is being placed on life safety, and decisions are being tailored to incorporate life safety to a greater degree. The USACE has made the case of selecting a larger plan with lower net benefits (where the economic NED plan was lower), but it could be justified based on life safety. A levee failure may not have a large life loss impact but property damage could be significant.

Property Damages vs. Critical Infrastructure Damages

Priority is in favor of Property Damages.

Critical infrastructure relates to overall health and welfare of public that is derived from the continued operation of these regional facilities. To some extent, it also impacts life safety (e.g. hospitals, fire protection, etc.). But, the Corps makes its decisions based on economics of damages. The project must be economically justified. Primary drivers of the system are based on National Economic Development (NED) decisions using the other factors as modifiers to enhance the NED.

Life Safety vs. Critical Infrastructure Damages

Priority is in favor of Life Safety.

Both are modifiers of property damage (NED decision), but life safety is a more important modifier.

Sub-attributes under Residual Risks

Minimize Growth Inducement vs. Design Capacity Exceedance

Priority is in favor of Design Capacity Exceedance.

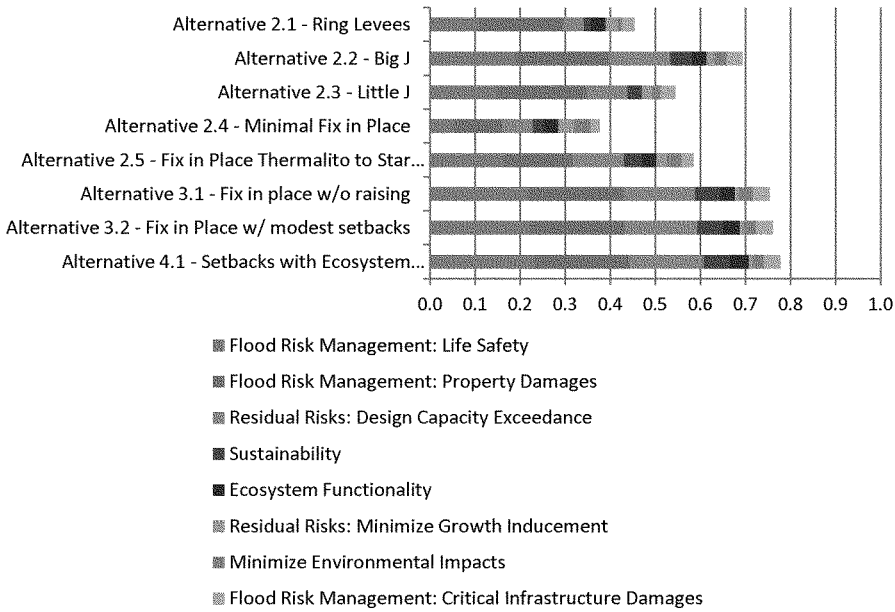
Unwise use of land includes growth inducement. Unprotected life and property is that which remains in areas that are outside the protected areas within the project boundaries. "If you build it, they will

come", but this can be controlled by zoning and floodplain ordinances. It does little good to address a problem in the short term that becomes a bigger problem in the long term. The long term effects represented by the damage caused by an event above and beyond the design capacity should be more important. SB 5 would not allow unwise use of floodplain land in urban or urbanizing areas. But if the 1/200 level of flood protection is constructed, there would no longer be a requirement to prevent growth in the area. Within protected areas, added residual risks can also be experienced from added development as well as flood events that exceed the design.

Measure Performance of Baseline Concepts

The project team and stakeholders evaluated the performance of the Baseline Concepts relative to performance attributes described above. The total performance scores reflect the performance rating for each attribute multiplied by its overall priority (weight) expressed using a ratio scale. A total performance score of "1" would indicate the highest level of desired performance (i.e., "ideal" performance). The chart below compares the total performance scores for the Baseline Conceptual Alternatives.

Comparison of Performance



The information below reflects the performance ratings and associated rationale for each attribute.

RING LEVEES ALTERNATIVE (Alternative 2.1)

Cost

The total estimated first cost of this alternative is $582 to 1,248 million. A breakdown of approximate first cost for each ring levee is provided below.

Measure S1 (Biggs Ring Levee): $60 to $129 million
Measure S2 (Gridley Ring Levee): $95 to $204 million
Measure S3 (Live Oak Ring Levee): $82 to $177 million
Measure S4 (Yuba City Ring Levee): $313 to $671 million

Life Safety

This alternative would reduce flood risk for a majority of the concentrated population and property within Yuba City, Live Oak, Gridley, and Biggs. Locations outside of the ring levees (non-urban areas) would not receive flood reduction benefits from the ring levees. However, these areas are relatively low in population density. The ring levee around Yuba City would include a reach of the Feather River levee system. Thus, there would only be one line of protection around Yuba City versus two lines of protection provided by the ring levees of the other communities. A drawback of this alternative is that ring levees would rely on flood gates and other measures at crossings with railroads and roadways that would need to be actively operated in order to be effective. This alternative would also require access to evacuation routes. An evacuation plan would be included as a nonstructural measure for this alternative to address life safety.

Property Damages

This alternative provides flood risk reduction to key urban development areas, thus property damages from flood events would be minimized. The ring levees around the four urbanized communities would reduce the flood risk for much of the property within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. Based on estimated net benefits, Yuba City is the only potentially economically justified increment.

Critical Infrastructure Impacts

Ring levees would reduce flood risk for key regional facilities and other critical infrastructure within the ring levees, but would not reduce the risk of flooding of roadways and railroads outside of the ring levees.

Design Capacity Exceedance

If design capacity was exceeded, the interior of the ring levees would flood rapidly, which could result in loss of life. In addition, the ring levee around Yuba City would include a reach that is part of the

Feather River levee system. Thus, there would be only one line of protection for Yuba City versus two layers from the ring levees of the other three communities.

Minimize Growth Inducement (Wise Use of Floodplain)

This alternative would limit growth of local communities and future regional growth, while allowing in-fill and redevelopment within the existing developed area.

Sustainability

This alternative would require maintenance of pump stations and closure structures to ensure effective continued operation and flood risk management for the ring levees. In addition, this alternative would require maintaining the existing levees within the study area, which are currently at risk of failure due to through-seepage and underseepage. Maintenance of new ring levees would also be required. However, the maintenance requirements of new levees would be less than existing levees because they would be constructed on new foundations and to modern engineering standards.

Ecosystem Functionality

Opportunities may exist for ecosystem restoration near the reaches of levee at Yuba City that would be incorporated into the Yuba City ring levee. There are few opportunities for ecosystem restoration associated with the other ring levee locations. Constructing new ring levees may impact existing functionality.

Minimize Environmental Impacts

This alternative preserves the existing floodplain while minimizing the potential for future growth and associated adverse effects on air quality and other resources. However, this alternative has the potential to conflict with local land use plans. Construction of the ring levees would require multiple railroad crossings as well as crossings of two significant drainage canals in Yuba City. Significant borrow material would be required for construction of the new levees. Direct and indirect impacts associated with this alternative could affect environmentally and culturally sensitive areas. In addition, construction of the levees would occur in urban areas that are more susceptible to air and noise quality impacts. Ring levees would also separate the communities of Yuba City, Live Oak, Gridley, and Biggs from their surrounding supporting areas and would result in aesthetic impacts by disrupting existing viewsheds. Pump stations would have to be operated periodically, which may result in air quality and noise impacts. There may also be HTRW issues associated with new levee alignments.

BIG "J" LEVEE ALTERNATIVE (Alternative 2.2)

Cost

The total estimated first cost of this alternative is $703 to $1,506 million.

Life Safety

This alternative would reduce flood risk to the majority of the population and property within the study area. Areas in the southern portion of the study located below the Big "J" cross-levee would be located within the 1/100 AEP floodplain. No actively operated closures would be necessary to maintain this alternative. All existing evacuation routes would be maintained.

Property Damages

This alternative would capture approximately 93% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. The benefits would be limited by the performance of the Sutter Bypass levees, which have a lower performance than the Feather River levees.

Critical Infrastructure Impacts

This alternative would provide flood risk reduction for hospitals, power plants, and other critical infrastructure within the study area, but would not reduce risk for all critical roadways within study area limits.

Design Capacity Exceedance

If design capacity was exceeded, the evacuation route on westbound Route 20 would be impacted. Flood depths would be greater due to the height of the southern cross levee south of Yuba City. The flood depths within the urbanized area of Yuba City would increase at a faster rate due to changes in the location of floodplain storage. Areas in the southern portion of the study area (below Sutter Bypass levee) would remain at high risk to flooding.

Minimize Growth Inducement (Wise Use of Floodplain)

This alternative reduces flood risk in Yuba City and other communities, which would allow for growth in existing urbanized areas. The cost of complying with the floodplain regulations could limit growth in the study area outside the Big J levee.

Sustainability

This alternative would result in reduced maintenance on the majority of existing levees along the Feather River, which are currently at risk of failure due to through-seepage and underseepage. New cross-levees for this alternative would be constructed on new foundations and to modern engineering standards. In addition to the maintenance required for the existing levees, these new reaches would require additional maintenance.

Ecosystem Functionality

Opportunities exist for ecosystem restoration within the segments of this alternative that include existing levees. There are few opportunities for ecosystem restoration on other segments of this

alternative. Constructing cross-levees may invade existing functioning ecosystems. Preserving existing levees may allow for future ecosystem restoration projects.

Minimize Environmental Impacts

Construction of the new cross levee associated with this alternative would directly impact farmland and potential sensitive habitat areas. Construction impacts would be limited where land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. The alternative would also require crossing two significant drainage culverts in Yuba City and significant borrow material to construct new levee reaches. Construction of cutoff walls could potentially disrupt groundwater flows. Potential HTRW issues exist for new levee alignments. The alternative would include construction of levee reaches in urban areas, which are more susceptible to air and noise quality impacts. These new levee reaches would result in aesthetic impacts by disrupting existing viewsheds. This alternative would also separate the agricultural areas in the southern portion of the study area from the communities located in the northern portion.

LITTLE "J" LEVEE ALTERNATIVE (Alternative 2.3)

Cost

The total estimated first cost of this alternative is $560 to $1,201 million based on a reconnaissance level of detail.

Life Safety

This alternative would reduce flood risk to the majority of the population and property within the study area due to the population density in Yuba City. Areas in the southern portion of the study located below the Little "J" cross-levee would remain at risk of flooding. This alternative would impact the evacuation route on westbound Route 20 and two major drainage areas in Yuba City.

Property Damages

This alternative would capture approximately 93% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk.

Critical Infrastructure Impacts

This alternative reduces the risk of flooding for hospitals, power plants, and other critical infrastructure within the study area, but does not reduce risk for certain roadways within project limits.

Design Capacity Exceedance

If design capacity was exceeded, the evacuation route on westbound Route 20 and two major drainage areas in Yuba City would be impacted. Areas in the southern portion of the study area

(below Sutter Bypass levee) would remain at risk to flood. The area north of the Little "J" levee would capture flood waters from the breach resulting in greater depths and faster stage increases.

Minimize Growth Inducement (Wise Use of Floodplain)

This alternative reduces flood risk in Yuba City and other communities, which would allow for growth in existing urbanized areas. It provides limited flood risk reduction in all other parts of the study area, which could limit future growth. It focuses development in areas designated or already developed in lieu of encouraging development scattered through floodplain.

Sustainability

This alternative would result in reduced maintenance on the majority of existing levees along the Feather River, which are currently at risk of failure due to through-seepage and underseepage. New cross-levees for this alternative would be constructed on new foundations and to current engineering standards. In addition to the maintenance required for the existing levees, the new levee reaches would require additional maintenance. This alternative would also require maintenance of pump stations and closure structures to ensure effective continued operation and flood risk management.

Ecosystem Functionality

Opportunities exist for ecosystem restoration within the reaches of this alternative that include existing levees. There are few opportunities for ecosystem restoration on other reaches of this alternative. Constructing cross-levees may invade existing functioning ecosystems. Preserving existing levees may allow for future ecosystem restoration projects.

Minimize Environmental Impacts

Construction of the new cross levee associated with this alternative would directly impact farmland and potential sensitive habitat areas. Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. The alternative would also require crossing two significant drainage systems in Yuba City and significant borrow material to construct levee reaches. Construction of cutoff walls could potentially disrupt groundwater flows. Potential HTRW issues exist for new levee alignments. The alternative would include construction of levee reaches near urban areas, which are more susceptible to air and noise quality impacts. These new levee reaches would result in aesthetic impacts by disrupting existing viewsheds. This alternative would also separate the agricultural areas in the southern portion of the study area from the communities located in the northern portion.

MINIMAL FIX-IN-PLACE ALTERNATIVE (Alternative 2.4)

Cost

The total estimated first cost of this alternative is $177 to $381 million based on a reconnaissance level of detail.

Life Safety

This alternative would reduce flood risk to some portions of Yuba City and surrounding areas, but would not reduce flood risk for the communities in the northern study area (Live Oak, Gridley, and Biggs) and some portions of Yuba City. This alternative addresses high life risk areas south of the Yuba River and Feather River confluence and in Yuba City. In the event of flooding, the eastbound SR-20 evacuation route would be accessible, but evacuation routes SR-99 and Westbound SR-20 would be cut off.

Property Damages

This alternative would provide flood risk reduction to approximately half of Yuba City, which includes approximately 77% of the total property within the study area. It would provide some protection to agricultural lands. The alternative would capture approximately 29% of total benefits within the study area. Compared to the other structural alternatives, it would provide the least amount of flood risk reduction and expose the maximum amount of property to potential damage.

Critical Infrastructure Impacts

The alternative would not provide flood risk reduction for all key critical infrastructure (hospitals, power plants) and would not provide flood risk reduction for roadways or railroads within the study area.

Design Capacity Exceedance

Given the limited extent of levee improvements, it is anticipated that design capacity would be exceeded on a frequent basis. In the event of flooding, the eastbound SR-20 evacuation route would be accessible, but evacuation routes SR-99 and Westbound SR-20 would be cut off. The alternative would not result in the ponding issues caused by the cross-levees in the J-levee alternatives.

Minimize Growth Inducement (Wise Use of Floodplain)

This alternative reduces flood risk in approximately half of Yuba City. It does not provide flood risk reduction in all other parts of the study area, which could limit future growth.

Sustainability

Compared to the other structural alternatives, this alternative would result in the minimum amount of existing levees being improved. Thus, maintenance efforts for existing levees would be greater as compared to the other alternatives. It is assumed that new or improved levees constructed to current standards will require less maintenance than existing levees. However, the alternative would not add any additional reaches of levees to be maintained.

Ecosystem Functionality

Opportunities exist for ecosystem restoration along existing levees. Preserving existing levees may allow for future ecosystem restoration projects.

Minimize Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows.

FIX-IN-PLACE THERMALITO TO STAR BEND ALTERNATIVE (Alternative 2.5)

Cost

The total estimated first cost of this alternative is $422 to $905 million based on a reconnaissance level of detail.

Life Safety

This alternative would provide a consistent level of flood risk reduction to northern areas and communities within the study area, including Yuba City. It would not provide flood risk reduction from an event in the western portion of the study area. Due to the downstream levee height and its impacts on backwaters, there is an inflection point on improving the levees to address life safety south of Star Bend. This alternative would preserve eastbound SR-20 as an evacuation route, but would cut off SR-20 westbound and SR-113 as evacuation routes.

Property Damages

The alternative would capture approximately 79% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk.

Critical Infrastructure Impacts

This alternative would reduce risk for the majority of hospitals, power plants, and other critical infrastructure within the study area, but would not reduce risk for certain roadways.

Design Capacity Exceedance

It is anticipated that design capacity would be exceeded on a frequent basis. However, the levees along the northern segments of the Feather River would be improved and the probability of potential breaches would decrease. This alternative would preserve eastbound SR-20, but would cut off SR-20 westbound and SR-113 as evacuation routes. The alternative would not result in the ponding issues caused by the cross-levees in the J-levee alternatives. However, deep ponding in the southern portion of the study area would exist.

Minimize Growth Inducement (Wise Use of Floodplain)

This alternative would provide flood risk reduction to a significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development in these areas. By reducing risk to the existing urbanized areas, it focuses development in areas designated or already developed in lieu of encouraging development scattered through floodplain.

Sustainability

This alternative would improve reaches of existing levees that currently have issues related to underseepage and through-seepage, thus reducing maintenance requirements. The alternative would not add any additional levees to be maintained. The Sutter Bypass levees and Feather River levees below Star Bend would not be improved and maintenance requirements are anticipated to remain the same.

Ecosystem Functionality

Opportunities exist for ecosystem restoration along existing levees. Preserving existing levees may allow for future ecosystem restoration projects.

Minimize Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows.

FIX-IN-PLACE WITHOUT RAISING ALTERNATIVE (Alternative 3.1)

Cost

The total estimated first cost of this alternative is $737 to $1,579 million based on a reconnaissance level of detail.

Life Safety

This alternative would provide flood risk reduction to most of the study area, including Yuba City, Live Oak, Gridley, and Biggs. In comparison to the previous alternatives, it would also reduce flood risk in the southern part of the study area. However, it would not provide flood risk reduction from an event in the western portion of the study area. This alternative would preserve SR-20 and SR-113 as evacuation routes.

Property Damages

The alternative would capture most of the total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk.

Critical Infrastructure Impacts

The alternative would reduce risk for hospitals, power plants, and other critical infrastructure as well as roadways and railroads within the study area.

Design Capacity Exceedance

This alternative would provide flood risk reduction to most of the study area. Flooding from an event that exceeded the design capacity would be similar to the existing (without-project condition). This alternative would preserve SR-20 and SR-113 as evacuation routes.

Minimize Growth Inducement (Wise Use of Floodplain)

This alternative would provide flood risk reduction to a significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development to these areas. However, existing building codes and land use restrictions could limit future growth.

Sustainability

This alternative would improve the majority of reaches of existing levees, thus reducing maintenance requirements. The alternative would not add any additional levees to be maintained.

Ecosystem Functionality

Opportunities exist for ecosystem restoration along existing levees. Preserving existing levees may allow for future ecosystem restoration projects.

Minimize Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows.

PRIMARILY FIX-IN-PLACE W/ MODEST SETBACKS ALTERNATIVE (Alternative 3.2)

Cost

The total estimated first cost of this alternative is $882 to 1,900 million based on a reconnaissance level of detail.

Life Safety

This alternative would provide flood risk reduction to most of the study area, including Yuba City, Live Oak, Gridley, and Biggs. It would reduce flood risk in the southern part of the study area, but would not provide flood risk reduction from an event in the western portion of the study area. This

alternative would preserve SR-20 and SR-113 as evacuation routes. Setback levees would reduce the water surface elevation. There would be a marginal factor of safety improvements due to setback levees being built on new foundations.

Property Damages

The alternative would capture almost 100% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk.

Critical Infrastructure Impacts

The alternative would reduce risk for hospitals, power plants, and other critical infrastructure as well as roadways and railroads within the study area.

Design Capacity Exceedance

This alternative would provide flood risk reduction to most of the study area. It would not create the ponding issue that would be caused by the cross-levees of the Big "J" and Little "J" alternatives and would provide more area for ponding in the southern portion of the study area. In comparison to the previous alternatives, it would also reduce flood risk in the southern part of the study area. However, it would not provide flood risk reduction from an event in the western portion of the study area. This alternative would preserve SR-20 and SR-113 as evacuation routes. Setback levees would allow levees to withstand erosion during design exceedance better than fixing the existing levees in place.

Minimize Growth Inducement (Wise Use of Floodplain)

This alternative would provide flood risk reduction to a significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development to these areas. However, existing building codes and land use restrictions could limit future growth.

Sustainability

This alternative would improve the majority of reaches of existing levees, thus reducing maintenance requirements. Setback levees would be constructed on new foundations and to latest engineering standards, thus reducing maintenance efforts. Setback levees would have access points and distances to allow maintenance vehicles access.

Ecosystem Functionality

Levee setbacks would create opportunities for restoration of riparian and wetland habitats within the setback areas (approximately 700 acres). A wider river channel would contribute to improvements in fish habitats.

Minimize Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows. Where setback levees are proposed, construction may require removal or relocation of structures and include conversion of farmland to upland, riparian or wetland habitats.

SETBACKS WITH ECOSYSTEM RESTORATION ALTERNATIVE (Alternative 4.1)

Cost

The total estimated first cost of this alternative is $1,543 to $3,308 million based on a reconnaissance level of detail.

Life Safety

This alternative would provide flood risk reduction to most of the study area, including Yuba City, Live Oak, Gridley, and Biggs. It would reduce flood risk for most of the study area. This alternative would preserve SR-20 and SR-113 as evacuation routes. Setback levees would reduce the water surface elevation. There would be a marginal factor of safety improvement due to setback levees being built on new foundations.

Property Damages

The alternative would capture almost 100% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk.

Critical Infrastructure Impacts

The alternative would reduce risk for hospitals, power plants, and other critical infrastructure as well as roadways and railroads within the study area.

Design Capacity Exceedance

This alternative would provide flood risk reduction to most of the study area. It would not create the ponding issue that would be caused by the cross-levees of the Big "J" and Little "J" alternatives and would provide more area for ponding in the southern portion of the study area. In comparison to the previous alternatives, it would also reduce flood risk in the southern part of the study area. However, it would not provide flood risk reduction from an event in the western portion of the study area. This alternative would preserve SR-20 and SR-113 as evacuation routes. Setback levees would allow levees to withstand erosion during design exceedance better than fixing the existing levees in place.

Minimize Growth Inducement (Wise Use of Floodplain)

This alternative would provide flood risk reduction to a significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development to these areas. However, existing building codes and land use restrictions could limit future growth.

Sustainability

This alternative would improve the majority of existing levees, thus reducing maintenance requirements. Setback levees would be constructed on new foundations and to latest engineering standards, thus reducing maintenance efforts. Setback levees would have access points and distances to allow maintenance vehicles access.

Ecosystem Functionality

Levee setbacks would create opportunities for restoration of riparian and wetland habitats within the setback areas (approximately 4,100 acres). A wider river channel would contribute to improvements in fish habitats.

Minimize Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows. Where setback levees are proposed, construction may require removal or relocation of structures and include conversion of farmland to upland, riparian, and wetlands habitats.

Compare Value

The cost elements were compared and normalized for the Baseline Conceptual Alternatives using the following table. The table illustrates how cost scores were derived. In this comparison, a lower score is desirable as the project will benefit from lower costs.

Strategies	Cost	Score
Alternative 2.1 - Ring Levees	$853,900,000	0.101
Alternative 2.2 - Big J	$1,070,900,000	0.126
Alternative 2.3 - Little J	$839,200,000	0.099
Alternative 2.4 - Minimal Fix in Place	$267,000,000	0.031
Alternative 2.5 - Fix in Place Thermalito to Star Bend	$651,800,000	0.077
Alternative 3.1 - Fix in place w/o raising	$1,157,400,000	0.136
Alternative 3.2 - Fix in Place w/ modest setbacks	$1,376,900,000	0.162
Alternative 4.1 - Setbacks with Ecosystem Restoration	$2,273,500,000	0.268
TOTAL	**$8,490,600,000**	**1.000**

Once relative scores for performance and cost have been derived, the next step is to synthesize a value index for the Baseline Conceptual Alternatives. The basic equation for value is:

$$Value = \frac{Performance}{Cost + Time}$$

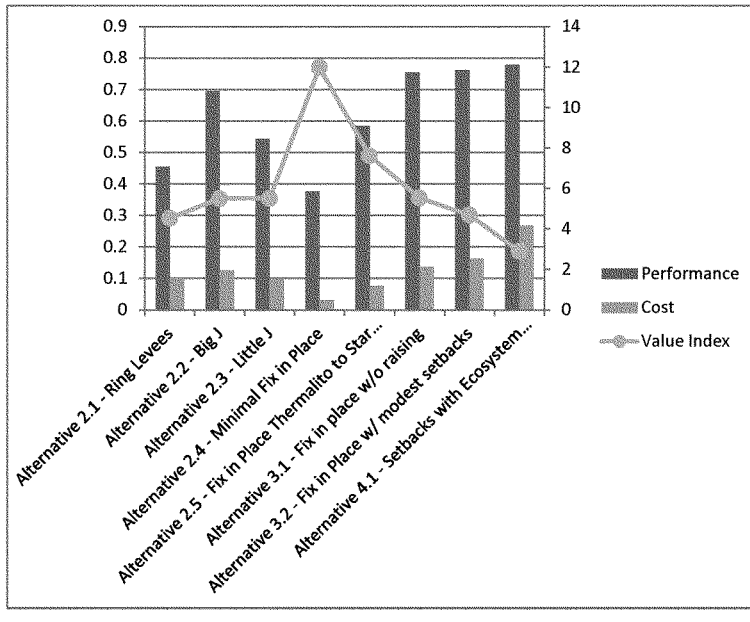
A Value Matrix was prepared which facilitated the comparison of the Baseline Conceptual Alternatives by organizing and summarizing this data into a tabular format. The performance scores for each alternative were divided by the total cost scores for each alternative to derive a value index.

Value Matrix

Baseline Conceptual Alternatives

Strategies	Performance Score	Cost/Time Score	Value Index
Alternative 2.1 - Ring Levees	0.456	0.101	4.529
Alternative 2.2 - Big J	0.694	0.126	5.504
Alternative 2.3 - Little J	0.544	0.099	5.505
Alternative 2.4 - Minimal Fix in Place	0.377	0.031	11.989
Alternative 2.5 - Fix in Place Thermalito to Star Bend	0.585	0.077	7.622
Alternative 3.1 - Fix in place w/o raising	0.754	0.136	5.535
Alternative 3.2 - Fix in Place w/ modest setbacks	0.761	0.162	4.693
Alternative 4.1 - Setbacks with Ecosystem Restoration	0.778	0.268	2.906

Comparison of Value – Baseline Conceptual Alternatives



VALUE ENGINEERING

VALUE ENGINEERING

This section documents the Creativity, Evaluation, and Development phases of the VE Study.

CREATIVE IDEA SPECULATION

The VE team generated and evaluated ideas on how to perform the various project functions using other approaches. All of the ideas that were generated during the Speculation Phase using brainstorming techniques were recorded and are included at the end of this section.

VE CONCEPTS

The ideas that the VE team considered of highest potential for value improvement or further consideration are presented as VE Concepts. Each VE Concept consists of a brief description of the suggested change and a narrative comparing the baseline concept with the VE Concept. Given this study was conducted at an early stage of project development, the VE Concepts generated are of a conceptual nature and focus primarily on optimization of the Baseline Conceptual Alternatives array through either incorporating additional flood risk reduction measures and/or modifying the Conceptual Alternatives per lessons learned during the previous workshop exercises (Function Analysis and Value Metrics). The VE team also identified suggested revisions to the Baseline Conceptual Alternative array through the combination of certain alternatives or the elimination of alternatives from further consideration.

VE CONCEPTS SUMMARY

Summary of VE Concepts

VE Concept No. & Description	Disposition	Disposition Comments
Refinement of Measures		
A-1 Adopt State's floodplain development regulations (wise use of floodplain)	Further Study Needed	PDT to review SB-5 for clarification on regulations. Make part of Without Project Conditions or revise project per regulations. Does it have enough teeth to prevent future development or do additional regulations need to be enacted in the Federal Government preferred plan?
A-2 Establish pre-stage flood fighting areas and equipment	Accept	Add as Measure (NS-9) under each Conceptual Alternative
A-3 Coordinate emergency responses to all floodplain (in lieu of by county)	Accept	Revise NS-6 and NS-7 per VE Concept

VE Concept No. & Description	Disposition	Disposition Comments
A-4 Exempt slurry walls from 408 certification process	Further Study Needed	Local sponsor to propose revision of 408 process to USACE
Modifications to Preliminary Conceptual Alternatives		
M-1 Construct ring levee around Yuba City only in lieu of around other urbanized communities	Accept	Alternative 2.1 to be revised and reevaluated accordingly. PDT to identify non-structural measures required for areas not being provided with ring levees.
M-2 Construct evacuation routes for ring levee alternative	Accept	Yuba City has evacuation routes for the ring levee alternative, but these may need to be upgraded or improved to function as evacuation during failure of the ring levee. Consider high ground refuges may function in lieu of evacuation routes.
M-3 Add S-15 (southern relief feature) to Alternatives 2.2, 2.3, 2.4, 2.5	Accept	Concept to be reviewed as an optional supplemental measure to subject Alternatives
M-4 Add measure for Fix in Place for Sutter Triangle area	Accept / Further Study Needed	PDT to review cost of measure. Consider for optional supplemental measure (S-28) for Alternatives 3.1 and 2.2
M-5 Construct hydraulic elevation control in southern part of basin to prevent certification of southern segment levees to 200 years.	Further Study Needed	Hydraulic control already exists for current levee elevations.

Revise Conceptual Alternatives Array		
R-1 Implement non-structural measures across all structural alternatives in lieu of holding independent non-structural alternative	Already Being Done	PDT to review new Alternative 1.2 (Minimal Fix in Place with Non-Structural Measures) to determine scope of work for non-structural measures to evaluate the new alternative.
R-2 Combine Alternative 3.1 and Alternative 3.2 and evaluate as single alternative	Accept	Modest setbacks become optional separate optimizations of Alternative 3.1.
R-3 Eliminate Alternative 4.1 from future consideration	Accept	Concur.
R-4 Revise Alternative 2.1	Accept	Alternative 2.1 to be revised to ring levee around only Yuba City. PDT to identify non-structural measures required for communities not being provided with ring levees.
R-5 Combine Alternative 2.4 with Alternative 2.1 (Nonstructural)	Accept	PDT to review new alternative (Minimal Fix in Place with Non-Structural Measures) to determine scope of work for non-structural measures to evaluate the new alternative.

Revise Conceptual Alternatives Array		
R-6 Eliminate Alternative 2.2 Big J from consideration	Accept	It was recommended that the Big "J" levee be eliminated from further evaluation based on a comparison with the Little "J" levee, which are functionally similar. The Big "J" levee and the Little "J" levee are expected to have similar flood damage benefits. However, the Big "J" levee would be approximately 30% greater in cost based on conceptual cost estimates. Additionally, the benefits associated with the Big "J" levee would be limited by the performance of the Sutter Bypass levees, which have a lower performance than the Feather River levees. The Little "J" levee does not utilize the Sutter Bypass levees and can therefore obtain a higher level of performance. Finally, if the design capacity of the Sutter Bypass reach of the Big "J" levee was exceeded, flood depths would be greater than existing conditions due to the height of the southern cross portion of the "J" levee (south of Yuba City). The flood depths would also increase at a faster rate due to less floodplain storage.

VE CONCEPTS DEVELOPMENT

The following sections include the narrative development of the VE Concepts as they were developed by the VE team. The narratives are provided for the additional information and understanding of the reviewer relative to each idea and are independent of their respective dispositions. After developing the VE Concepts, the VE team reviewed and discussed each VE Concept and developed a consensus relative to its implementation. In some cases, the latter discussion resulted in dispositions of "Further Study Needed" or Rejection of certain concepts altogether. As such, some concepts included below were not implemented into the project's development, but are included for information purposes only. The disposition decision of each VE Concept as determined by the VE Team is provided in the preceding table.

REFINEMENT OF MEASURES

A-1 Adopt State floodplain development regulations (wise use of floodplains). Institute state and local ordinances to avoid floodplain development

The State of California has adopted SB-5 which limits development in areas without 200-year level of protection, and is in accordance with FEMA regulations. The State and local government also have restrictions on floodplain development within Title 24 (California Building code). If the Corps selected plan provides less than 200-year protection to areas with deep flooding depths (e.g. south of Yuba City), the result would be that State law would prevent additional development in the deeper portions of the floodplain, allowing the Corps to address the wise use of floodplains directed by E.O. 11988.

A-2 Establish stage flood fighting areas and equipment

One or more secured area will be identified and stocked with appropriate flood fighting supplies, including lighting, flares, and equipment to allow working at night. Stockpiles of geotextile fabric, sand for fill, and rip-rap of various sizes must be available. The following should also be considered:

- A rapid flood fighting response cache including trained local response force capable of containing a levee breach.
- Coordinated communications efforts with California National Guard and local law enforcement must be planned for and accomplished for traffic control during evacuation.
- Coordination with local and state emergency response authorities to evacuate immediate area needs to be in place.
- USACE must assure that these measures have been planned, documented and exercised for this feasibility study.
- Reduce response time hence improve performance level (lower damages and life loss when failure occurs).

A-3 Coordinate emergency responses to all floodplain (in lieu of by county)

Emergency response will include evacuation authority directives. The flood warning system will be coordinated with Butte and Sutter Counties. A coordinated response protocol directed for information dissemination will be developed and exercised between city EMS, county EMS and State EMS offices. Appropriate decision makers will be identified and documented at the city, county, regional, state, and federal levels. Direct lines of communication will be established with decision makers to assure prompt response effort. Response operation orders will be established, and assignments and responsibilities in order to direct residents and non-residents to the most appropriate evacuation routes. USACE will assure the presence and adequacy of local, emergency response plans and assure that coordination has occurred with state and federal counterparts.

A-4 Exempt slurry walls from 408 certification process

Exempting slurry walls from the Section 408 process implies that the modifications would be reviewed under the Section 208 process. The distinction between Section 208 and 408 is that for a project to be modified under 208, it must not change hydraulics or the structural geometry of the levee, and approval of the 208 may be made by the District Engineer, otherwise approval at HQ level is required. The result would be potentially lower costs to the sponsor in form reduced effort of review by the Corps. Changes to the process require changes in USACE policy; the ability to affect change is beyond the scope of the PDT effort, and likely does not affect the selection of alternatives.

MODIFICATIONS TO PRELIMINARY CONCEPTUAL ALTERANTIVES

M-1 Construct Ring Levee around Yuba City 'only' in lieu of around other urbanized communities

Early parametric analysis leads to preliminary conclusion that smaller rings around Biggs, Gridley and Live Oak are not economical in comparison to the ring levee around Yuba City.

M-2 Construct evacuation routes for ring levee alternative

Ring levees are likely to be perceived by the public as 'refuge' areas and are not likely to be evacuated before a mainstem levee break. Therefore, confined populations are trapped within the rings so at least one evacuation route or high-ground 'refuge' should be included within the ring levee alternative. Several measures have been proposed for this purpose including Hwy 99 Causeway which links all the rings, widened ring levees to serve as high-ground 'refuge', elevated 'critical' structures, and various rescue mechanisms. This alternative is unacceptable without this evacuation route as a 'failure' of the ring levee would quickly inundate the ring and the resulting loss of life would be unacceptable.

M-3 Add Measure S-15 (southern relief structure) to Alternatives 2.3, 2.4 & 2.5

The unimproved portions of the levees under these alternatives would still be subject to levee failure, causing deep flooding in the southern portion of the study area. A Relief Structure or Emergency Relief Mechanism could help relieve both stage and duration of deep ponding (20'+).

M-4 Add measure for Fix-in-Place for Sutter Triangle Area

The Right Bank, Wadsworth Canal and Left Bank, Sutter Bypass protect parts of the small town of Sutter. This measure would reduce flood impacts in that area. The area is also subject to flood risks from the Northern Feather River levee breaks. Other measures would address the Feather River Levee Improvements, however, this measure is necessary to protect this area from adjacent levee failures.

M-5 Construct Hydraulic Elevation Control in the Southern part of the basin to prevent/preclude certification of Southern segment levees to 200 years

The southern portion of the basin is agricultural at present and subject to deep flooding. Wise use of the floodplain could be facilitated by improving the levees to less than a 200-year level of protection. State law (SB-5) precludes urbanization in areas where there is less than 200-year level of protection after 2015. Additional local land-use restrictions may also be required to meet this objective.

REVISED CONCEPTUAL ALTERNATIVE ARRAY

R-1 Combine Alternatives 3.1 and 3.2

This new alternative would combine 3.1 (Fix in place without raising) with 3.2 (Primarily fix in place including modest setbacks). The only difference between these two alternatives is the addition of modest setback levees in isolated locations. Therefore, the outputs and the costs of 3.1 and 3.2 are not distinctive enough to warrant carrying them forward as separate alternatives. Any ecosystem restoration opportunities as a result of the setbacks can be considered a first added increment should this new alternative move forward.

R-2 Implement Nonstructural measures across all structural alternatives

A standalone nonstructural alternative does not significantly address project objectives. Therefore, Alternative 1.1 will be modified by combining it with Alternative 2.4. Due to residual risk, nonstructural measures would enhance all project alternatives in achieving objectives and will be added to those alternatives as appropriate. See VE Concept R-5 below.

R-3 Eliminate Alternative 4.1

This alternative is significantly cost ineffective. The additional cost of this alternative compared to combined alternatives 3.1 and 3.2 exceeds the additional restoration benefits. However, if the hydraulic benefits of setting back the Sutter Bypass east levee in combination with other measures upstream and downstream of the study area result in greater system-wide benefits, then this alternative should be revisited.

R-4 Modify Alternative 2.1

Refine Alternative 2.1 by eliminating the individual ring levees around Biggs, Gridley, and Live Oak. The cost of constructing of ring levees around Biggs, Gridley, and Live Oak are significantly greater than the estimated annual benefits could support

The refined alternative consists of constructing a ring levee around Yuba City in combination with nonstructural measures focused on reducing risk in areas outside of the ring levee.

R-5 Combine Alternative 2.4 with Alternative 1.1

USACE policy requires a predominantly nonstructural alternative. This policy requirement could be achieved by adding a new Alternative 1.2 that is a combination of Alternative 2.4 and 1.1.

R-6 Eliminate Alternative 2.2

It was recommended that the Big "J" levee be eliminated from further evaluation based on a comparison with the Little "J" levee, which are functionally similar. The Big "J" levee and the Little "J" levee are expected to have similar flood damage benefits. However, the Big "J" levee would be approximately 30% greater in cost based on conceptual cost estimates. Additionally, the benefits associated with the Big "J" levee would be limited by the performance of the Sutter Bypass levees, which have a lower performance than the Feather River levees. The Little "J" levee does not utilize the Sutter Bypass levees and can therefore obtain a higher level of performance. Finally, if the design capacity of the Sutter Bypass reach of the Big "J" levee was exceeded, flood depths would be greater than existing conditions due to the height of the southern cross portion of the "J" levee (south of Yuba City). The flood depths would also increase at a faster rate due to less floodplain storage.

IDEA EVALUATION

EVALUATION PROCESS

Prior to development the creative ideas were evaluated to determine which ideas would be considered further and developed into VE Concepts. Each idea was evaluated with respect to the functional requirements of the project. Performance, cost, time, and risk were also considered during this evaluation.

Once each idea was discussed, it was given a rating. This is based on a go/no-go approach as indicated by the following rating index. This rating represents the subjective opinion of the VE team regarding the potential benefits of the concepts in order to prioritize them for development. Comments on the VE team's rating rationale are included as well.

1 = Develop	Concept results in performing project functions in a manner that results in increased value potential. Concepts in this rating group were considered relevant to the VE Study's analysis of the Conceptual Alternatives array and level of project development at the time of the study.
2 = Rationale for Rating	Concept is not technically feasible, does not meet project need and purpose, or represents programmatic operations outside of design development. **OR** Concept was considered not relevant to the VE Study and level of project development at the time of the study. Additional information or design development may be required for concept to be fully evaluated. Concepts in this rating group should be considered during later design development stages. Only ideas that were given a rating of 2 include the rationale for the rating.

Ideas rated 1 were developed further and those that were found to have the greatest potential for value improvement for the project were incorporated into the Final Conceptual Alternative Array.

IDEA SUMMARY LIST

Idea No.	Idea Description	Rating	Rating Rationale
1	Construct ring levee around Yuba City only in lieu of around other urbanized communities	1	
2	Extend the minimal fix in place alternative to Star Bend	1	
3	Close the J	2	Technically infeasible
4	Open the J on the southern end	2	Costly without benefit
5	Combine Minimal Fix in Place with ring levees around northern communities	2	Costly without benefit
6	Abandon southern portion of the project and return to natural floodplain	2	Requires further refinement
7	Install sensors in levees to monitor conditions for early warning system	2	Eliminate. Has maintenance issues. Costly
8	Convert SR-20 into causeway to facilitate evacuation	2	Costly
9	Convert SR-113 into causeway	2	Costly
10	Convert SR-99 into causeway	Combine with 24	
11	Extend Sutter Bypass to east	2	Affects beyond the study area, regional, system-wide impacts
12	Convert Cherokee Canal into bypass	2	Costly, affects beyond study area, fish affects
13	Connect Tisdale Bypass to Feather River	2	hydraulically Ineffective, fish passage affects
14	Implement widespread relocations of residences and businesses in project area	2	Costly due to widespread definition
15	Connect East interceptor to Feather River	2	hydraulically Infeasible

Idea No.	Idea Description	Rating	Rating Rationale
16	Construct safe havens / raised islands for area south of Yuba City	2	Consider during project development
17	Institute boat patrols for ring levee alternative	2	Consider during project development
18	Relocate portion of Sutter, CA that is within floodplain	2	
19	Construct structure on Yuba River to create storage	2	Large regional effects
20	Combine Alternative 3.1 and Alternative 3.2 and evaluate as single alternative	1	
21	Combine Alternatives 2.4, 2.5, and 3.1 and evaluate as single alternative	2	Alternatives have distinctiveness and outputs that needs to be demonstrated
22	Add inflatable rubber dam to increase capacity of Oroville	2	Outside of project scope, regional effects, would only provide rare event protection
23	Relocate measure S-24 (Gilsizer Cross Levee) further to north	2	Option of cross-levee alternative, but more costly
24	Construct evacuation routes for ring levee alternative	1	
25	Armor ring levees to resist failure from overtopping	2	Consider during project development
26	Incorporate nonstructural measures to improve Minimal Fix in Place alternative	1	
27	Adopt State's floodplain development regulations (wise use of floodplain). Institute state and local ordinances to avoid floodplain development	1	
28	Establish pre-stage flood fighting areas and equipment	1	
29	Implement housing standards for flood proofing of buildings in floodplain	2	Assumed as part of Without Project conditions
30	Coordinate emergency responses to all floodplain (in lieu of by county)	1	

Idea No.	Idea Description	Rating	Rating Rationale
31	Combine Alternatives 2.2 and 2.3 into single alternative	2	Little J has more significant impacts, residual risks are unique to alternatives
32	Consider removing homes nearest to existing levees	2	Already being considered as measures
33	Incorporate pump stations to enhance flood risk reduction provided by levees	2	Consider during project development
34	Develop plans to implement fuse plugs during flood event	2	Consider during project development
35	Develop plans to breach levees during flood event	2	Consider during project development
36	Consider rapid levee repair measures being developed by ERDC	2	Failures being considered are more significant than rapid repair measures could address
37	Add measure for Fix in Place for Sutter Triangle area	1	
38	Construct setback levee in Yuba City in location of depression (low lying area)	2	Consider during project development, Costly
39	Implement measures to support emergency evacuation (helicopters, trains, etc.)	2	Incorporated into emergency response plan
40	Consider surface berms in areas where development near levees permits	2	Consider during project development
41	Add relief wells	2	Consider during project development
42	Conduct geophysical survey of levees and implement measures to fix underseepage/through-seepage in critical areas only	2	Extent of fixes would be similar to full fix in place
43	Construct hydraulic elevation control in southern part of basin to prevent preclude certification of southern segment levees to 200 years.	1	
44	Convert J alternatives to construct L with gap	2	Hydraulic infeasible, water outflanks it
45	Compartmentalize the basin	2	Consider during future project development,

Idea No.	Idea Description	Rating	Rating Rationale
			optimization option
46	Perform evaluation of existing levees per segment to determine measures in each area	2	Has been completed
47	Allow adaptable fix in place over time to address problem areas as they arise	2	Implementation/phasing strategy of ultimate project solution
48	Exempt slurry walls from 408 certification process	1	
49	Allow slurry walls be constructed wherever needed	Combines with 49	
50	Construct "straight" alignment of offset Feather River levees to reduce O&M	2	Consider as enhancement of S-10, political ramifications need to be considered, new levee is 3 times the cost of fix in place, thus alternative is costly
51	Consider constructing soil cement levees	2	Consider during future project development, optimization option
52	Authorize funds for Sac bank	2	Outside of project scope and addressed by other study
53	Incorporate fuse gates into Ring Levee alternative	2	Design detail
54	Reduce height of northern ring levees to 100 year event	2	Consider during project development
55	Combine ring levee around Biggs and Gridley into single ring	2	Costly, combines "bathtubbing"
56	Elevate structures inside ring levees and promote additional agricultural development outside	2	Costly
57	Transfer ring levees to local authorities	2	Could consider local input to ring levee alignments
58	Use borrow areas from inside ring levees and use for interior storage	2	Could create seepage problems

Idea No.	Idea Description	Rating	Rating Rationale
59	Implement non-structural measures across all structural alternatives in lieu of holding independent non-structural alternative	1	
60	Minimize flood risk reduction measures to areas south of Big J levee to allow agricultural activities under reduced protection	1	
61	Incorporate minimal protection of areas to allow agricultural use without growth inducement	Combine with 61	
62	Fix problem areas identified by PL-8499 program only	1	
63	Add Measure S-15 (Southern Relief Feature) as an option to Alternative 2.2	2	Breach so far south would be self-draining
64	Implement levee overtopping protection in select areas	2	Consider during future project development, considered by current measures
65	Construct transverse hydraulic conveyance measure in lieu of cross-levee	2	Hydraulic infeasible
66	Add S-15 (southern relief feature) to Alternatives 2.3, 2.4, 2.5	1	
67	Expand Gilsizer slough to handle or divert flood waters	2	Hydraulic infeasible
68	Add Measure S-27 (improve upstream fish passage) to Alternatives 3.2	2	Wouldn't change the selection of the measure
69	Include hydraulic control on southern portion of basin into Alternative 3.1 and 3.2	2	Consider during future project development
70	Incorporate additional setback levee locations into Alternative 3.2	2	Consider during future project development
71	Modify Measure S-26 (managed overtopping) to include selective superiority based on geotechnical	2	Design detail

Idea No.	Idea Description	Rating	Rating Rationale
72	Use deep soil mixing in lieu of slurry walls for fix in place measures	2	Design detail
73	Use fly ash slurry in lieu of bentonite slurry for fix in place	2	Design detail
74	Consider structural flood walls in locations of limited ROW	2	Design detail
75	Include Sutter Bypass levee full setback in Alternative 3.1 per CVFPP plan	2	Regional impacts, system-wide effects, relies on others
76	Use relief wells in lieu of levee improvements	2	Design detail
77	Over construct levee crowns to support emergency borrow and safe havens	Combine with 24	
78	Develop evacuation routes to access Sutter Butte during flood event	Combine with 24	
79	Elevate existing roads to serve as interim cross-levees	2	Less expensive to construct adjacent to roads than raise roads
80	Over-widen ring levees	2	Lack of material, costly
81	Allow farming on levees	2	Infeasible and conflicts with policies, only works on over-widened levees
82	Consider secant pile wall for flood wall structures	2	Design detail
83	Use vinyl sheetpile for flood wall structures	2	Design detail
84	Create floatable critical structures	2	Technical infeasible
85	Allow all underground parking structures to flood for storage purposes	2	Technical infeasible
86	Use barges for evacuation of people	2	Technical infeasible
87	Instigate penalties for development in floodplain	2	Programmatic issue
88	Put flood insurance into exchange program that pays for	2	Programmatic issue

Idea No.	Idea Description	Rating	Rating Rationale
	improvements		
89	Elevate all critical structures	2	Included in non-structural measure analysis, modify NS-3 to include critical infrastructure
90	Designate and develop natural floodways within project area	2	hydraulically Infeasible
91	Construct bypass in northern portion of project	2	Previously considered and rejected due to cost and fish passage
92	Construct U levee on northeast side of northern communities	2	hydraulically Infeasible due to topography
93	Upgrade and modification of Tisdale weir	2	Regional impacts, system-wide effects, outside of project/study scope
94	Widen and improve Fremont weir	2	Previously dismissed, Outside of project scope, regional effects, requires improvements by others
95	Install measures to improve fish passage on Sutter Bypass	2	Already being done or considered as measure
96	Install control structure at Feather River and Cherokee Canal bypass	2	Control structure only relevant for bypass channel
97	Eliminate Alternative 4.1 from future consideration	1	
98	Eliminate Alternative 2.1 from consideration	1	
99	Eliminate Alternative 2.4 from consideration	1	
100	Combine and optimize Alternative 2.5, 3.1 and 3.2	2	Alternatives have distinctiveness and outputs that needs to be demonstrated
101	Eliminate Alternative 2.3 from consideration	1	
102	Widen Sutter Bypass south of study area and southern portion of project limits to reduce depths	2	Requires improvements outside of project limits, relies on others to implement, downstream impacts

Idea No.	Idea Description	Rating	Rating Rationale
103	Construct new Feather River bridge south of Star Bend	Combines with 24	
104	Forecast reservoir operations to lower stage downstream	2	Regional considerations, impacts water supply
105	Redirect water by altering existing areas, regrade mining tailings	2	Consider during future project development, already being considered
106	Manage hydraulic flows and characteristics in floodway to reduce impacts from floods	2	Consider during future project development, already being considered
107	Manage vegetation to optimize hydraulic conveyance in channels and maintain ecosystem function	2	Consider during future development

VALUE ANALYSIS OF
OF FINAL ALTERNATIVES ARRAY

VALUE ANALYSIS OF FINAL ALTERNATIVES ARRAY

FINAL ALTERNATIVE ARRAY SUMMARY

The following summarizes the scope of work of the final alternatives.

All Alternatives

- Coordinated flood warning and evacuation system
- Pre-staging equipment and flood fighting areas (Measure NS-9)
- Levees surrounding urban and urbanizing areas should consider SB-5 requirement of 1/200 flood risk reduction
- Consider economic and flood risk reduction justification for setback levee alignments and isolated weak spots as supplemental options where feasible

Primarily Nonstructural with Minimal Levee Improvement Reaches

- Improve Feather River Levees from Sunset Weir to Star Bend
- Implement non-structural measures focused on reducing risk to loss of life
- Prioritize properties based upon annualized economic value and flood risk probability to determine which structures get relocated or flood-proofed (likely focused on critical infrastructure and large industrial properties)
- Some evacuation route or refuge area improvements may be necessary

Yuba City Ring Levee

- Construct ring levee around Yuba City
- Implement non-structural measures focused on reducing risk to loss of life
- Mitigations for induced damages resulting from ponding on north side of ring levee
- Some evacuation route or refuge area improvements may be necessary
- Prioritize properties based upon annualized economic value and flood risk probability to determine which structures get relocated or flood-proofed (likely focused on critical infrastructure and large industrial properties)

Little "J" Levee

- Improve Feather River Levees from Thermalito to Shanghai Bend
- Construct partial southern cross-levee
- Construct levee north of cross-levee on west side of Yuba City
- Assume alignment of southern levee to be identical to southern levee of ring levee alternative. Levee alignment will be based upon flood risk reduction of existing development with possible consideration to accommodate sphere of influence

Fix in Place Feather River from Thermalito to Star Bend

- Improve Feather River Levees from Thermalito to Star Bend
- Includes Star Bend setback levee
- Implement non-structural measures focused on reducing risk to loss of life
- Prioritize properties based upon annualized economic value and flood risk probability to determine which structures get relocated or flood-proofed (likely focused on critical infrastructure and large industrial properties)
- Some evacuation route or refuge area improvements may be necessary

Fix in Place Feather River, Sutter Bypass, and Wadsworth Canal

- Improve Feather River Levees from Thermalito to Sutter Bypass Confluence (southern basin)
- Improve Sutter Bypass East Levee from Wadsworth Canal to the Feather River and the Wadsworth Canal East Levee, East Interceptor to the Sutter Bypass
- Includes Star Bend setback levee
- Includes Northern Feather River setback levee
- Improve Wadsworth Canal South Levee
- Optional Sutter Triangle levee improvement
- Consider economic and flood risk reduction justification for setback levee alignments and isolated weak spots as supplemental options where feasible
- Optional consideration of "full" Sutter Bypass East Levee setback

VALUE METRICS

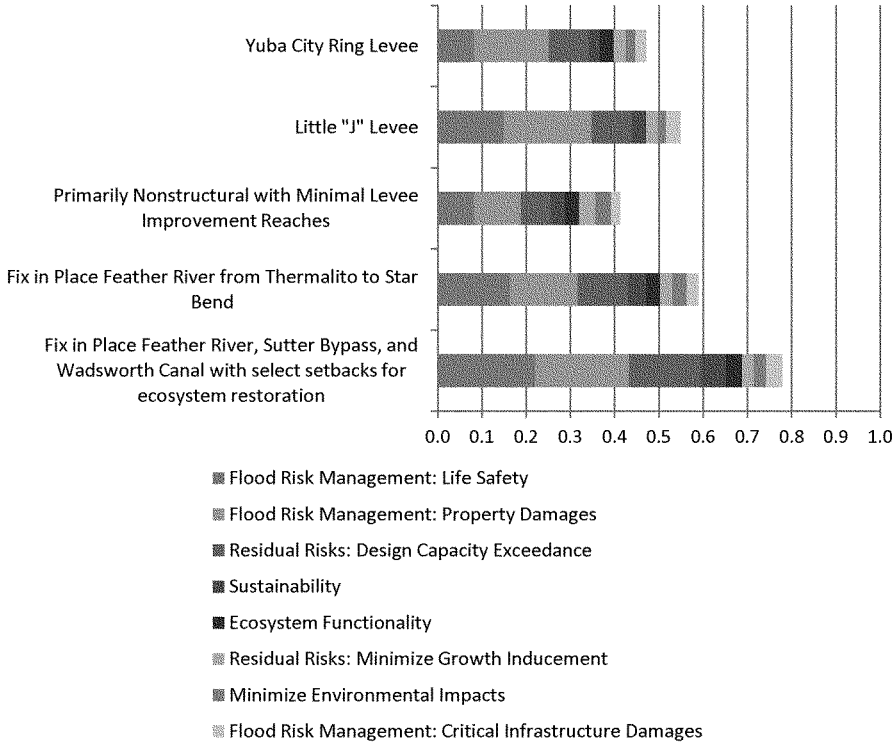
Measure Performance of Final Alternatives

The project team and stakeholders evaluated the performance of the Final Alternatives relative to the performance attributes previously identified.

Compare Performance of Final Alternatives

The total performance scores reflect the performance rating for each attribute multiplied by its overall priority (weight) expressed using a ratio scale. A total performance score of "1" would indicate the highest level of desired performance (i.e., "ideal" performance). The following chart compares the total performance scores for the final alternatives.

Comparison of Performance



The information below reflects the performance ratings and associated rationale for each attribute.

Yuba City Ring Levee

Flood Risk Management: Life Safety
Rating: **3.0**

Rationale: Ring levees protect a majority of the concentrated population and property. Evacuation routes are assumed to be into the areas surrounded by the ring levees, however, it is assumed some measure of evacuation route will be provided. The ring levee around Yuba City is partially part of the Feather River levee system, thus there is only one line of protection (vs. two layers from the ring levees of the other communities). Locations outside of the ring levees are excluded from the additional protection, however, these areas are relatively small in population density. Does not reduce flood risk in areas outside of ring levee (i.e. northern communities of Gridley, Biggs, and Live Oak and southern basin). Ring levees rely on flood gates and other measures at crossings with

railroads and roadways to be actively operated in order to be effective. Pump stations are required to maintain flood protection. Non-structural measures will be implemented to reduce risk to life safety. Any project that relies on the existing levee has a higher life safety risk due to less predictable performance (levees can fail prior to overtopping at any location).

Flood Risk Management: Property Damages
Rating: **7.2**

Rationale: Protects key urban development areas, thus property damages from flood events should be minimized. The ring levees around just Yuba City accounts for protecting 77% of all property values. Some agricultural and some rural structures would still be exposed to flood risk. Captures approximately 72% of total benefits.

Residual Risks: Design Capacity Exceedance
Rating: **4.0**

Rationale: Does not correct deficient flood risk in areas not surrounded by ring levees. Evacuation routes are assumed to be into the areas surrounded by the ring levees, however, it is assumed some measure of evacuation route will be provided. The ring levee around Yuba City is partially part of the Feather River levee system, thus there is only one line of protection (vs. two layers from the ring levees of the other communities). Ring levees may create an exacerbated situation of a catch basin for flood waters when a breach in the levee occurs. Locations outside of the ring levees (non-urban areas) are excluded from the additional protection.

Sustainability
Rating: **3.0**

Rationale: Alternative requires maintenance of pump stations and closure structures to ensure effective continued operation and flood risk management. Ring levees on new alignments would be constructed on new foundations and to modern engineering standards. Requires maintaining existing levees as well as the additional ring levees surrounding Yuba City. Revision to Alternative results in significantly less new ring levees and fewer pump stations and closure structures.

Ecosystem Functionality
Rating: **6.0**

Rationale: Opportunities exist for ecosystem restoration projects on the existing levees at Yuba City where they are combined with the ring levees. There is little opportunity for ecosystem restoration on other portions of the project. Constructing ring levees may invade existing functioning ecosystems. Preserving existing levees may allow future ecosystem restoration projects.

Residual Risks: Minimize Growth Inducement
Rating: **6.0**

Rationale: Limits growth of local communities and future regional growth. The ring levees around northern communities had limited space to allow future development, thus rating did not change when these ring levees were eliminated.

Minimize Environmental Impacts
Rating: **5.0**

Rationale: Preserves the existing floodplain while minimizing the potential for future growth and its adverse effects on air quality and other resources. Conflicts with local land use plans. Protects existing urban development but not areas approved for future growth in local land use plans. Direct impacts from construction could affect environmentally and culturally sensitive areas within the new levee footprint. Ring laves separate the communities from their surrounding supporting areas. Pump stations will have to be operated periodically which may create air quality and noise impacts. Potential HTRW issues on new levee alignments. Construction of levees in urban areas which are more susceptible to air and noise quality impacts. Requires multiple crossings of railroads and crossing two significant drainage culverts in Yuba City. Requires significant borrow material to construct levees. Ring levees would impact the view sheds.

Revision to Alternative results in significantly reduced environmental impacts due to reduced ring levee reaches.

Flood Risk Management: Critical Infrastructure Damages
Rating: **6.0**

Rationale: Ring levees protect medical facilities and other critical infrastructure within the concentrated areas, but do not protect roadways and railroads.

Little "J" Levee

Flood Risk Management: Life Safety
Rating: **5.5**

Rationale: Evacuation route on Westbound Route 20 is cut off. Areas in the southern portion of the project (below Sutter Bypass levee) would remain at risk to flood. Cuts off two major drainage areas in Yuba City.

Flood Risk Management: Property Damages
Rating: **8.4**

Rationale: Captures approximately 84% of total benefits. Ten percent of benefits captured would be agricultural and residual.

Residual Risks: Design Capacity Exceedance
Rating: **4.0**

Rationale: Evacuation route on Westbound Route 20 is cut off. Areas in the southern portion of the project (below Sutter Bypass levee) would remain at risk to flood. Flood depths would be greater (significantly more than 3 feet) and faster due to more concentration of flooding in areas north of Little J levee due to capturing of flood water from upstream levee breach. Cuts off two major drainage areas in Yuba City.

Sustainability
Rating: **4.0**

Rationale: Alternative requires maintenance of pump stations and closure structures to ensure effective continued operation and flood risk management.

Ecosystem Functionality
Rating: **6.0**

Rationale: Opportunities exist for ecosystem restoration projects on the existing levees. There is little opportunity for ecosystem restoration on other portions of the project. Preserving existing levees may allow future ecosystem restoration projects.

Residual Risks: Minimize Growth Inducement
Rating: **6.0**

Rationale: Reduces flood risk to Yuba City and other existing urbanized areas. Focuses development in areas designated or already developed in lieu of encouraging development scattered through floodplain.

Minimize Environmental Impacts
Rating: **4.0**

Rationale: Construction of new cross-levee would directly impact farmland and potential sensitive habitat areas. Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows. Potential HTRW issues on new levee alignments. Construction of levees in urban areas that are more susceptible to air and noise quality impacts. Requires crossing two significant drainage systems in Yuba City. Requires significant borrow material to construct levees. New cross-levees may impact view sheds. Separates the agricultural areas in the southern portion of the project.

Flood Risk Management: Critical Infrastructure Damages
Rating: **8.0**

Rationale: Alternative protects all hospitals, power plants, and other critical infrastructure but does not protect certain roadways within project limits.

Primarily Nonstructural with Minimal Levee Improvement Reaches

Flood Risk Management: Life Safety
Rating: **3.0**

Rationale: Reduces flood risk to certain portion of project limits only and would not reduce flood risk to communities in northern area of project limits (Live Oak, Gridley, and Biggs) or portions of Yuba City. Majority of life risk occur in areas south of the Yuba River and Feather River confluence and in Yuba City, which this alternative does address. Cuts off all major evacuation routes (SR-99 and

Westbound SR-20). Eastbound SR-20 evacuation route would remain. Does not create ponding issue caused by cross-levees. Non-structural measures will be implemented to reduce risk to life safety. Any project that relies on the existing levee has a higher life safety risk due to less predictable performance (levees can fail prior to overtopping at any location).

Flood Risk Management: Property Damages
Rating: **4.5**

Rationale: Captures approximately 45% of total benefits. Exposes the maximum amount of property to potential damage. Alternative provides least amount of flood risk reduction to the project. Yuba City includes 77% of total property values in the project limits. Alternative provides flood risk reduction to approximately half of Yuba City, thus achieving some reduction in property damages. Provides some protection to agricultural lands.

Residual Risks: Design Capacity Exceedance
Rating: **3.0**

Rationale: Given limited extent of levee improvements, design capacity is exceeded on a frequent basis. Cuts off all major evacuation routes (SR-99 and Westbound SR-20). Eastbound SR-20 evacuation route would remain. Does not create ponding issue caused by cross-levees, however, deeper ponding in southern portion would occur.

Sustainability
Rating: **4.0**

Rationale: Minimum amount of existing levees are improved, thus maintenance efforts are greater as compared to fixed in place.

Ecosystem Functionality
Rating: **6.0**

Rationale: Opportunities exist for ecosystem restoration projects on the existing levees. There is little opportunity for ecosystem restoration on other portions of project. Preserving existing levees may allow future ecosystem restoration projects.

Residual Risks: Minimize Growth Inducement
Rating: **8.0**

Rationale: Protects Yuba City and other communities, however, provides limited risk reduction in all other areas of the project limits.

Minimize Environmental Impacts
Rating: **8.0**

Rationale: Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows.

Flood Risk Management: Critical Infrastructure Damages
Rating: **5.0**

Rationale: Does not provide flood risk reduction for key critical infrastructure (hospitals, power plants) and does not provide flood risk reduction for roadways or railroads within project limits.

Fix in Place Feather River from Thermalito to Star Bend

Flood Risk Management: Life Safety
Rating: **6.0**

Rationale: Provides consistent level of flood risk reduction to northern areas and communities within project limits as well as to Yuba City. Does not provide flood risk reduction from an event in the western portion of project areas. Due to the downstream levee height and its impacts on backwaters, fixing south of Star Bend there is an inflection point on life safety. Cuts off SR-20 Westbound and SR-113 as evacuation routes.

Flood Risk Management: Property Damages
Rating: **6.5**

Rationale: Captures approximately 65% of total benefits. Ten percent of benefits captured would be agricultural and residual.

Residual Risks: Design Capacity Exceedance
Rating: **5.0**

Rationale: Design capacity is exceeded on a frequent basis, however, the levees in northern segments of Feather River would be improved thus the probability of potential breach is reduced. Cuts off all major evacuation routes (SR-99 and Westbound SR-20). Eastbound SR-20 evacuation route would remain. Does not create ponding issue caused by cross-levees, however, some ponding in southern portion would exist.

Sustainability
Rating: **5.0**

Rationale: Improves segments of existing levees, reducing maintenance requirements. Retains Sutter Bypass levees and Feather River levees below Star Bend as they exist.

Ecosystem Functionality
Rating: **6.0**

Rationale: Limited opportunities for ecosystem restoration projects where levees are fixed in place. However, any levee setback options exercised would create opportunities for restoration of riparian and wetland habitats within the setback areas (700 acres). Wider river channel contributes to improvements in fish habitats.

Residual Risks: Minimize Growth Inducement
Rating: **6.0**

Rationale: Provides flood risk reduction to significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development to these areas.

Minimize Environmental Impacts
Rating: **7.5**

Rationale: Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows.

Flood Risk Management: Critical Infrastructure Damages
Rating: **6.5**

Rationale: Alternative protects all hospitals, power plants, and other critical infrastructure but does not protect certain roadways within project limits.

Fix in Place Feather River, Sutter Bypass, and Wadsworth Canal with select setbacks for ecosystem restoration

Flood Risk Management: Life Safety
Rating: **8.1**

Rationale: Provides flood risk reduction to the most areas within the project limits. Does not create ponding issue caused by cross-levee of the Little J Alternative. Does not provide flood risk reduction from an event in the western portion of project areas. Protects evacuation routes for SR-20 and SR-113. Reduces flood risk to southern part of project limits. Setbacks reduce the water surface elevation. Marginal factor of safety improvements due to levees built on new foundations.

Flood Risk Management: Property Damages
Rating: **9.0**

Rationale: Captures approximately 90% of total benefits. Ten percent of benefits captured would be agricultural and residual. Some flood stage reduction is possible.

Residual Risks: Design Capacity Exceedance
Rating: **7.1**

Rationale: Provides flood risk reduction to the most areas within the project limits. Does not create ponding issue caused by cross-levee of the Little J Alternative and provides the most area for ponding in southern portion. Does not provide flood risk reduction from an event in the western portion of project areas. Protects evacuation routes for SR-20 and SR-113. Reduces flood risk to southern part of project limits. Setbacks allow levees to withstand erosion during design exceedance better than fixing existing levees.

Sustainability
Rating: **7.1**

Rationale: Improves majority of segments of existing levees, reducing maintenance requirements. Does not add any additional segments of levees to be maintained. Offset segments will be constructed on new foundations and to latest engineering standards, thus reducing maintenance efforts. Offset segments will have access points and distances to allow maintenance vehicles access.

Ecosystem Functionality
Rating: **7.0**

Rationale: Levee setbacks would create opportunities for restoration of riparian and wetland habitats within the setback areas (700 acres). Wider river channel contributes to improvements in fish habitats.

Residual Risks: Minimize Growth Inducement
Rating: **6.0**

Rationale: Provides flood risk reduction to the entire study area, thus removing flood risk as an obstacle to future regional growth and development.

Minimize Environmental Impacts
Rating: **6.0**

Rationale: Same as Alternative 3.1, but where modest setback levees are proposed, construction may require removal or relocation of structures and loss of farmland. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows.

Flood Risk Management: Critical Infrastructure Damages
Rating: **9.0**

Rationale: Alternative protects all hospitals, power plants, and other critical infrastructure as well as all roadways and railroads within project limits.

Compare Value

The cost elements were compared and normalized for the Final Alternatives using the table on the following page. This table illustrates how the cost scores were derived. In this comparison, a lower score is desirable as the project will benefit from lower costs.

Strategies	Cost	Score
Yuba City Ring Levees	$482,900,000	0.103
Little "J" Levee	$839,200,000	0.179
Primarily Nonstructural with Minimal Levee Improvement Reaches	$267,000,000	0.057
Fix in Place Feather River from Thermalito to Star Bend	$651,800,000	0.139
Fix in Place Feather River, Sutter Bypass, and Wadsworth Canal with select setbacks for ecosystem restoration	$1,376,900,000	0.294
TOTAL	**$4,688,700,000**	**1.000**

Once relative scores for performance and cost have been derived, the next step is to synthesize a value index for the alternatives. The basic equation for value is:

$$Value = \frac{Performance}{Cost + Time}$$

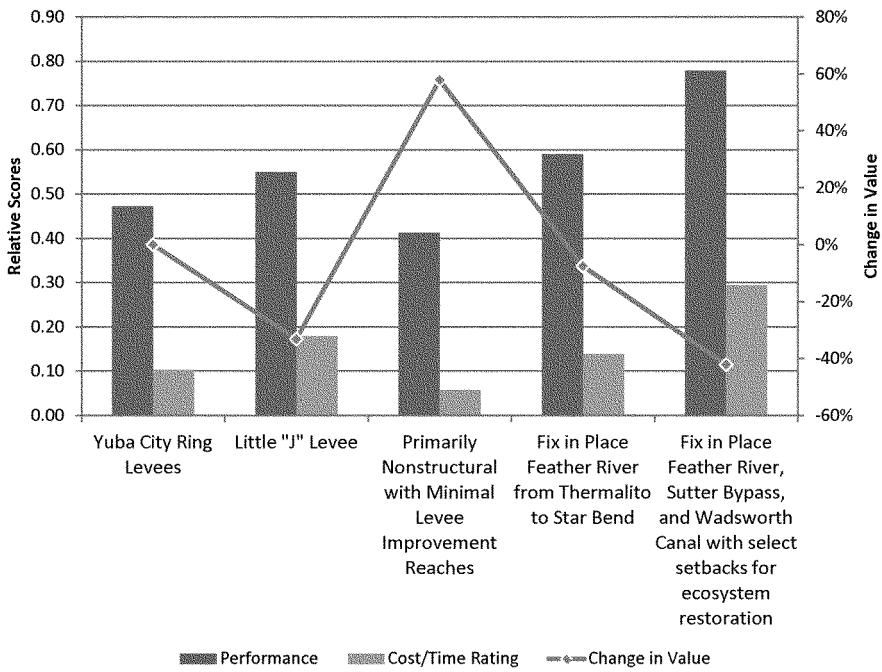
A Value Matrix was prepared which facilitated the comparison of the alternatives by organizing and summarizing this data into a tabular format. The performance scores for each alternative were divided by the total cost/time scores for each alternative to derive a value index.

Value Matrix

Final Conceptual Alternatives

Strategies	Performance Score	Cost/Time Score	Value Index
Yuba City Ring Levees	0.472	0.103	4.585
Little "J" Levee	0.549	0.179	3.066
Primarily Nonstructural with Minimal Levee Improvement Reaches	0.412	0.057	7.242
Fix in Place Feather River from Thermalito to Star Bend	0.590	0.139	4.242
Fix in Place Feather River, Sutter Bypass, and Wadsworth Canal with select setbacks for ecosystem restoration	0.779	0.294	2.654

Comparison of Value – Final Conceptual Alternatives



VALUE ENGINEERING/
PLANNING CHARETTE PROCESS

VALUE ENGINEERING/PLANNING CHARETTE PROCESS

This report section describes the procedures used during the VE study/Planning Charette. It is followed by the workshop agenda and workshop attendance sheets.

A systematic approach was used in the VE study and the key procedures followed were organized into three distinct parts: (1) Pre-Study Preparation, (2) VE Study/Planning Charette Workshop, and (3) Post-Study Procedures.

PRE-STUDY PREPARATION

In preparation for the VE study/Planning Charette, the team leader reviewed critical aspects of the project and areas for improvement with the Project Delivery Team (PDT). In the week prior to the start of the workshop, preliminary performance attributes and requirements and project risks were identified that would later be reviewed and verified during the workshop.

VE STUDY/PLANNING CHARETTE WORKHSOP

The VM job plan was followed to guide the team in the consideration of project functionality and performance, potential schedule issues, high cost areas, and risk factors in the design. These considerations were taken into account in developing alternative solutions for the optimization of project value. The job plan phases are described in order below.

Information Phase

At the beginning of the workshop, a presentation of the project was made by representatives from the PDT. This presentation included an overview of the project and a brief history of the project background and its current status. The workshop attendees were then led through a discussion that included the project's mission (purpose and need) and identification of the project objectives.

Function Phase

Key to the VM process is the function analysis technique used during the Function Phase. Analyzing the functional requirements of a project is essential to assuring an owner that the project has been designed to meet the stated criteria and its need and purpose. The analysis of these functions in terms cost, performance, time, and risk is a primary element in a VE study, and is used to develop alternatives. This procedure is beneficial to the VE team, as it forces the participants to think in terms of functions and their relative value in meeting the project need and purpose. This facilitates a deeper understanding of the project.

Speculation Phase

The Speculation Phase involves identifying and listing creative ideas. During this phase, the VE team participated in a brainstorming session to identify as many means as possible to provide the necessary project functions. Judgment of the ideas was not permitted in order to generate a broad range of ideas.

The idea list includes all of the ideas suggested during the study. These ideas should be reviewed further by the project team, since they may contain ideas that are worthy of further evaluation and may be used as the design develops. These ideas could also help stimulate additional ideas by others.

Evaluation Phase

The purpose of the Evaluation Phase is to systematically assess the potential impacts of ideas generated during the Speculation Phase relative to their potential for value improvement. Each idea was evaluated in terms of its potential impact to performance, cost, time, and risk. Once each idea is fully evaluated, it is rated on develop/eliminate basis, as set forth in the *Idea Evaluation* section of this report.

Development Phase

During the Development Phase, the highly rated ideas were expanded and developed into VE concepts. The development process included describing the concept in more detail and narrative discussion of the concept's impact on the performance attributes.

Presentation Phase

The VE study/Planning Charette concluded with a presentation of the VE team's assessment of the project and the VE concepts. The presentation provided an opportunity for the project stakeholders to preview the project objectives and performance attributes as well as the VE concepts identified by the VE team and develop an understanding of the rationale behind them.

POST-STUDY PROCEDURES

A Draft VE Study/Planning Charette Report was prepared after the completion of the workshop. This report summarized the activities and results of the VE study. When the draft report was reviewed by the PDT and other stakeholders, the Final VE Study/Planning Charette Report is prepared incorporating any review comments received.

Workshop Agenda
Value Engineering Study and Planning Charette
Sutter Basin Pilot Study – Sutter County, CA

Day 1 – Monday, October 31, 2011; Location: COE-Sacramento District Offices, Room 814 (8th floor)

0800 VE Team Set-up

0830 Introductions; VE Process Overview and Agenda Review,
Information Gathering (Planning Process Steps 1, 2, & 3): Overview of problems, opportunities, objectives and constraints; Discuss future and w/o project conditions; Present conceptual alternatives previously identified; Present risk analysis results

1130 Lunch

1230 Develop/Review Project Purpose & Need Statement

1300 Function Analysis

1400 Analyze Project Performance using Value Metrics

- Define/Review Performance Requirements and Performance Attributes
  Identify attributes that represent those aspects of a project's scope that possess a range of potential values
- Determine Relative Importance of Attributes (Stakeholder voting to determine Attribute priorities)

1600 Adjourn

Day 2 – Tuesday, November 1, 2011; Location: COE-Sacramento District Offices, Room 814 (8th floor)

0830 Present and Discuss FAST Diagram

0900 Evaluation Phase (Planning Process Step 4): Evaluation of previous Conceptual Alternatives based on Performance Attributes

1200 Lunch

1300 Speculation Phase (Planning Process Step 3): Brainstorming of additional alternatives, alternative optimization, value improvements recommendations, and risk reduction/mitigation

1600 Adjourn

Day 3 – Wednesday, November 2, 2011; Location: COE-Sacramento District Offices, Room 814 (8th floor)

0830 Evaluation of Creative Ideas

1130 Lunch

1230 Team Assignments for Development of Alternative Narrative Write-ups

1600 Adjourn

Day 4 – Thursday, November 3, 2011; Location: COE-Sacramento District Offices, Room 814 (8th floor)

0830 VE Alternative Development

1130 Lunch

1230 Re-evaluation of conceptual alternatives and identify final array of alternatives
Planning Process Step 5: Comparison of final array of alternate plans

1600 Adjourn

Day 5 – Friday, November 4, 2011; Location: COE-Sacramento District Offices, Room 814 (8th floor)

0830 Summary of VE Results and Presentation Preparation

1000 Presentation of VE Study Results to all Project Stakeholders
Summary, Wrap-Up, Steps Forward

1200 Adjourn

MEETING ATTENDEES
Value Engineering Study and Planning Charette
Sutter Basin Pilot Study

2011 October/November					NAME	ORGANIZATION	POSITION / RANK	PHONE	EMAIL
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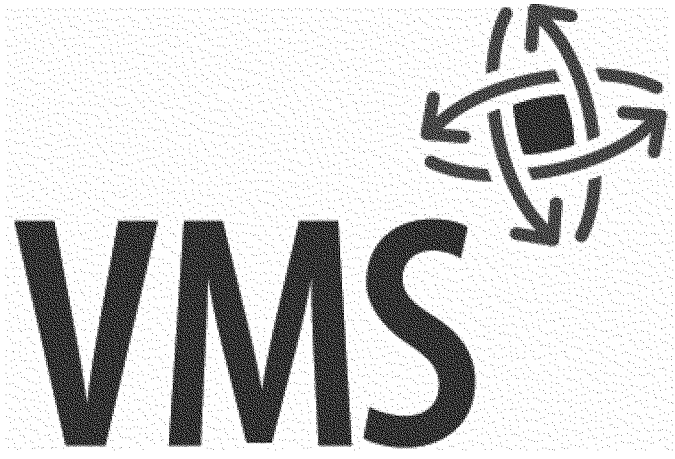
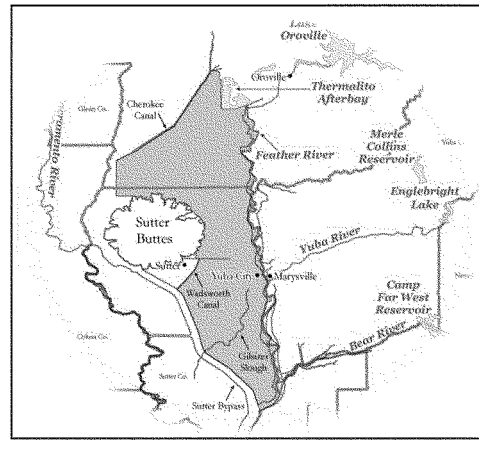


Value Management Strategies, Inc.

Offices in Escondido and Sacramento, California; Grand Junction, Colorado; Sarasota, Florida; Indianapolis, Indiana Marietta, Georgia; Portland, Oregon; Seattle, Washington; Kansas City, Missouri; and Great Falls, Montana

Sutter Basin, California
Pilot Feasibility Study

Progress Document #1:
Without Project & Alternative Development
DRAFT



US Army Corps of Engineers

Sacramento District

Version: 07 March 2013

Progress Document Purpose:

This is a summary document of the progress and process of the Sutter Basin Pilot Feasibility Study up to the development of a Refined Array of Alternatives.

A subsequent progress document will summarize the work and process of the Sutter Basin Pilot Feasibility Study to a Draft Array of Alternatives to a Tentatively Selected Plan.

Sutter Basin Pilot Feasibility Study

Progress #1 Document: Without Project and Alternative Development

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14: Yuba City Ring Levee Alternative

15: Little "J" Levee Alternative

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Sutter Basin Pilot Feasibility Study Progress #1 Document: Without Project and Alternative Development

1.0 INTRODUCTION

1.1 PURPOSE AND NEED FOR THE STUDY AND DOCUMENT

A high risk of flooding from levee failure threatens the public safety of approximately 80,000 people, as well as property and critical infrastructure throughout the Sutter Basin study area. Past flooding has caused loss of life and extensive economic damages. Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees do not meet U.S. Army Corps of Engineers (USACE) levee design standards, authorized level of performance, and are at risk of breach failure at stages less than overtopping of the levees. Within the study area, as throughout the Sacramento Valley, floodplain and native habitats have been lost or degraded. Federally listed species and other special status species that are dependent on floodplain habitats have declined. Opportunities exist to restore land formerly converted by mining or agriculture to more natural habitats through Ecosystem Restoration (ER) in conjunction with flood risk management (FRM). There are also opportunities to provide outdoor recreational features on FRM and ER project lands. The purpose of the Sutter Basin Feasibility Study is to address FRM in conjunction with ER and recreation.

This document summarizes progress to the determination of the refined array of alternatives on the Sutter Basin Pilot Study. This array of alternatives will be considered in greater detail as the study progresses toward selection of the Tentatively Selected Plan. The information presented in this document will be incorporated into the draft Feasibility Study and Environmental Impact Statement/ Environmental Impact Report (EIS/EIR), which will integrate plan formulation with documentation of environmental effects. The Feasibility Study/EIS/EIR will serve to satisfy documentation requirements of ER 200-2-2 as well as the National Environmental Policy Act (NEPA) of 1969, as amended, and the requirements of the California Environmental Quality Act (CEQA).

1.2 STUDY AUTHORITY

The authority for the U.S. Army Corps of Engineers (USACE) to study FRM and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962 (Public Law 87-874). A portion of the authorization reads as follows:

"The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes…to be made under the direction of the Chief of Engineers, in drainage areas of the United States…, which include the following named localities: Sacramento River Basin and streams in northern California, draining into the Pacific Ocean for the purpose of developing,

where feasible, multi-purpose water resource projects, particularly those which would be eligible under the provision of title III of Public Law 85-500."

The authority for including ecosystem restoration as a study objective or purpose in association with FRM is found in numerous Federal laws and executive orders establishing National policy for and Federal interest in the protection, restoration, conservation and management of environmental resources. These provisions endorse Federal efforts to advance environmental goals, and a number of these general statements declare it national policy that full consideration is given to the opportunities which projects afford to ecological resources. Recent water resources authorizations have specifically or programmatically enhanced opportunities for Corps involvement in addressing objectives related to the restoration of ecological resources and ecosystem management.

The legislative basis for Federal participation in recreation development is found in the Flood Control Act of 1944, as amended, the Federal Water Project Recreation Act of 1965 (Public Law 89-72), and the Water Resources Development Act of 1986 (Public Law 99-662). These give broad authority to include recreation as a project purpose. Present policy limits exercise of these authorities as defined in ER 1105-2-100, Planning Guidance.

1.3 STUDY SPONSORS

The non-Federal project sponsors include the State of California Central Valley Flood Protection Board (CVFPB) and the Sutter Butte Flood Control Agency (SBFCA). SBFCA is a joint powers agency formed in September 2007 by Sutter and Butte Counties, the cities of Biggs, Yuba City, Gridley, Live Oak, and levee districts 1 and 9 to finance and construct regional levee improvement projects.

1.4 LOCATION AND DESCRIPTION OF THE STUDY AREA

The study area is located in Sutter and Butte Counties California and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area covers approximately 300 square miles and is approximately 43 miles long and 9 miles wide. The study area includes the communities of Yuba City, Live Oak, Gridley, Biggs, and Sutter with a total population of approximately 80,000. Yuba City is the largest community in the study area, with a population of approximately 65,000. A map of the watershed is included as Plate 1 and a map of the study area is included as Plate 2.

The study area is essentially encircled by project levees of the Sacramento River Flood Control Project (Plate 3) and high ground of the Sutter Buttes. In 1917, the Federal government authorized the Sacramento River Flood Control Project (See Plate 3), which adopted a system of locally built levees as Federal levees, and constructed additional levees, bypasses, overflow weirs, and pumping facilities. Although the Sacramento River Flood Control Project levees were often constructed of poor foundation materials such as river dredge soils that would not meet today's engineering standards, the levees are relied upon today to provide FRM for numerous communities.

The primary sources of flooding within the study area are the Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and local interior drainage. Flood depths and

frequency vary throughout the study area. Probability of flooding within the study area is primarily related to the stage of floodwaters within the river channels and the geotechnical probability of levee failure at or below flood stage.

The Butte Basin is a natural overflow and flood storage area north west of the Sutter Buttes and east of the Sacramento River. The basin provides approximately 1 million acre-feet of transitory storage at flood stage (DWR, 2010). Excess floodwaters from the Sacramento River enter Butte Basin via overbank areas along the river and through the Moulton and Colusa weirs. Butte Creek and its tributaries, including Cherokee Canal, also flow into the Butte Basin. Outflow from the Butte Basin is regulated by hydraulic conditions of Butte Slough and floodplain topography at the upstream entrance to the Sutter Bypass. In order to maintain the flood storage capabilities within Butte Basin, California has included regulation of the overflow area in Title 23 of the California Code of Regulations. In general these standards require approval from the board for any encroachments that could reduce or impede flood flows or would reclaim any of the floodplain within the Butte Basin (DWR, 2010).

The Sutter Bypass is a leveed flood control structure approximately three quarters of a mile wide, bordered on each side by levees. The bypass is an integral feature of the Sacramento River Flood Control Project's flood bypass system. The Sutter Bypass conveys flood waters from the Butte Basin, Sacramento River, and Feather River to the confluence of the Sacramento River and Yolo Bypass at Fremont Weir. Additional flood flows from the Sacramento River enter the Sutter Bypass through Tisdale Bypass. The lower portion of the Sutter Bypass also conveys the Feather River. Within this reach the Feather River is separated from the main conveyance of the bypass by a low levee. This design maintains higher velocities and sediment transport capacity within the Feather River during low flow events while utilizing the large conveyance of the Sutter Bypass during larger events. The Sutter Bypass also receives minor natural flow and agricultural return flow from Reclamation District 1660 to the west and from Wadsworth Canal and DWR pumping plants 1, 2, and 3 to the east. The Sutter Bypass includes four hydrologic reaches determined on tributary inflows; Butte Slough to Wadsworth Canal, Wadsworth Canal to Tisdale Bypass, Tisdale Bypass to Feather River, Feather River to Sacramento River.

The Feather River is a major tributary to the Sacramento River, merging with the Sutter Bypass upstream from the Sacramento River and Fremont Weir. The Yuba and Bear Rivers are major tributaries to the Feather River. Two major flood management reservoirs are located within the Feather River watershed: Oroville on the Feather River and New Bullards Bar on the Yuba River. The Feather River is described by four hydrologic reaches based on significant inflows; Thermalito to Honcut Creek, Honcut Creek to Yuba River, Yuba River to Bear River, and Bear River to Sutter Bypass.

The Cherokee Canal is a tributary to Butte Creek and the Butte Basin. The leveed canal was constructed between 1959 and 1960 by USACE. The canal drainage area is 94 square miles and varies in elevation from 70 feet to 2200 feet. The drainage area is bounded by the Feather River watershed to the east and southeast, Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south.

The Wadsworth Canal is a leveed tributary to the Sutter Bypass near the town of Sutter. The canal conveys flow from the East and West interceptor canals to the Sutter Bypass. The East and

West interceptor canals collect runoff from canals and shallow floodplain runoff into the Wadsworth Canal.

1.5 RELATED PROJECTS AND STUDIES

1.5.1 Advance Work by Local Interests in Study Area

Sections 104 and 3041 of WRDAs 1986 and 2007, respectively, provide authorization for non-Federal sponsors to receive credit for the cost of local advanced work to be applied to the required local contribution for the project. Section 104 authorizes credit for local work accomplished prior to authorization of the project provided that the Assistant Secretary of the Army for Civil Works has approved the proposed work prior to initiation of construction. Section 3041 authorizes credit for local work accomplished prior to the date of the Project Partnership Agreement for the project; credit to be provided in accordance with the provisions of Section 221 of the Flood Control Act of 1970. Section 221, as modified by Section 2003 of WRDA 2007, requires that the local work be performed after project authorization and after an In-Kind Memorandum Of Understanding is executed.

Under Section 408 (33 USC 408), temporary or permanent alteration, occupation, or use of any public works, including levees, for any purpose is allowable only with the permission of the Secretary of the Army. Under the terms of 33 USC 408, any proposed levee modification requires a determination by the Secretary that the proposed alteration, permanent occupation, or use of a Federal project will not be injurious to the public interest and will not impair the usefulness of the levee. The authority to make this determination and approve modifications to Federal works under 33 USC 408 has been delegated to the Chief of Engineers, USACE.

1.5.1.1 Feather River West Levee Project

SBFCA is proposing a levee improvement project along the Feather River west levee under the California Department of Water Resources (DWR) Early Implementation Program (EIP). EIPs are for flood control construction projects that rehabilitate, reconstruct, replace, improve, or add to the facilities of the State Plan of Flood Control. DWR provides bond funds to cost share for early implementation of state-federal flood control system modifications This two phase project proposes to construct levee improvements between the Thermalito Afterbay and the Feather River/Sutter Bypass confluence. Primary deficiencies of the levee include through-seepage, underseepage, and embankment instability. A Phase I Pre-Design Formulation Report was completed in August of 2011 and the 60% design was completed by March 2012. An EIS/EIR is being prepared for the project as part of a Section 408 application to obtain permission from USACE to alter project levees. The Draft EIS/EIR was released to the public in Spring 2012. This local project will be evaluated as one of the alternatives in the Pilot Study, and could potentially be considered for Section 221 crediting.

1.5.1.2 Star Bend Setback Levee Project

Construction of 3,400 feet of setback levee was recently completed within the study area under the DWR Early Implementation Program. The purpose of the setback levee was to address through-seepage, underseepage, and flow constriction issues. A request for approval under 33 USC Section 408 was granted and an application for consideration of Section 104 credit was

approved in 2009. This project and the request for Section 104 credit will be evaluated in the Pilot Study1.5.1.3 Lower Feather River Corridor Management Plan.

The purpose of the Lower Feather River Corridor Management Plan (CMP) by the Department of Water Resources is to develop a integrated strategy and long-term vision for managing the river corridor between the Yuba River and the Sutter Bypass in a way that facilitates and promotes economic sustainability and compatibility in future land uses, flood protection system management, maintenance of flood control facilities, and the restoration and enhancement of ecosystem functions and habitats.

1.5.1.4 Yuba River Basin, California, Marysville Ring Levee EngineeringDocumentation Report.

The Yuba River Basin Flood Risk Management Project, authorized by WRDA 99 Section 101(a)(10) and WRDA 07 Section 3041, is currently under reevaluation in the Yuba Basin General Reevaluation Report. During the project reevaluation it was determined that the Marysville Ring Levee was separable and common to all alternatives under consideration. The project team determined that the Marysville Ring Levee should proceed to implementation under the WRDA 99 authorization, as amended.

1.5.2 Systemwide Studies

1.5.2.1 Central Valley Flood Protection Plan

As required by State of California Senate Bill (SB) 5, the State has initiated the Central Valley Flood Protection Plan (CVFPP). The purpose of the CVFPP is to guide California's participation (and influence federal and local participation) in managing flood risk along the Sacramento and San Joaquin River systems. The CVFPP will require a 200-year level of flood risk management (1/200 annual exceedance probability) for urban and urbanizing areas by the year 2025, and no new development would be permitted if this target is not met. An urban area is defined as a developed area in which there are 10,000 residents or more. An urbanizing area is defined as a developed area or an area outside a developed area that is planned or anticipated to have 10,000 residents or more within the next 10 years.

The CVFPP proposes an initial systemwide investment approach for sustainable, integrated flood management in areas currently protected by facilities of the State Plan of Flood Control (SPFC). This investment approach includes system and regional elements, some of which are located in the Sutter Pilot study area. These elements, including the Feather River West Levee Project, are being considered as part of the Pilot Study effort. The draft 2012 CVFPP was released for public review in January 2012 and must be adopted by the CVFPB by July 1, 2012. The CVFPP will be updated every five years.

1.5.2.2 Central Valley Integrated Flood Management Study

The Central Valley Integrated Flood Management Study (CVIFMS) is a continuation of the Sacramento and San Joaquin River Basins Comprehensive Study. The Comprehensive Study was initiated by USACE and The Reclamation Board of the State of California in 1998 and authorized in the 1998 Energy and Water Development Appropriations Act, Public Law 105-62. The U.S. House of Representatives Report 105-190, which accompanied the 1998 act, directed

USACE to conduct a comprehensive assessment of the flood management system for the Sacramento and San Joaquin River Basins. CVIFMS is the federal complement to the State CVFPP. Through CVIFMS, the State and USACE are pursuing a common and shared approach to flood risk management in the Central Valley. The Project Management Plan for CVIFMS was completed in 2011 and the study has received limited funding to date.

1.5.2.3 Sacramento Bank Protection Project

A USACE continuing construction project to address bank erosion and protection within the Sacramento River Flood Control Project.

1.5.2.4 Central Valley Hydrologic Study (CFHS)

The Department of Water Resources and the U.S. Army Corps of Engineers (USACE Sacramento District) have partnered in the development of the Central Valley Hydrology Study (CVHS). CVHS is a comprehensive assessment of stream flow frequencies and magnitudes in the Sacramento and San Joaquin river basins. The goal of the hydrologic analysis is to estimate peak flows and hydrographs for various annual exceedence probabilities to describe flood hazard throughout the basins.

1.5.2.5 Central Valley Floodplain Evaluation and Delineation Program (CVFED) DWR study of floodplains in the central valley.

1.5.2.5 Sacramento San Joaquin Comprehensive Study

"Sacramento River and San Joaquin River Basins Comprehensive Study, California. In response to the devastating floods of 1997, Congress directed the Corps of Engineers to conduct a comprehensive assessment of the entire flood control system within the existing study authorizations of the Sacramento River Watershed Management Plan (authorized by the Flood Control Act of 1962) and the San Joaquin River and Tributaries authority (authorized by 1964 Resolution of the House Committee on Public Works). The Comprehensive Study was initiated in 1998. The results were a post-flood assessment and system-wide hydrologic/hydraulic model that included extensive public involvement and planning for flood damage reduction and ecosystem restoration purposes.

1.6 PLANNING STRATEGY

1.6.1 Pilot Study Background

The Sutter Basin Feasibility Study was selected for inclusion in the National Pilot Program in February 2011. The pilot initiative provides an opportunity to test principles that have been outlined in the USACE *Recommendations for Transforming the Current Pre-Authorization Study Process* (January 2011), which was drafted by a workgroup of planning and policy experts from USACE and the Office of the Assistant Secretary of the Army for Civil Works referred to as the 17+1 Team.

This new process requires heavy involvement as well as input and decisions from the Vertical Team at multiple points throughout the study. The new process focuses on early decision

making and the reduction of unnecessary detail. Instead of following the traditional USACE planning milestones, the pilot study is divided into four phases, each with a key decision point and associated In-Progress Reviews (IPRs). Table 1 summarizes the four pilot study phases and associated decision points.

Table 1. Pilot Study Phases and Associated Decision Points

Pilot Study Phase	Decision Point
Scoping Phase	Decision Point 1 – Federal Interest Determination
Analysis Phase	Decision Point 2 – Tentatively Selected Plan and Draft Report
Review Phase	Decision Point 3 – Civil Works Review Board
Confirmation Phase	Decision Point 4 – Chief's Report

Based on the pilot program principles, the Sutter Basin Feasibility Pilot Study strategy focuses on utilizing an appropriate level of detail based on the decisions being made at each stage of the study. This strategy includes qualitative analysis that will be increasingly detailed at each Decision Point or IPR and early elimination of alternatives with little probability of implementation.

Decision Point 1 for the Sutter Basin Pilot Study was held in August 2011. The Decision Point 1 panel members reached consensus that there was a Federal Interest in continuing the study toward Decision Point 2, which will focus on Vertical Team agreement on the Tentatively Selected Plan. This document summarizes the increasingly detailed analysis that has been completed to date and concludes with the array of alternatives that will be evaluated in further detail as the team progresses toward selection of the Tentatively Selected Plan to be confirmed by the Vertical Team at Decision Point 2. Since the information presented in this document will be incorporated into the draft Feasibility Study/EIS/EIR, the format and content is designed to comply with the target length of 100 pages or less specified in the memorandum from MG Walsh issued on 8 Feb 2012.

1.6.2 Level of Detail

The Pilot Study utilizes five classes to describe the analysis level of detail and potential uncertainty. Results presented in this memorandum are based on a class 4 level of detail. The five classes are described in Table 1 of EM 1110-2-1302 Civil Works Cost Engineering. The table is based on ASTM E 2516-06, Standard Classification for Cost Estimate Classification System. The purpose of the classification system is to improve communication among all the stakeholders involved with preparing, evaluating, and using cost estimates (ASTM, 2011). Class definitions, as they relate to the Pilot Study, are described below.

Class 5 is least accurate and is the minimum required for assessing rough order of magnitude. The level of project definition is 0% to 2% of a complete definition. The expected cost accuracy (+/-) is 4 to 20 times the accuracy of the best (Class 1) estimate.

Class 4 is minimum required for Reconnaissance/905b Reports and alternative analysis in feasibility studies. The level of project definition is 1% to 15% of a complete definition. The expected cost accuracy (+/-) is 3 to 12 times the accuracy of the best (Class 1) estimate.

Class 3 is the minimum required for the feasibility NED Plan and Feasibility Sponsor Preferred Plan. The level of project definition is 10% to 40% of a complete definition. The expected cost accuracy (+/-) is 2 to 6 times the accuracy of the best (Class 1) estimate.

Class 2 is minimum required for Planning, Engineering, and Design up to 90% Plans and Specifications. The level of project definition is 30% to 70% of a complete definition. The expected cost accuracy (+/-) is 1 to 3 times the accuracy of the best (Class 1) estimate.

Class 1 is minimum required for Planning, Engineering, and Design 100 % Plans and Specifications and the Independent Government Estimate. The level of project definition is 50% to 100% of a complete definition. This is considered the most accurate estimate. It does not imply that all unknowns and risk are eliminated.

2.0 PROBLEM IDENTIFICATION

2.1 NATIONAL OBJECTIVE

The National or Federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to national economic development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation. The National objective is not specific enough for the development of a water resource project. The formulation of alternative plans requires the identification of study specific planning objectives.

Benefits from plans for reducing flood risk accrue primarily through the reduction in actual or potential damages to affected land uses. There are three primary benefit categories, reflecting three different responses to a flood risk reduction plan. Inundation reduction benefits are the increases in net income generated by the affected land uses when the same land use pattern and intensity of use is assumed for with- and without-project conditions. Intensification benefits are increases in net income generated by intensified floodplain activities when the floodplain use is the same with and without the project but an activity (or activities) is more intense with the project. The third category of benefits is location benefits. If an activity is added to the floodplain because of a plan, the location benefit is the difference between aggregate net incomes (including economic rent) in the economically affected area with and without the project.

2.2 PUBLIC INVOLVEMENT

Public input has been received through coordination with the sponsors, coordination with other agencies, and through public workshops. As part of the NEPA and CEQA process, USACE, the CVFPB, and SBFCA have reached out to government agencies and the public to solicit input on the study. A Notice of Intent and a Notice of Preparation for the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) were published on May 20, 2011. Public scoping meetings were held in Yuba City and Gridley on June 27 and June 28, 2011. The

meetings provided the public and agencies an opportunity to learn about the study and provide input as to what components of the project are important to them, as well as what environmental resources should considered in formulation of plans and in impact analyses. A public scoping meeting summary is included in Appendix A.

The list below summarizes the views expressed in oral and written comments received during the four scoping meetings and in response to the Notice of Intent and Notice of Preparation. These represent the areas of interest or concern to the public and stakeholders in the study area:

Keep landowners apprised of associated activities occurring on their lands.

Keep the feasibility study on schedule so the State will be able to release early implementation program funding for the Feather River West Levee Project.

Coordinate with the State Department of Water Resources' Lower Feather River Corridor Management Project so that duplicative efforts pertaining to environmental studies are avoided.

Consider levee setbacks in the study area.

Consider a perimeter levee around Yuba City or a "J" levee on the south and west sides.

Project lead agencies must obtain appropriate water quality/discharge permits including those related to dewatering, discharge, sewer, and construction and land disturbance.

The area being studied is located in the planning area of the Yuba/Sutter Habitat Conservation Plan/Natural Community Conservation Plan (HCP/HCCP); therefore please provide the Sutter County Community Services Director's office with all future notices regarding this project.

Project teams need to review the current effective Flood Insurance Rate Maps for all counties and cities in the study area. Please note that these cities and counties are participants in the National Flood Insurance Program and the minimum, basic NFIP floodplain management building requirements are described in 44 Code of Federal Regulations (CFR) §§59–65.

General requests for more detailed information about the boundaries of each project and the relationship between the two projects.

A request to memorialize, in some way, the unreported deaths in 1955 caused by a levee break at Shanghai Bend.

The California State Lands Commission (CSLC) requests that as the Project proceeds, SBFCA submits additional information (e.g., detailed maps) to enable CSLC staff to determine if any components of the Project will require a lease or permit. CLSC additionally requests to be placed on any future distribution mailing list for the Project. A thorough project description should be included in the EIS/EIR in order to facilitate meaningful environmental review of potential impacts, mitigation measures, and alternatives.

The project's EIS/EIR should carefully consider issues and mitigation alternatives in order to formulate a more comprehensive and sustainable approach to flood management in the Sutter/Butte region. These include growth inducing impacts, downstream flood impacts, impacts under climate change, and evaluation of a broad range of alternatives.

Feather River Air Quality Management District (AQMD): Recommends discussing potential air quality and climate change impacts for both projects. The EIS/EIR should include a discussion of greenhouse gas emissions and climate change impacts. The project should submit a Fugitive Dust Control Plan to the Feather River AQMD prior to beginning work.

The California Department of Fish and Game (CDFG) would like to emphasize the critical importance of coordination with CDFG during the California Environmental Quality Act (CEQA) and regulatory processes.

- The Native American Heritage Commission (NAHC) recommends adequately assessing and mitigating project impacts related impacts to cultural resources.

2.3 PROBLEMS, OPPORTUNTIES, OBJECTIVES, AND CONSTRAINTS

Following inclusion of the Sutter Basin Feasibility Study in the National Pilot Program, the PDT and non-Federal sponsors participated in a study risk workshop with several members of the Vertical Team during which the following problem, opportunity, objective, and constraint statements were developed and refined.

2.3.1 Problems

A high risk of flooding from levee failure threatens the public safety of approximately 80,000 people, as well as property and critical infrastructure throughout the study area.
Flooding has caused loss of life and extensive economic damages. A levee failure in 1955 resulted in unexpected rapid flooding of Yuba City and caused $327 million in damages (2011 dollars) and 37 recorded fatalities. Additionally, there have been three levee breaches adjacent to the study area since 1986. The adjacent levees are of similar design and age as those within the Sutter Basin Feasibility study area and the failures occurred prior to overtopping. . Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees do not meet USACE levee design standards and are at risk of breach failure at stages less than overtopping. This is evidenced by historical boils and heavy seepage at stages less than authorized design flows. Almost every location within the study area is afforded some flood risk reduction by these levees. . The risk of unexpected levee failure coupled with the consequence of deep flooding presents a continued threat to public safety, property, and critical infrastructure.

Existing levees have isolated the floodplains from waterways, which has eliminated channel capacity and significant floodplain habitats for native species, including federally listed species and other special status species. Conversion of high value habitats to other land uses has reduced the abundance, distribution and diversity of native species. Historically, lands subject to regular flooding or occasional overflow covered about one-third of the Sacramento Valley in 1880, or about 1 million acres. Within the study area, as throughout the Sacramento Valley, floodplain and native habitats have been lost or degraded. Federally listed species and other special status species that are dependent on floodplain habitats have declined.

2.3.2 Opportunities

There are FRM structural and non-structural opportunities to decrease known flood risks within the study area.

Direct and indirect conversion of land and water resources due to mining and agriculture has degraded ecosystems, reducing the quantity and quality of high value habitat. These factors

contributed to a number of species being listed as threatened, endangered or extirpated. Land formerly converted by mining or agriculture can be restored to more natural habitats in conjunction with FRM.

There is an opportunity to provide outdoor recreational features on FRM and ER project lands. The levees within the study area effectively cut off public access to waterways and associated recreation amenities. Facilities can be included at recommended flood risk management and ecosystem restoration features to provide public access and use and improved outdoor recreation experiences.

2.3.3 Objectives

The problems and opportunities identified for this study are refined and stated as specific planning objectives to provide focus for the formulation of alternatives. These planning objectives reflect the problems and opportunities and represent desired positive changes in the without project conditions. The planning objectives include the following:

- Reduce the risk to life, health, and public safety due to flooding.
- Reduce the risk of property damage due to flooding.
- Reduce the risk of damage to critical infrastructure due to flooding.
- Encourage wise use of the floodplain.
- In conjunction with FRM, restore floodplain connectivity and associated dynamic riverine processes.
- In conjunction with FRM, restore aquatic, wetland, riparian, and terrestrial habitats for special status and other native species.
- In conjunction with FRM and ER, improve the public's access to and use of outdoor recreational opportunities in the study area.

2.3.4 Additional Non-Federal Sponsor Objective

The CVFPP will require a 200-year level of flood risk management (1/200 annual exceedance probability) for urban and urbanizing areas by the year 2025, and no new development would be permitted if this target is not met. Based on this requirement, the following non-Federal sponsor objective has been included:

- Reduce the probability of flooding to urban and urbanizing areas to less than 1/200 annual exceedance probability.

2.3. 5 Constraints

A constraint is a restriction that limits the extent of the planning process. It is a statement of things the alternative plans should avoid. Constraints are designed to avoid undesirable changes between future with and without-project conditions. The planning constraints include:

- Minimize significant adverse impacts to the human environment.

- Comply with applicable Federal laws, regulations, and policies such as the National Environmental Policy Act, Endangered Species Act, Fish and Wildlife Coordination Act, Clean Water Act, Clean Air Act, and the National Historic Preservation Act.

2.4 EXISTING CONDITIONS

Existing conditions are those at the time the study is conducted and form the basis for extrapolation to other conditions. Existing conditions within the study area are discussed below.

2.4.1 Flow Frequency Estimates

A tabulation of the regulated peak flows at select locations and reaches within the study area is shown in Table 2. These estimates are based on unsteady hydraulic model output and may be revised at the TSP selection phase.

Table 2. Design Flows and Regulated Flows

Stream and Reach	Design Flow (cfs)	Regulated Peak Flows (cfs)						
		50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Sacramento River								
Colusa to Tisdale Weir	66000	44,000	48,000	50,000	53,000	55,000	59,000	68,000
Tisdale Weir to Sutter Bypass	30000	28,000	30,000	31,000	32,000	34,000	36,000	41,000
Feather River								
Oroville to Honcut Creek	210,000	60,000	100,000	150,000	150,000	150,000	174,000	327,000
Honcut Creek to Yuba River	210,000	49,000	106,000	156,000	146,000	151,000	195,000	311,000
Yuba River to Bear River	300,000	71,000	192,000	253,000	279,000	287,000	356,000	501,000
Bear River to Sutter Bypass	320,000	81,000	207,000	276,000	302,000	314,000	380,000	500,000
Sutter Bypass								
Meridian to Wadsworth Canal	150,000	57,000	102,000	126,000	155,000	184,000	228,000	327,000
Wadsworth Canal to Tisdale Weir	155,000	59,000	103,000	127,000	156,000	185,000	229,000	250,000
Tisdale Weir to Feather River	180,000	70,000	114,000	139,000	161,000	194,000	231,000	258,000
Feather River to Sacramento River	380,000	145,000	276,000	392,000	435,000	493,000	585,000	726,000
Wadsworth Canal								
East - West Interceptor to Sutter Bypass	1,500	750	1,900	2,550	3,050	3,550	4,050	4,720
Cherokee Canal								
Nelson Shipee Road to Western Canal	8,500							
Western Canal to Afton Road	11,500	6,000	10,300	12,100	13,200	14,300	15,200	16,300
Afton Road to Gridley-Colusa Road	12,500							

Peak Regulated flows obtained from HEC-RAS Model for the Sutter Basin Feasibility Study (August 2011 version).
Design Flows obtained from USACE file drawing 50-10-3334, Levee Channel Profiles, 15 March 1957
Note: Peak flow is the highest of the Sacramento or Shanghai Bend storm centering peak flows
Note: Wadsworth and Cherokee Canal are unregulated streams
Note: Peak flows for 0.5% and 0.2% ACE include effects from levee overtopping and may be reduced from their possible maximums.

Table 2 is subject to update by Peterson-Brustad Inc after new flood routings are complete. Flow frequency estimates for the Feather River and Sutter Bypass are based on analysis described in the Sacramento and San Joaquin River Basins Comprehensive Study and Yuba River Basin Feasibility Study documentation. Flow Frequency curves and hydrographs of unregulated flow were developed for the 50% (1/2) to 0.2% (1/500) annual chance Exceedance probability (ACE) frequencies. Regional synthetic hydrology presented in these studies represents the best available data for the large flood sources (Sutter Bypass and Feather River) of

the Sutter Basin Feasibility Study. These hydrologic analyses have also been used as the foundation for several other feasibility studies in the region, such as the American River Common Features and Yuba River Basin studies. DWR and USACE are in the process of developing new hydrologic frequency estimates. However, the results will not be available until late 2012. Therefore, this study utilizes the results from the San Joaquin River Basins Comprehensive Study hydrologic analysis.

Synthetic hydrology of the Sacramento and San Joaquin River Basins Comprehensive Study was based on transformation of unregulated hydrologic conditions to regulated conditions. This was accomplished by developing balanced unregulated hydrographs based upon historically patterned storm events. Balanced hydrographs have the same annual exceedance frequency for all flood durations. For example a 10% (1/10) ACE hydrograph contains the 10% (1/10) ACE 1-day flow, 10% (1/10) ACE 3-day average flow, 10% (1/10) ACE 5-day average flow etc. These balanced hydrographs were then transformed to regulated hydrographs using an HEC-5 reservoir operations model of the system. The HEC-5 model, also developed and calibrated for the Sacramento and San Joaquin River Basins Comprehensive Study, simulates reservoir operations and produces regulated hydrographs. The comprehensive study transferred the hydrographs from the HEC-5 model at 'handoff' points and modeled in more hydraulic detail using UNET. The portion of the UNET model downstream of Sacramento River at Colusa and Butte Slough near Meridian was replaced by an HEC-RAS unsteady model developed for this study (see hydraulics section). Hydrographs at Sacramento River at Colusa and Butte Slough near Meridian were obtained from the UNET model. All other hydrograph boundary conditions were obtained from the HEC-5 model.

The Sacramento and San Joaquin River Basins Comprehensive Study hydrology utilized a storm centering approach to evaluate possible hydrologic scenarios. A storm centering is a storm positioned (centered) over a watershed to produce flow rates or stages of specific frequencies at the specified runoff location or gage. Multiple storm centering scenarios are possible due to the diverse spectrum of floods that can occur from different combinations of concurrent storms on tributaries, orographic influences, and other factors that influence regional rainfall runoff events. The Sacramento and San Joaquin River Basins Comprehensive Study evaluated a suite of storm centerings and selected the centering that produced the largest stage or flow rate at a given location. For the smaller geographic area of the Sutter Basin Feasibility study area, the Sacramento and San Joaquin River Basins Comprehensive Study results were reviewed and narrowed to two possible centerings. The Sacramento storm centering predominantly applies to the Sacramento River and the Sutter Bypass, while the Shanghai Bend storm centering predominantly applies to the Feather and Yuba Rivers.

Flow frequency of the Cherokee Canal was estimated by detailed methods using gage records on the Cherokee Canal and contributing streams. Frequency curves and hydrographs of unregulated flow were developed for the 50% (1/2) ACE to 0.5% (1/200) ACE events.

Flow frequency of Wadsworth Canal was estimated by detailed methods using gage records. Frequency curves and hydrographs of unregulated flow were developed for the 50% (1/2) ACE to 0.5% (1/200) ACE events.

Hydrologic analysis of the Sutter Basin interior area was done by approximate methods using a conceptual level HEC-HMS model. Approximate methods were deemed suitable because the feasibility study is not evaluating FRM projects to address flooding at the existing interior drainage pump locations. Model parameters were based on comparison to measured runoff volumes at the three DWR pumping plants during the February 1983 and March 1986 storm events. It was determined that approximately 24 days are required to pump the volume of a significant flood out of the basin, therefore a 30-day storm duration has been used to produce runoff estimates..

2.4.2 Hydraulics

Hydraulic analyses were performed using one-dimensional and two-dimensional models.. Channel stages were estimated using a system wide HEC-RAS one-dimensional unsteady flow model. Floodplain stages were estimated using a FLO-2D two-dimensional floodplain model of the study area. HEC-RAS models were developed for two levee overtopping scenarios: Scenario A – infinitely tall levee with no breach and Scenario B – existing levee heights with simulated levee breach. FLO-2D was used to model overland flow from each simulated levee breach in Scenario B. Water surface profiles and levee breach inundation maps were developed for hydrologic events ranging from 50% (1/2) to 0.2% (1/500) ACE median hydrologic events. All models and stage data are relative to the NAVD88 vertical datum.

Water surface profiles for Sutter Bypass, Feather River, and Wadsworth Canal were estimated using a system wide HEC-RAS model. Profiles were computed for two hydrologic storm centerings (see hydrology section for description of storm centering). The final profile is the higher of the two possible storm centering profiles. Model geometry was based on topographic and bathymetric mapping collected for the Sacramento and San Joaquin River Basins Comprehensive Study (1997-1999). Manning's roughness values were based on unsteady model calibration and verification of the 1997 and 2006 flood events.

Water surface profiles of Cherokee Canal were estimated using a HEC-RAS model. Water surface profiles were computed for a single storm centered above Highway 162. Model geometry was based on topographic and bathymetric mapping provided by DWR.

Levee breach simulations were independently performed for thirteen spatially distributed levee breaches throughout the study area. Breach locations were placed at representative locations based on levee geotechnical characteristics and floodplain inundation characteristics. Eight breaches were simulated on the Feather River from Thermalito to Sutter Bypass. Two breaches were simulated on the Sutter Bypass between Wadsworth Canal and Feather River. Two breaches were simulated on Cherokee Canal with one upstream and one downstream of the Union Pacific Railroad. A single breach was simulated on Wadsworth Canal. All breach simulations assume remaining levee reaches would be overtopped without failure.

For each hydrologic frequency event, floodplain inundation maps were developed for the thirteen spatially distributed levee breaches throughout the study area. The inundation maps were conditional (assumed a levee breach). The hydrologic frequency of the inundation map is not the frequency of inundation. Inundation frequency estimates have to account for performance of the levee (probability of the breach). The inundation frequency is computed in the economic flood damage analysis using the geotechnical performance curves.

Floodplains for existing conditions were estimated by including areas impacted by a breach of any levee that had less than 90% reliability for the given flood. Floodplain depth maps that combine the probability of the conditional floodplain inundation into a single ACE event were not developed. The probability of flooding from each source is based on the hydrologic frequency, stage-discharge relationship and the geotechnical performance. The combination of these parameters is done in the FDA economic model. The FDA economic model does not have the capability to display the geographic variability of flood risk on a map because it aggregates the results at index locations.

2.4.3 Geotechnical Levee Performance

Geotechnical conditions of the existing levees within the study area were evaluated to assess the probability of unsatisfactory performance/reliability (levee fragility curve) over a range of flood events. Risk and uncertainty based methods were utilized in accordance with ETL 1110-2-556, ETL 1110-2-561, and accepted guidance for planning studies.

Data gathered by USACE and the State of California's Urban Levee Evaluations (ULE) Program were utilized. The State's ULE Program performed a comprehensive geotechnical investigation suitable for feasibility studies between 2007 and 2012. ULE subsurface explorations have been conducted at approximately 1,000 foot intervals throughout the entire study area excluding Cherokee Canal. The inventory was augmented with nine additional explorations conducted for this study along the east levee of Cherokee Canal performed by the Corps. The explorations include Cone Penetration Tests (CPT), auger borings with standard penetrations tests, and sonic borings. Geophysical data including helicopter electromagnetic surveys (HEM) were performed as well as data gathering on past performance and as-built conditions.

The ULE evaluation subdivided the levee segments within the study area into 50 reaches, based on expected geotechnical performance. For the Pilot Study, the ULE reaches were adopted as subreaches and grouped into 12 larger reaches with similar characteristics for the economic analysis. An additional reach for Cherokee Canal was also evaluated, resulting in a total of 13 reaches.

An evaluation was performed for each reach using methods described in ETL 1110-2-556 (Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies) and consistent with applicable guidance on underseepage described in ETL 1110-2-569 (Design Guidance for Underseepage).

For each of the 12 reaches, a levee fragility curve was prepared for the existing levee conditions. These curves included probability of failure for the following modes:

- Underseepage
- Landside Slope Stability
- Judgment (Erosion, Animal Burrow, Penetrations)

An evaluation of through-seepage was not conducted at this time. Through-seepage is estimated to be a minor factor and will be included during evaluation of the selected alternative. The

probability of geotechnical levee failure for each location is provided in Table 3. The table is based on the stage estimates for a median hydrologic event.

Table 3. Probability of Geotechnical Failure by Median Hydrologic Annual Chance Exceedance (ACE)

	Probability of Geotechnical Failure by Median Hydrologic ACE						
	50% (1/2)	10% (1/10)	4% (1/25)	50% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Feather River							
Hamilton Bend LM0.51	0.00-0.00	0.05-0.11	0.22-0.45	0.22-0.45	0.22-0.45	0.40-0.63	0.89-1.00
MA 16-LM0.90	0.00 -0.00	0.00-0.03	0.05-0.32	0.14-0.42	0.13-0.41	0.35-0.61	0.94-1.00
LD9-LM0.52	0.00-0.00	0.09-0.19	0.26-0.35	0.30-0.41	0.31-0.42	0.49-0.63	0.88-1.00
LD1-LM9.31	0.01-0.02	0.02-0.02	0.06-0.11	0.09-0.15	0.11-0.16	0.19-0.25	0.39-1.00
LD1-LM3.99	0.00-0.00	0.12-0.17	0.21-0.27	0.25-0.30	0.26-0.32	0.35-0.40	0.46-1.00
MA3-LM4.92	0.00-0.00	0.29-0.35	0.38-0.44	0.41-0.46	0.44-0.49	0.49-0.54	0.57-0.60
Sutter Bypass							
SBE-LM6.2	0.19-0.24	0.31-0.39	0.40-0.47	0.46-0.53	0.52-0.59	0.60-0.65	0.65-1.00
SBE-LM11.9	0.19-0.24	0.31-0.39	0.41-0.49	0.46-0.53	0.51-0.58	0.58-0.64	0.64-1.00
Wadsworth Canal							
WCE-LM0.84	0.02-0.05	0.08-0.14	0.14-0.39	0.35-0.60	0.56-0.76	0.78-1.00	0.89-1.00
Cherokee Canal							
CCE-LM9.5	0.08-0.19	0.22-0.32	0.27-1.00	0.30-1.00	0.33-1.00	1.00-1.00	1.00-1.00

2.4.4 Flood Damages

Existing condition damages were estimated using results from the hydrologic, hydraulic, and geotechnical analysis described above. For this preliminary screening phase, Expected Annual Damages (EAD) were estimated for Yuba City using the HEC-FDA software program and graphical probability-stage curves. Total damages for the remaining study area were estimated based on the ratio of total damageable property between the unknown area and the Yuba City area. Yuba City contains approximately 70% of the total damageable property within the study area.

An economic inventory was assembled following standard USACE methods. For the study area, a base geographic information system (GIS) inventory with parcel attribute data was provided by the local sponsor for both Sutter and Butte counties. Building attribute data were used to determine land use and valuation of structures and contents. Detailed GIS data were unavailable for all multifamily and commercial properties. These data were estimated using available digitized footprints and aerial imagery. Field visits were conducted to collect and validate the base inventory data.

Parcels with structures were categorized by land use and grouped into the following categories:

Residential – Includes all parcels represented by a single unit such as detached single-family homes and parcels with more than one unit such as apartment complexes, condominiums, and multiplex units. Each parcel may have multiple structures.

- *Commercial* – Includes retail, service stations, office buildings, restaurants, and shopping centers.
- *Industrial* – Includes warehouses, light and heavy manufacturing facilities, and food and agricultural processing facilities.
- *Public* – Includes both public and semi-public uses such as post office, fire dept, hospitals, government buildings, schools, and churches.

The value of damageable structures was estimated based on depreciated replacement values. The depreciated replacement value of a structure was determined by multiplying the structures square footage by the cost per square foot and a remaining-value ratio. Values for cost per square foot were obtained from the Marshall and Swift Valuation Service based on land use, building type, construction class, and quality. The remaining-value ratio was based on the factors such as condition of the structure and the year the structure was built.

The value of damageable building contents was estimated as a percentage of depreciated structure value based on associated land use. Content percentages were based on the expert elicitation findings used in the *American River Watershed Common Features Natomas Basin Post-Authorization Change Report and Interim General Reevaluation Report* (USACE, 2010).

The total value of damageable property (structures and contents) within the Sutter Basin study area is estimated at $7.1billion. Table 4 displays the total value of damageable property by category.

Table 4. Damageable Property ($1,000's)

Stutter Basin Feasibility Study Area EIA	Structure Value ($1,000's)	Content Value ($1,000's)	Total Value ($1,000's)	Percent of Total
Biggs	54,757	23,560	78,318	1%
Gridley	278,501	133,560	412,061	6%
Live Oak	250,603	105,118	355,721	5%
Yuba City	3,327,010	1,636,411	4,963,421	77%
Rural-Butte	160,829	66,573	227,401	4%
Rural-Sutter	302,114	132,396	434,510	7%
TOTAL	$4,373,815	$2,097,617	$7,118,575	100%

Agricultural damage analysis is currently being completed. Agricultural crop and equipment values are estimated to be approximately 10% of the value of the total urban damageable property ($647 million). Future analysis will include an assessment of production costs of crops grown within the project area and the inventory of crops expected to be flooded.

2.4.5 Environmental

Existing and future without-project conditions have been developed for the study area and are described in the draft *Sutter Basin Feasibility Study Environmental Without-Project Conditions Report* (ICF International, 2011). This report will be the basis for the "Affected Environment" and "No Action Alternative" sections of the Sutter Pilot Feasibility Study/EIS/EIR. Following is a brief summary of existing environmental conditions based on the report.

The study area is located within the northern portion of California's Central Valley. The Sacramento Valley is a semi-arid region with an annual rainfall of approximately eighteen inches. There are two distinct annual seasons, a hot dry summer and a cool wet winter. Approximately eighty percent of the annual rainfall occurs in between October to March.

Sutter County is primarily rural, with extensive agricultural areas and a low population density. The county is one of California's major agricultural counties and its traditional job base is agriculture. Eighty-six percent of Sutter County's lands are dedicated to agriculture; uses include field and row crops, orchards, rice, livestock grazing, dry farming, and timber according to the Sutter County General Plan, dated 2010. Nearly two thirds of the county's residents live in the incorporated cities of Live Oak and Yuba City. The California Department of Finance provides population data estimates and projections for cities and counties throughout California. Based on these estimates, the population of Sutter County increased from 78,930 to 99,154 between April 2000 and January 2010. For that same timeframe, the population within the incorporated cities of Live Oak and Yuba City grew from 6,229 to 8,791 and 36,758 to 65,372, respectively.

Butte County occupies the northern portion of the study area and includes the small communities of Gridley and Biggs. Agricultural lands dominate the landscape of the county. Agriculture is a major employment sector in Butte County. According to the California Department of Finance, between April 2000 and January 2010, the population of Butte County increased from 203,171 to 221,768. For that same timeframe, the population of the incorporated City of Gridley rose from 5,408 to 6,454. The population within the City of Biggs declined from 1,793 to 1,787.

Due to agricultural development and urbanization little historic native habitat remains within the Basin. According to some estimates, riparian forests in the Central Valley have declined by as much as 89 percent from the time of the Gold Rush. The study area is largely agricultural with about 80 percent of the area in farmland (orchards and rice fields), 10 percent in urban and developed lands, and about 10 percent in natural areas. Most remaining natural wetland areas that do exist are protected and are in State (Department of Fish and Game (CDFG)) or Federal (United States Fish and Wildlife Service (USFWS)) ownership. Most of the remaining land is used for agriculture and does not contain native vegetation. Existing rice fields however do provide valuable waterfowl habitat and habitat for the federally-listed threatened giant garter snake (GGS).

The project levees are covered primarily with grasses and forbs with widely scattered trees. While the levees are relatively free of woody vegetation compared to other levees within the

Sacramento region, the levees have been determined based on a periodic inspection in 2010 to be in noncompliance with ETL-1110-2-571, *Engineering and Design: Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures* (USACE, 2009). Efforts are underway to determine how to bring the levees into compliance while preserving where feasible vegetation. Obtaining a variance and/or incorporating design measures to retain vegetation are strategies being considered.

Along the Feather River within the designated floodway, significant habitats of riparian woodlands and grasslands occur. A wide band of riparian vegetation up to a mile in width extends from the river to the project levees. Most reaches of levees on the Feather River are set back some distance from the river channel allowing for a significant riparian corridor. This is unlike the Sacramento River where below Colusa the levees tightly constrain the river. Riparian habitat types include willow riparian, cottonwood riparian, and Great Valley mixed riparian.. Riparian habitats in general provide shelter, nesting, and foraging habitat for countless wildlife species in the Central Valley including numerous species of migratory birds protected via the federal Migratory Bird Treaty Act 1973.

Significant areas of native riparian vegetation along the Feather River are within the California Department of Fish and Game Feather River Wildlife Management Area and the Audubon Society's Bobelaine Sanctuary. Both areas include typical valley riparian species interspersed with freshwater marshes. The riparian tree species include large Fremont cottonwood trees along with sycamore, black walnut, Oregon ash, and valley oak. The understory vegetation consists of box elder, willow, wild rose, blackberry, wild grape, and poison oak.

A number of Federal and State listed species are known to occur or potentially occur in the study area. Many of these species are located within the riparian areas along the Feather River. Federally listed species identified by the USFWS as potentially occurring in the study area include the valley elderberry longhorn beetle, giant garter snake, vernal pool fairy shrimp, California tiger salamander, Central Valley steelhead, Central Valley spring-run Chinook salmon, and the green sturgeon. State listed species include the bank swallow, Swanson's hawk, western yellow-billed cuckoo, greater sandhill crane, and giant garter snake.

The Feather River and other rivers in the general area provide spawning, rearing, and migratory habitat for a diverse assemblage of native and nonnative fish species. Native species present in these streams can be separated into anadromous (species that spawn in fresh water after migrating as adults from marine habitat) and resident species. Native anadromous species include two runs of Chinook salmon, steelhead, green and white sturgeon, Pacific lamprey, and river lamprey. Native resident species include Sacramento pikeminnow, Sacramento splittail, Sacramento sucker, hardhead, California roach, and rainbow trout. Nonnative anadromous and resident species are also present. Chinook salmon, steelhead, green sturgeon, Pacific lamprey, and Sacramento splittail have experienced declines in abundance as a result of natural and human-related factors.

The elderberry shrub, present within the riparian zone and near project levees, is the sole host plant to the federally-listed threatened valley elderberry longhorn beetle. Elderberry shrubs are a common component of riparian forests and adjacent uplands throughout California's Central Valley. The GGS, a state and federally threatened species, also has potential habitat along the

existing levees. Typically inhabiting marshes, sloughs, ponds, small lakes, and low gradient streams, GGS also heavily utilize agricultural wetlands such as irrigation and drainage canals, rice fields, and the adjacent uplands. These two listed species and the Swanson's hawk are considered the most likely species to be potentially adversely affected by levee construction activities. In some locations, elderberry shrubs and Swanson hawks can occur in the riparian habitat in close proximity to the levees and GGS aquatic habitat occurs in canals and ditches located near the toe of levees. Additional information regarding habitat conditions is included in the *Environmental Constraints Analysis for the Feather River West Levee Project* (ICF International, 2011), which was prepared to identify sensitive habitat areas along the west levee of the Feather River.

The Sutter National Wildlife Refuge operated by the USFWS is located within and along the Sutter Bypass consists of about 3,000 acres along about 20 miles of riparian channels on both sides of the interior of the bypass. Within the Sutter Bypass, riparian and emergent marsh vegetation is limited to narrow bands of woody vegetation near the low flow streams waterward of the project levees. Cottonwood and willow are the most common riparian tree species. During periods of high flow when the bypass is flooded, the bypass provides seasonal winter wetland habitat for migratory waterfowl. Segments of drainage ditches that are located landward of the Sutter Bypass and parallel the levee toe support areas of emergent marsh and the State and Federally-listed threatened GGS.

Various recreation activities are actively pursued along the banks of the Feather River. Fishing and boating are the major recreational activities. There are a number of County and city parks along the river. CDFG operates several areas within the Feather River Wildlife Area that are managed primarily for wildlife but offer recreation opportunities, including hunting, fishing, bird watching, and nature study. During the NEPA scoping period for the study, a concern was expressed regarding lack of river access for recreation. Use of levee top for hiking and biking is restricted because the public is not allowed to use most of the levee tops for recreation.

The study area is located in a federally designated nonattainment area for PM10 (particulate matter equal or less than 10 microns in diameter) under the Clean Air Act. Construction generated emissions of dust and diesel particulate matter is an air quality health concern.

2.5 FUTURE WITHOUT PROJECT CONDITION

The future without-project condition is the most likely condition expected to exist in the future in the absence of a proposed water resources project and constitutes the benchmark against which alternatives are evaluated. These forecasts of future conditions are from the base year (year when a project is expected to be operational) to the end of the period of analysis (50 years). Future without-project conditions for this study are projected assuming a base year of 2020 and a 50 year period of analysis out to year 2070. Current economics efforts do not include a future without project condition with future development estimates. It is scoped to do these calculations after the TSP selection as more detailed analysis is warranted. Some discussions on possible approaches follow.

Circumstances regarding flood risk may influence community development and population growth. One such circumstance is through imposition of development restrictions if target levels of flood protection are not in place. As stated in Section 1.5.2, the CVFPP will require a 200-year level of flood risk management (0.5% (1/200) ACE) for urban and urbanizing areas by the year 2025, and no new development would be permitted if this target is not met. As an interim measure under SB 5, no new development would be permitted if adequate progress is not being made toward this goal by 2015.

These measures apply to the study area and therefore may result in development restrictions if the required conditions are not met, which in turn may negatively influence community build-out as prescribed in the general plans, and similarly may negatively influence population growth projections. Therefore, two future growth scenarios have been described to bracket the potential circumstances of full growth and limited growth. Although these scenarios are highly speculative, the California Department of Finance assisted by providing unpublished data to support the potential population changes based on these scenarios. The scenarios are presented below.

2.5.1 Full-Growth Scenario

The following conditions apply to the full-growth scenario:

- The communities of Yuba City and Live Oak as well as surrounding areas within Sutter County are currently mapped by the Federal Emergency Management Agency (FEMA) as Zone X. It is anticipated that FEMA will issue updated floodplain maps for the portion of the study area within Sutter County by 2013. Updated FEMA Flood Insurance Rate Maps for the portion of the study area within Butte County became effective on January 6, 2011. The communities of Biggs and Gridley as well as surrounding areas within Butte County are mapped as FEMA Zone X. Under the full-growth scenario, current officially adopted FEMA maps would remain in place; no new FEMA restrictions.
- No SB 5 restrictions would be triggered; 200-year protection would be met via non-Federal actions area wide or over large planning areas.
- Current municipal general plans would be built out and continue beyond those plans to 2070; planned community development would continue as described in the general plans.
- Population growth would continue as described under current municipal general plans and would continue beyond those plans to 2070.

2.5.2 Limited-Growth Scenario

The following conditions apply to the limited-growth scenario:

- Current officially adopted FEMA maps would remain in place; no new FEMA restrictions.
- SB 5 restrictions would be triggered; 200-year protection would be met on a per parcel basis or over small, discrete planning areas.
- Current municipal general plans would not be built out beyond 2025; limited community development would continue but would be shifted from urbanized areas, under SB 5

restrictions, to non-urbanized areas.

- Population growth would continue but would be restricted according to community development.

2.5.3 Population

2.5.3.1 Full-Growth Scenario

According to California Department of Finance (2007c), "California's population is projected to reach almost 60 million people by 2050, adding over 25 million since the 2000 decennial census." In this time frame, Sutter County is expected to more than triple in size and experience the state's largest population increase (+255%). In 2050, the total population of Sutter County is expected to reach 282,894 (California Department of Finance 2007a), and the total population of Butte County is expected to reach 441,596 (California Department of Finance 2007b).

Specific population and other long-term projection data related to socioeconomics are not yet available for 2070; however, California Department of Finance prepared unofficial 2070 population estimates for Sutter and Butte Counties for this project. It is estimated that the population of Butte County will be 512,095 and the population of Sutter County will be 341,216. These projections are based on very preliminary analysis of migration and fertility trends, which will change. Also, it is important to note that 60-year projections are subject to an enormous amount of potential external changes that could render these values completely inaccurate (Schwarm pers. comm.). Based on these projections, the population in the study area would continue to increase, and it can be assumed that employment, income, and the demand for housing would also increase between 2011 and 2070.

2.5.3.1 Limited-Growth Scenario

The California Department of Finance prepared unofficial population estimates for Sutter and Butte Counties under the limited-growth scenario (Schwarm pers. comm.). It is estimated that the population of Butte County will be 438,676 and the population of Sutter County will be 301,516. As described above, these projections are based on very preliminary analysis of migration and fertility trends, which will change. Butte County is assumed to be slightly more affected by SB 5 and the provisions associated with it than Sutter County. Also, it is important to note that 60-year projections are subject to an enormous amount of potential external changes that could render these values completely inaccurate. However, under the limited-growth scenario, the population of both counties would be significantly less than it would be under the full-growth scenario.

2.5.4 Land Use

2.5.4.1 Full-Growth Scenario

It is anticipated that build out of Sutter County's General Plan will be achieved by the year 2070. Development rates in 2070 are expected to coincide with population growth over the next 60 years. The county's land use goals include maintaining adequate land use supply and preserving

agricultural heritage and natural resources. It is anticipated that in 2070 the primary land use will be agriculture in the unincorporated county. The main areas of growth will be in the Yuba City and Live Oak spheres of influence, rural planned communities, employment corridors, and industrial/commercial use. By 2070 the majority of the land use in unincorporated Butte County in the study area would remain in agriculture. It is likely that the 2030 build out numbers projected in the Butte County General Plan 2030 would be realized. While it could be assumed that the build out numbers for 2030 would be realized earlier, the county does not have a history of reaching planned build out numbers.

2.5.4.2 Limited-Growth Scenario

Under a limited-growth scenario in 2070, the estimated population of Sutter and Butte Counties will be approximately 13% smaller than the population numbers under a full-growth scenario. It is anticipated that there will be continued growth in cities and counties in the study area between 2025 (the year in which the CVFPP will require limitations on new development in urban and urbanizing areas) and 2070. Growth has been the trend within the study area and is anticipated, planned for, and encouraged in the municipal general plans. As this trend continues into the future, it will broaden the economic base. It is probable that because new development will be restricted in urbanized areas, existing smaller cities (such as Gridley, Biggs, and Live Oak) and unincorporated towns will grow and new communities will come into existence in areas with populations presently below 10,000. This will increase suburban growth, with the city spreading outward through low-density and auto-dependent development on rural and often unincorporated lands. As a result of new populations moving to currently undeveloped areas, there is the potential for cities and counties to change land use designations to accommodate the shift in population, despite the current emphasis on preserving agricultural lands for economic and recreational benefits.

The potential effects of the limited-growth scenario on land use in all jurisdictions in the study area could include conversion of important farmland to non-agricultural uses. Because housing in urban and urbanizing areas will be fully occupied and development limited after 2025, new housing will likely be driven to rural areas. This may ultimately require lands that are designated for agriculture, recreation, or open space to be converted to uses that support the development of housing. Land may also be converted to accommodate commercial districts that support the developing suburban communities. Furthermore, temporary zoning conflicts associated with suburban development are likely to occur.

In both Sutter and Butte Counties, it is likely that the dominant land use in 2070 under a limited-growth scenario will continue to be agriculture. This is because of the foreseeable demand for the area's agricultural commodities. Agriculture represents the economic base for both counties, and the preservation of open space and agricultural lands is highly regarded in the region.

2.5.5 Additional Assumptions

Additional assumptions regarding the future without-project condition are listed below:

- For purposes of evaluating the transfer of flood risk, the future without-project condition will assume the levees do not fail due to geotechnical conditions since their original design was not based on failure assumptions.

- Ongoing levee maintenance will result in no change to geotechnical conditions and levee performance curves.

- Oroville and New Bullards Bar reservoirs on the Feather and Yuba River Systems will continue to be operated using the existing rule curves.

- Vegetation and topographic conditions within the channel are expected to remain the same as existing conditions.

- Remaining natural areas are not expected to substantially decline in acreage and value over the period of analysis.

- Future urban development is expected to occur within agricultural lands rather than natural areas based on current adopted general plans.

- Since refinements, additions, and deletions of elements associated with the Systemwide Investment Approach presented in the 2012 CVFPP are anticipated, these elements will not be included in the future without-project condition.

- Quantitative estimates of flood damage related to climate change will not be made. However, a sensitivity analysis to changes in hydrologic frequency will be conducted. Evaluating the impact of climate change on local flood extremes would require lengthy and complex analysis. For example, evaluation of global climate models would be necessary to estimate changes in extreme rainfall amounts and temperature as well as seasonal changes to snowpack. Hydrologic modeling would be necessary to compute runoff from the basins hydrologic characteristics, precipitation amounts, precipitation temperature, and snowmelt excess. Reservoir modeling would be necessary to evaluate flood control operations based on downstream control points. DWR is developing a new methodology for estimating the impacts of climate change on flood hydrology (DWR, 2011). The study will evaluate climate change impacts on extreme events based on estimated changes to local extremes. The results of this complex analysis will not be available within the schedule of this study.

- Section 104 of WRDA 86 allows for the plan formulation analysis to exclude work conducted by the sponsor from the without project condition, thereby allowing the work to potentially be incorporated in to the recommended plan, if it is found to be in the Federal interest. Since the application for consideration of Section 104 credit for the completed Star Bend setback levee was approved in 2009, this project will not be considered part of the future without-project condition.

- Per direction from the Vertical Team at In-Progress Review #1, the Feather River West Levee Project <u>will not</u> be considered part of the future without-project condition (assumes no contract prior to the Chief's Report for the pilot study).

3.0 MEASURES AND CONCEPTUAL ALTERNATIVES

3.1 PLAN FORMULATION PROCESS

The plan formulation process develops and evaluates alternative plans to address the needs and desires of society as expressed in specific planning objectives. Accordingly, the TSP best satisfies the objectives as well as the Federal interest. Consistent with the Federal Water Resources Council's Principles and Guidelines (P&G) and the Planning Guidance Notebook (ER 1105-2-100), the procedure is broken down as follows:

- Establish specific planning objectives.
- Determine the nature and extent of issues to be addressed and identify the most important issues raised by the proposed action.
- Engage Federal and State resource agencies in the formulation process.
- Define constraints and criteria for formulating an implementable plan.
- Identify management measures to address the planning objectives. Retain those measures that are effective and produce NED benefits at less cost than other measures.
- Develop alternatives from the measures to meet or address the planning objectives and criteria.
- Compare alternatives in terms of economic cost and benefit, and identify the alternative that reasonabily maximizes net NED benefits if applicable.
- Identify the LPP.
- Reconcile differences between the NED plan and the LPP to develop a TSP that retains Federal interest. The overall TSP must continue to be economically feasible, and any deviation from the NED must be justified and must be approved by the ASA (CW). Any significant deviation from the NED may be a local sponsor responsibility and the local sponsor may be required to pay for entire project costs beyond what was identified in the NED Plan.

3.2 MANAGEMENT MEASURES

A broad array of management measures was developed based on information from existing reports and studies, as well as public input and professional judgment. The measures included the following categories: FRM structural, ER with FRM structural component, FRM non-structural, and recreational. These measures were presented at the Sutter Basin Pilot Study

Critical Thinking Charette held at the Sacramento District on July 18-19, 2011. The charette was attended by the PDT and non-Federal sponsors, along with several members of the Vertical Team and the National Pilot Program 17+1 Team. The measures were presented in an interactive format utilizing GIS and Google Earth. The team reviewed each measure, identified additional measures, and then evaluated the measures based on study objectives, study constraints, and Water Resources Council Principles and Guidelines (P&G) criteria. A group decision was made as to whether each measure should be retained or dropped from further consideration. Table 5 provides a description of the measures evaluated at the charette and indicates whether each one was retained or dropped and the reason(s) for dropping. Of the total 46 measures that were evaluated, 32 were retained.

Table 5. Summary of Measures Considered

ID	Measure	Measure Description	Retained	Dropped	Primary Reason(s) for Dropping Measure
S1	Biggs Ring Levee	Construct ring levee around highly developed area of Biggs.	X		
S2	Gridley Ring Levee	Construct ring levee around highly developed area of Gridley.	X		
S3	Live Oak Ring Levee	Construct ring levee around highly developed area of Live Oak.	X		
S4	Yuba City Ring Levee	Construct ring levee around highly developed area of Yuba City.	X		
S5	Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend	Fix in Place Feather River West Levee from Thermalito to Shanghai Bend.	X		
S6	Southern Portion of J-Levee	Construct Southern Portion of J-Levee. This measure would prevent potential levee failures on Sutter Bypass or Feather River downstream of Shanghai bend from backing up into Yuba City. However, if a failure occurred upstream of Shanghai, the measure would increase flood depths in Yuba City by ponding behind the J- levee.	X		
S7	Fix-in-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee	Fix in Place existing Feather River west levee from Shanghai Bend to Sutter Bypass, Sutter Bypass East levee, and Wadsworth Canal Levee.	X		
S8	Butte Bypass	Construct a 1400 foot wide bypass from Feather River to Butte Basin.		X	This measure was dropped from further consideration because it would need to be combined with Sutter Bypass increase in capacity and additional easements. This measure would also require a fix-in-place levee. Additional engineering requirements along Feather River and Sutter Bypass and/or ring levee would be needed before this measure would be effective.

S9	Sutter Bypass Setback Levee	Construct a 500 foot setback levee along Sutter Bypass.	X		This measure would utilize the existing DWR pumping stations.
S10	Northern Feather River Setback Levee	Construct a 5.3 mile long setback levee.	X		
S11	Sutter Bypass and Feather River Confluence Setback Levee	Construct 2.1 mile long setback levee near Feather River and Sutter Bypass confluence.	X		
S12	Star Bend Setback Levee	Construct a 0.8 mile long setback levee at Star Bend.	X		
S13	Oroville DFG Wildlife Management Area – Degrade Land Surface and Restore Wetlands	Measure consists of degrading land surface and restoring wetlands. However, current ground surface is not hydraulically efficient and measure may only result in a small stage reduction.	X		
S14	Nelson Slough Sediment Removal at Sutter Bypass and Feather River Confluence	Measure consists of removal of sediment upstream from Nelson Slough rock weir.		X	This measure was dropped from further consideration because it would provide minor hydraulic benefit. The benefits would be temporary because this area would continue to have sediment deposition. This measure would result in high operations and maintenance costs, along with potential increased costs related to HTRW concerns.
S15	Southern Relief Structure	Construct relief structure in the levee at the south end of the Basin. If a levee were to fail upstream this downstream gate or fuse plug type feature would be used to convey floodwaters back the Feather River and Sutter Bypass channel In a levee breach scenario this may reduce peak stages in the southern portion resulting in less structures being flooded in the Yuba City area.	X		
S16	Modify Fremont Weir	Modify Fremont Weir to reduce stages in the study area.		X	This measure would not reduce the water surface elevations enough to reduce seepage under and through the levees nor address the stability issues.
S17	Reoperation of Oroville Dam & Reservoir (Feather River)	This measure seeks to offset approximately 100,000 acre-feet of water supply for flood control storage space in Oroville Reservoir.		X	This measure was dropped from further consideration because fixes to the existing levee would still be required. This measure provides limited benefits downstream. Other listed measures would provide more efficient means to achieve performance.
S18	Increased flood storage in Shasta and Black Butte Reservoirs upstream of Sutter Bypass	This measure seeks to offset approximately 1,460,000 acre-feet of water supply in Shasta Reservoir and 674,000 acre-feet in Black Butte Reservoir for flood control storage space.		X	Based on the Sacramento San Joaquin Comprehensive Study results, this measure was found to have almost no impact on flood stages in the study area.

S19	Authorized Marysville Reservoir (South Yuba River)	Marysville Reservoir is a USACE authorized project that has not been constructed. Marysville Reservoir would be located on the Yuba River just upstream of the City of Marysville and downstream from New Bullards Bar and Englebright dams.		X	This measure is considered cost-infeasible due to deep foundation problems.
S20	Feather River Dredging	This measure consists of dredging the Feather River from Oroville to the mouth of Sacramento River.		X	This measure was dropped from further consideration because it does not fix the under seepage problem occurring within the existing levee. This measure also results in high costs of ongoing operation and maintenance and land acquisition. In addition, there are environmental concerns with mercury and heavy metals.
S21	Modify pumps along Sutter Bypass	This measure seeks to reduce or eliminate flooding due to ponding of excess flood waters in the southwestern portion of the study area.		X	This measure was dropped from further consideration because it does not fit within the study objectives. The study objectives do not focus on interior drainage.
S22	Cherokee Canal Sediment Removal	This measure would remove sediment that may have accumulated in the Cherokee Canal.		X	This measure was dropped from further consideration because canal maintenance is the responsibility of another party. There are other ongoing efforts to address sediment removal in the Cherokee Canal.
S23	Sunset Weir Modification	This measure would modify a hydraulic structure in the Feather River that is used to divert water into an irrigation canal.	X		
S24	Gilsizer Cross Levee with flap gates	This measure would involve constructing a new levee across the Sutter Basin from Star Bend on the Feather River to Pumping Plant #2 on the Sutter Bypass. The areas to the north and south of the new levee would have different residual flood probability.	X		
S25	Wadsworth Canal Tributary Drainage	This measure would involve increasing the capacity of the Wadsworth Canal to accommodate additional runoff.	X		
S26	Managed overtopping (levee superiority) on Feather River and Sutter Bypass.	This measure would increase the resilience of the existing levee system by providing designated overtopping locations similar to spillways.	X		
S27	Improve upstream fish passage in Sutter Bypass. (Remove fish passage barriers). Dependent on S9	This measure would identify and remove fish passage barriers in the Sutter Bypass. This measure is dependent on measure S9.	X		
S28	Sutter Bypass Sediment Removal	This measure would remove sediment that may have accumulated in the Sutter Bypass.		X	This measure was dropped from further consideration because it is considered maintenance. Maintenance is the responsibility of another party.

S29	Vegetation Management in Sutter Bypass	This measure would manage vegetation that affects stages within the Sutter Bypass.		X	This measure was dropped from further consideration because it is considered maintenance. Maintenance is the responsibility of another party.
S30	Vegetation Management in Lower Feather River	This measure would manage vegetation that affects stages within the Lower Feather River.		X	This measure was dropped from further consideration because it is considered maintenance. Maintenance is the responsibility of another party.
S31	Vegetation Management in Upper Feather River	This measure would manage vegetation that affects stages within the Upper Feather River.		X	This measure was dropped from further consideration because it is considered maintenance. Maintenance is the responsibility of another party.
NS1	Relocate structures and critical infrastructure in floodplain.	This measure would include relocation of structures and critical infrastructure in floodplains.	X		
NS2	Floodproof at isolated locations.	Residential structures and other buildings would be evaluated for potential damages during flood events from water entering the structure. Floodproofing techniques would be selected on a case-by-case basis.	X		
NS3	Elevate structures and transportation infrastructure	This measure would include elevating structures, railroads, and highways.	X		
NS4	Establish flood-resistant housing	This measure would include construction of flood-resistant housing.	X		
NS5	Secure large floatable objects	Objects that might be mobilized and strike people during a flood event would be removed, relocated, or secured.	X		
NS6	Flood-warning system	This measure would involve developing, establishing, and implementing a system for warning the public about potential flood events.	X		
NS7	Evacuation plan	This measure involves coordination with local entities to establish and implement a plan for evacuation during a flood event.	X		
NS8	Construct ring levees at isolated locations	This measure would involve construction of ring levees around structures that are subject to damage from flood waters.	X		
NS9	Floodfight pre-staging equipment and supply area	This measure includes establishing designated sites within the study area for pre-staging floodfighting equipment and supplies.	X		
R1	Multi-Use Trails	Establish an interconnected multiuse trail system.	X		
R2	Bicycle Trails	Connect bike trails to a larger trail system, with a focus on Class 1 trails.	X		
R3	Equestrian Trails	Equestrian trails are designed for horses and their riders. They are typically separated from bike and pedestrian trails.	X		
R4	Day Use Area	Day use areas are staging or access points to recreation spaces that have	X		

		their own specific uses.			
R5	River Access	River access facilities allow the public to directly engage the water safely at controlled locations.	X		
R6	Scenic Overlook	This measure consists of wildlife viewing platforms and/or boardwalks on levees or flood risk management lands for bird watchers and wildlife enthusiasts separate from main trails.	X		
R7	Recreational parkway	This measure compliments the multi-use trail measure by preserving natural areas and wildlife habitat along the trail system.	X		

3.3 CONCEPTUAL ALTERNATIVES

Following the initial screening of measures, the team identified four themes (strategies) for plan formulation. The themes included the following: 1) Consequence Management Focused on Public Safety, 2) Urban FRM Focus, 3) Maximize Existing System with FRM Focus, and 4) Ecosystem Restoration Focus.

These themes were used to assist the team in establishing a preliminary array of conceptual alternatives by grouping measures according to the primary focus of each theme. Measures listed under each conceptual alternative were designated as either required measures or optional measures that could be incrementally added to the alternative. Based on the measures grouped under each theme, the team identified a total of nine conceptual alternatives. Aside from Alternative 1.1, all alternatives are comprised primarily of new levees or strengthening of existing levees. A matrix with the array of conceptual alternatives and measures associated with each of these alternatives is also included in Table 6. The nine conceptual alternatives are described below by theme. In addition to the nine conceptual alternatives, the No Action Alternative is described below.

Table 6. Themes and Conceptual Alternatives

ID	Management Measure	Theme 1: Consequence Management Focused on Public Safety	Alternative 1.1: Nonstructural	Theme 2: Urban FRM Focus	Alternative 2.1: Ring Levees	Alternative 2.2: Big J	Alternative 2.3: Little J	Alternative 2.4: Minimal Fix in Place	Alternative 2.5: Fix in Place Thermalito to Star Bend	Theme 3: Maximize Existing System with FRM Emphasis	Alternative 3.1: Fix in Place w/o Raising	Alternative 3.2: Fix in Place w/o Raising including Modest Setbacks	Theme 4: Ecosystem Emphasis	Alternative 4.1: Setbacks with Ecosystem Restoration
S1	Biggs Ring Levee			*	X									
S2	Gridley Ring Levee			*	X									
S3	Live Oak Ring Levee			*	X									
S4	Yuba City Ring Levee			*	X									
S5	Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend			*		X	X	X SBFCA segment 4 and 5 only (Sunset Weir to Shanghai Bend)	X	*	X May include sub reaches	X	*	X
S6	Southern Portion of J-Levee			*			X							
S7	Fix-in-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee			* South to Star Bend only		X Feather River North of Star bend and Shanghai Bend north of Gilsizer slough		X Shanghai Bend to Star Bend	X Shanghai Bend to Star Bend	*	X May include sub reaches	X	* w/o Sutter Bypass fix in place	X w/o Sutter Bypass fix in place
S9	Sutter Bypass Setback Levee									*		O	*	X

S10	Northern Feather River Setback Levee			*						*		O	*	X
S11	Sutter Bypass and Feather River Confluence Setback Levee									*		X	*	X
S12	Star Bend Setback Levee			*		X			X	*	X	X	*	X
S13	Oroville DFG Wildlife Management Area – Degrade Land Surface and Restore Wetlands					O	O				O	O	*	X
S15	Southern Relief Structure	*	O	*						*	O	O	*	X
S23	Sunset Weir Modification			*		O	O	O		*	O	O	*	X
S24	Gilsizer Cross Levee with flap gates	*		*		X								
S25	Wadsworth Canal Tributary Drainage			*		O	O			*	O	O		
S26	Managed overtopping (levee superiority) on Feather River and Sutter Bypass.			*		O	O	O		*	O	O		
S27	Improve upstream fish passage in Sutter Bypass. (Remove fish passage barriers). Dependent on S9												*	X
NS1	Relocate structures and critical infrastructure in floodplain.	*	O	*	O	O	O	O	O	*	O	O	*	O
NS2	Floodproof at isolated locations.	*	O	*	O	O	O	O	O	*	O	O	*	O
NS3	Elevate structures and transportation infrastructure	*	O	*	O	O	O	O	O	*	O	O	*	O
NS4	Establish flood-resistant housing	*	O	*	O	O	O	O	O	*	O	O	*	O

NS5	Secure large floatable objects	*	O	*	O	O	O	O	O	*	O	O	*	O
NS6	Flood-warning system	*	X	*	X	X	X	X	X	*	X	X	*	X
NS7	Evacuation plan	*	X	*	X	X	X	X	X	*	X	X	*	X
NS8	Construct ring levees at isolated locations	*	O	*	O	O	O	O	O	*	O	O	*	O
NS9	Floodfight pre-staging equipment and supply area	*	X	*	X	X	X	X	X	*	X	X	*	X
R1	Multi-Use Trails	*	O	*	O	O	O	O	O	*	O	O	*	O
R2	Bicycle Trails	*	O	*	O	O	O	O	O	*	O	O	*	O
R3	Equestrian Trails	*	O	*	O	O	O	O	O	*	O	O	*	O
R4	Day Use Area	*	O	*	O	O	O	O	O	*	O	O	*	O
R5	River Access	*	O	*	O	O	O	O	O	*	O	O	*	O
R6	Scenic Overlook	*	O	*	O	O	O	O	O	*	O	O	*	O
R7	Recreational parkway	*	O	*	O	O	O	O	O	*	O	O	*	O

*: Included in theme
X: Included in alternative
O: Optional to alternative

3.3.1 Consequence Management Focused on Public Safety

3.3.1.1 Alternative 1.1: Nonstructural

At a minimum, the team determined that this alternative will include a flood warning system and evacuation plan. Optional measures include relocation of structures and critical infrastructure in the floodplain, floodproofing at isolated locations, elevating structures and transportation infrastructure, establishing flood-resistant housing, securing large floatable objects, constructing ring levees at isolated locations, and incorporating a southern relief structure. A map of this alternative is included as Plate 4. Only those measures with site specific locations are shown on Plate 4 and the plates for the other alternatives.

3.3.2 Urban FRM Focus

3.3.2.1 Alternative 2.1: Ring Levees

A map of this alternative including estimated residual floodplains is provided as Plate 5. This alternative consists of ring levees around the communities of Biggs, Gridley, Live Oak, and Yuba City. The heights of the Biggs, Gridley, and Live Oak ring levees were estimated based on the 0.2% (1/500) ACE levee breach inundation depths and an assumed additional height to provide 90% reliability. The height of the Yuba City ring levee was estimated based on the 0.5% (1/200) ACE levee breach floodplain and additional height to provide

90% reliability. The eastern flank of the Yuba City ring levee would utilize the existing Feather River levee. The existing levee would be strengthened in place to its existing authorized height with no raising and would meet current USACE design standards. The higher level of performance for the Biggs, Gridley, and Live Oak ring levees was utilized because the flood depths are relatively shallow and do not vary significantly between flood frequencies. Each ring levee was assumed to require a pump station to address interior drainage. The capacity of the pump station was based on the rational method.

3.3.2.2 Alternative 2.2: Big J

A map of this alternative including estimated residual floodplains is provided as Plate 6. This alternative includes strengthening the Feather River levees from Thermalito to Star Bend, constructing a new cross-levee from Star Bend to Gilsizer Slough, strengthening the Sutter Bypass levee from Gilsizer slough to Wadsworth canal, and strengthening the south levee of the Wadsworth canal. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising. The new levee reach was assumed to be a straight line profile from the Feather River levee to the Sutter Bypass levee. The levee footprint follows the approximate drainage divide to the two existing DWR pumping plants. Therefore, additional pumping plants would not be required. This alternative also includes the Star Bend setback levee.

3.3.2.3 Alternative 2.3: Little J

A map of this alternative including estimated residual floodplains is provided as Plate 7. This alternative includes strengthening in place Feather River levees from Thermalito to Shanghai Bend and constructing a new levee to the south and west of Yuba City. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising. The "J" levee was assumed to require a pump station to address interior drainage. The capacity of the pump station was based on the rational method.

3.3.2.4 Alternative 2.4: Minimal Fix-In-Place

A map of this alternative including estimated residual floodplains is provided as Plate 8. This alternative consists of strengthening in place the Feather River levees from Sunset Weir to Star Bend. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising.

3.3.2.5 Alternative 2.5: Fix-In-Place Thermalito to Star Bend

A map of this alternative including estimated residual floodplains is provided as Plate 9. This alternative consists of fixing in place Feather River levees from Thermalito to Star Bend and corresponds to phase 1 of the Feather River West Levee Project described in Section 1.4.1. The alternative also includes the Star Bend setback levee. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising.

3.3.3 Maximize Existing System with FRM Focus

3.3.3.1 Alternative 3.1: Fix-In-Place Without Raising

A map of this alternative including estimated residual floodplains is provided as Plate 10. This alternative consists of fixing in place the Feather River levees from Thermalito to the confluence with the Sutter Bypass and improving the east levees of the Sutter Bypass. . Levees along the south side of Wadsworth Canal would also be improved. The alternative also includes the Star Bend setback levee. All fix in place levees would meet current USACE design standards and would be strengthened to the existing authorized height with no raising.

3.3.3.2 Alternative 3.2: Primarily Fix-in-Place Including Modest Setbacks

A map of this alternative including estimated residual floodplains is provided as Plate 11. This alternative is similar to Alternative 3.1. However, in lieu of fixing in place the existing levees, new setback levees would be constructed at Northern Feather River and at the Sutter Bypass and Feather River confluence. The alternative also includes the Star Bend setback levee.

3.3.4 Ecosystem Restoration Focus

3.5.4.1 Alternative 4.1: Setbacks with Ecosystem Restoration

A map of this alternative including estimated residual floodplains is provided as Plate 12. This alternative is similar to Alternative 3.2. However, in lieu of improving the existing Sutter Bypass levee, a new setback levee would be constructed along the Sutter Bypass.

3.3.5 No Action Alternative

Under this alternative, the Federal government would take no action toward implementing a specific flood damage reduction plan. The study area would continue to be subject to risk of flooding and will rely on emergency responses to ensure the safety of local communities. Significant damage to property and potential loss of life could occur if the levees were to fail. Subsequent improvements to the levees would be done under emergency or post-failure conditions. Emergency costs associated with evacuation, flood fighting, fire and police, and government disruptions would occur. Transportation through the area could be severely hampered by a major flood, and critical infrastructure could be rendered nonfunctional for an extended period of time after a flood.

4.0 CONCEPTUAL DESIGN

Following the charette, each alternative was further developed at a class 4 level of detail based on civil design, hydrologic, hydraulic, geotechnical, and engineering considerations. Quantities, costs, and economic benefits were then estimated for each alternative.

4.1 LEVEE DESIGN

All levees within each alternative assume a design that meets current USACE standards for slopes (1V:3H waterside, 1:2H or 1V:3H landside existing or new slopes respectively), crest

width (20 ft), O&M access (10 ft existing minimum), and seepage and stability (0.5 exit gradient at the toe and 1.4 factor of safety for long term steady state stability). This includes both cases of new levees and modification of existing levees. The levees are considered to be capable of performance to the authorized design level for loading conditions. To achieve this performance, seepage control measures have been included in every alternative based on a parametric approach.

The parametric levee design approach utilized a suite of nine levee cross section (referred to as templates; refer to Plate X) that represent typical design configurations applicable to the study area. The parametric templates include:

- Stability Berm Element
- Stability Berm with Relief Wells Element
- Seepage Berm Element
- Gravel Stability Berm Element
- Waterside Soil-Bentonite Cutoff Wall Element
- Centerline Soil-Bentonite Slurry Cutoff Wall Element
- New Levee Element
- New Levee with Centerline Soil-Bentonite Cutoff Wall Element
- Levee Crest Widening Element

Not every possible seepage control or stability mitigation measure was included at this level of detail. Soil-bentonite cutoff walls are assumed at this level of design, though at subsequent design level, a seepage berm or some other measure (e.g. relief fells, etc.) may be required. This was done for simplicity, given the low level of information available, and because soil-bentonite walls have a lower impact to the environment.

A set of applicable templates was assigned to each reach based on a review of the conditions. Each template was then specified as a percentage of overall reach length. For example, a reach might include 20% soil bentonite slurry wall template and 90% levee crest widening template (note that the totals can be more than 100%, even for seepage control measures). The basic parameters that define each template were then specified based on an assessment of the existing performance of the levee within each reach.

Parametric templates were specified to meet current USACE geotechnical design requirements. Cutoff walls were typically specified for levee strengthening instead of seepage berms. For new levees, it is more cost effective to construct a cutoff wall than a seepage berm. In general, seepage berms and cutoff walls are roughly the same overall cost (considering real estate acquisition, and the increasing number of local contractors capable of cutoff wall construction), but seepage berms usually have a higher impact to the environment during construction

Proposed seepage control measures, including type (berm, cutoff wall, etc.), sizing (depth, width, etc.) and length (or percentage of length) were based on the existing condition report, and augmented by professional judgment and specific local knowledge, and/ or geological and soil maps.

The alignment of new levees was refined following the charette. Alignments were based on a review of aerial photography and topographic features. Geographic placement was based on minimizing impacts to existing structures, environmentally sensitive areas, and features expected to require costly mitigation or relocation. The objective was to maximize FRM benefits to existing structures while minimizing the length (cost) of the new levee.

Geotechnical design template parameters for seepage control measures were based on "expected" or median values. Judgment was used to estimate the minimum and maximum possible values, followed by an assumption of a median value. For instance, a ring levee far from the river was assumed to require a cutoff wall for some portion of the ring, and the lowest possible value that was expected based on engineering judgment was selected (for instance 25%). Next, the highest possible value was estimated (for instance 75%). The same approach was used for het depth of the cutoff wall. Finally, based on engineering experience the "expected" value was estimated to lie between these extreme values. Note that the median value was not necessarily a conservative value, nor was it the "mean" value.

The current authorized height was used for the design height of existing levees. An increase to the currently authorized levee design height was not considered due to possible adverse hydraulic impacts to floodplains outside of the study area. The design height of new levees was based on modeled floodplain water surface elevations and additional estimated height to provide 90% confidence The water surface elevation was based on a worst case breach of any levees outside the strengthened reaches identified in the alternative. As previously indicated, design of existing levees was assumed to provide performance to the authorized design elevation. No range of evaluations for different loading conditions was developed, because past protect experience indicates that any modification at all provides improvement of the project to the design elevation, leaving segments of high and low level of performance, which does not provide a systematic approach. An assessment of large relocations (road and canal/ditch crossings) was based on visual inspection of aerial imagery. Relocations were tabulated based on common characteristics such as road crossings, flood gates, bridges, and closure structures.

Real estate and structure relocations were developed for each alternative based on estimated rights-of-way. Acreage was calculated using the levee template parameters within each reach.

Additional features necessary to meet current USACE standards were tabulated by levee reach. Examples of additional features include utility penetrations, drainage culverts, and pipelines. The additional features were estimated from levee logs recently completed by DWR.

4.2 COST ESTIMATES

Cost estimates were completed for each alternative. Quantities for levee improvements were developed from the levee design templates and levee logs. Quantities for relocations, additional non-levee features, and real estate were developed primarily from assessment of aerial imagery.

A spreadsheet developed by URS Corporation was used to prepare cost estimates for the levee improvements and new levees. This spreadsheet estimates costs based on a parametric approach. The spreadsheet calculates the cost based on the design cross section templates and typical parameters within the reach (levee top width, height, etc.). The spreadsheet utilizes a database of

unit price data from public bid results and projects that URS worked on for DWR and other public agencies. Unit prices in the spreadsheet were reviewed and updated to reflect present costs. For each levee reach and selected design template, the design parameters and quantities provided by USACE civil and geotechnical engineers were utilized to generate the cost estimate.

Other major cost items including roads, railroads and canals crossing new levees, utility relocations, interior drainage, traffic control, Storm Water Pollution Prevention Plan and erosion control, cultural resources, and fish and wildlife mitigation, along with corresponding project costs for Planning, Engineering & Design (PED), and Construction Management were considered separately. The costs for work relative to obstructions and structures crossing levees (special items) and interior drainage (pump stations) were based on preliminary quantity take-offs, hydrological analysis, existing cost data for similar projects, and historic cost estimates for projects with similar work. A percentage of the construction costs was used to compute costs for the other major cost items.

Real estate land costs were estimated using the parametric spreadsheet described above. The spreadsheet multiplies the estimated footprint area by the percentage of land in four typical categories found within the study area. The four categories included agricultural, residential, commercial, and orchard. The percentage of land within each category was based on a review of the linear distribution in recent aerial photography. The approximate land costs of each category were based on a range of values (high and low) provided by the appraisal section. The costs included in the parametric spreadsheet were based on the average of the high and low values within each category.

Real estate administration costs required to acquire a portion of a parcel or entire parcel by the non Federal sponsor include securing rights of entry for engineering and environmental surveys, topographic mapping, surveying existing levee toes, surveying existing roadways for Plats and Legal Descriptions, right of way field staking, appraisal services, Independent Appraisal Review, acquisition services, relocation assistance program, title and escrow support, and condemnation support if needed. Report development and future land crediting activities are also federal administrative costs required as part of the cost estimate.

Real estate administration costs were estimated by multiplying the estimated number of parcels within the levee footprint by a typical administration cost. Administrative costs were estimated to be $85,000 per parcel for new levees and $60,000 per parcel for existing levees. Administrative costs were assumed be less for existing levees because they are likely to be within an existing right-of-way. The costs were estimated based on historical Corps projects. Actual values would vary significantly because each parcel is unique. Major factors affecting this cost include willing seller, no willing seller and potential condemnation. Relocation costs for displaced residents or businesses as addressed in P.L. 91-646 (Uniform Relocation Assistance and Real Property Acquisition Policies Act) are not included, but will be determined as the array is refined..

The total estimated cost for each alternative is the summation of the costs from the parametric spreadsheet output, the costs developed for special items and interior drainage, and the costs of the other major cost items (as a percentage of construction cost).

4.3 WITH PROJECT FLOODPLAINS

With project residual floodplains were estimated for each alternative. The floodplains were estimated assuming levee heights would be sufficient to provide 90% reliability for the design flood. The floodplains for the with project conditions were estimated using the modeled breaches under existing conditions. For the fix in place alternatives, this was accomplished by only including breaches in the unimproved levee reaches. For the Ring and J-Levee alternatives, the existing condition breach maps were modified to remove the portions on the land side of the ring and J-levee.

4.4 ECONOMIC BENEFITS

Economic benefits were estimated for each alternative. The first step was to estimate the maximum economic benefit of fixing all levees to their design height. For each alternative, the benefit was estimated by applying a ratio based on the without and with project floodplains. The intent of the use of these results is solely to screen out those preliminary alternatives that do not appear economically justified even in the most favorable benefit/cost ratio ranges. Table 7 provides an economic comparison of the alternatives.

Table 7. Economic Comparison

Alternative	Total First Cost ($Millions)		Estimated Annual Net Benefits ($Millions)		Estimated Benefit to Cost Ratio	
	Low	High	Low	High	Low	High
1.1 - Nonstructural	TBD	TBD	TBD	TBD	TBD	TBD
2.1 - Ring Levees						
Yuba City	313	671	-10	29	0.4	3.2
Gridley	95	204	-6	0	0.1	0.9
Live Oak	82	177	-5	0	0.1	0.9
Biggs	60	129	-5	-2	0.0	0.3
2.2 - Big J	703	1,506	-35	26	0.2	1.9
2.3 - Little J	560	1,201	-24	32	0.3	2.4
2.4 - Minimal Fix- in -Place	177	381	-8	9	0.3	2.3
2.5 - Fix in Place Thermalito to Star Bend	422	905	-17	29	0.3	2.7
3.1 - Fix in Place w/o Raising	737	1,579	-36	29	0.2	2.0
3.2 Primarily Fix in Place including modest setbacks	882	1,900	-48	22	0.2	1.6
4.1 Setbacks with Ecosystem Restoration	1,543	3,308	-100	-3	0.1	0.9

5.0 ALTERNATIVE REFINEMENT

A combined Value Engineering (VE) Study and Planning Charette was held from 31 October to 4 November 2011. The VE methodology was incorporated into the planning process at an early stage of the study to compare, refine, and optimize alternatives based on multiple criteria in order to ensure a robust array. This process also provided an opportunity to validate the array of preliminary alternatives and to ensure that significant alternatives had not been overlooked. The

VE Study/Charette was attended by the PDT and non-Federal sponsors, the SPK VE Officer and SPD VE Program Manager, the SPD Plan Formulation Lead, and representatives from the National Pilot Program 17+1 Team. The team reviewed initial alternative evaluation criteria and expanded these criteria based on input from the group. Following are the final criteria that were used to assess each alternative in combination with the conceptual level cost estimates for each alternative.

5.1 VE STUDY/CHARETTE EVALUATION CRITERIA

5.1.1 Life Safety

This criterion focuses on the potential for life safety risk including the potential for the loss of human life and immediate health impacts that result from flood conditions as well as to facilities such as medical—hospitals, critical care units, helipads for medical; concentrated overnight places– nursing homes, motels; administrative coordination and assistance facilities. It also includes an assessment of the ability to maintain evacuation routes such as road systems leaving major population centers during flood events. Levees with lower geotechnical performance (higher probability of failure prior to overtopping) were considered to have higher life safety risk due to unexpected failure. A qualitative assessment of life safety was also conducted during the VE study.

5.1.2 Flood Damage Benefits

This criterion focuses on flood damage benefits which account for the reduction of flood damages to property. Property includes, for example, buildings, economic assets, and loss of standing crops and livestock in agriculture. Each alternative was qualitatively rated based on the geographic distribution of damageable property and the estimated 1% (1/100), 0.5% (1/200), and 0.2% (1/500) ACE residual floodplains for the alternative.

5.1.3 Critical Infrastructure Impacts

This criterion focuses on the potential for impacts to critical infrastructure such as power plants; transportation– road, rail, and air; power– energy supply and distribution systems, including oil; communications– telecommunications network including; public health services– regional healthcare facilities; and water supply and treatment facilities.

5.1.4 Design Capacity Exceedance

Design capacity exceedance measures the remaining flood risks after project measures are constructed that are above and beyond those risks being addressed by the project. This criterion also considers the issue of levee superiority to manage residual risk of catastrophic failures and measures the consequences to life and property if a given alternative's design is exceeded.

5.1.5 Wise Use of Floodplain (Minimize Growth Inducement in Floodplain)

This criterion considers the characteristics of the alternative which could encourage or facilitate growth in the floodplain in an unwise manner. Each alternative was qualitatively rated based on the degree to which the alternative would discourage development in the most high risk areas of the floodplain.

5.1.6 Sustainability

This criterion is a measure of the extent to which future funds and effort will be required to sustain the project measures provided. It is defined as developing and protecting the constructed measures in a manner that enables people to meet current needs and provides that future generations can also meet future needs, from the joint perspective of environmental, economic and community objectives.

5.1.7 Ecosystem Functionality

Ecosystem functionality is a measure of the project's ability to maintain or enhance the natural environment to support a functioning ecosystem. This criterion includes an assessment of the opportunities for riparian and wetland habitat preservation and restoration as well as the efforts to minimize impacts to environmentally sensitive areas adjacent to floodplain such as the riparian forest, oak woodland, and giant garter snake habitats . The criterion also considers the restoration or preservation of natural riverine processes in the floodplain. A wider river channel would also contribute to improvements in fish habitat. Alternatives should restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities.

In order to assess ecosystem functionality associated with each of the alternatives, the team identified areas for potential ER, in conjunction with FRM, by reviewing aerial photography, coordinating with the local sponsor, and reviewing existing reports. Primary information sources included the draft *Sutter Basin Feasibility Study Environmental Without-Project Conditions Report* (ICF International 2011), *Pre-Design Formulation Report Sutter Butte Flood Control Agency Feather River West Levee Project* (HDR, MHM, URS, & Wood Rodgers, 2011), and *Sutter Basin Feasibility Study Restoration Opportunities, Measures, and Sponsors* (ICF International, 2010).

5.1.8 Environmental Impacts

This criterion focuses on the project's temporary and permanent impacts to the environment. It includes the preservation of the existing floodplain and avoiding adverse effects on air quality, water quality, and other resources. Land disturbance outside the existing levee footprint should be minimized. The criterion also considers the loss of farmland and impacts to existing structures.

In order to identify sensitive habitat and qualitatively assess potential environmental impacts associated with each of the alternatives, the team reviewed available information from various databases and existing reports. Primary information sources included the draft *Sutter Basin Feasibility Study Environmental Without-Project Conditions Report* (ICF International, 2011) and the *Environmental Constraints Analysis for the Feather River West Levee Project* (ICF International, 2011). The team also reviewed the *Environmental Site Assessment, Sutter Basin*

Pilot Study Preliminary Assessment of Alternatives report (USACE, 2011) to assess potential HTRW issues associated with each of the alternatives.

5.2 VE STUDY/CHARETTE ALTERNATIVE EVALUATION

During the VE Study/Charette, each preliminary alternative was qualitatively rated on a relative scale of 1 (worst) to 10 (best) based on the criteria presented in Section 2.2. A discussion of each alternative in relation to these criteria is provided below. The VE Study/Charette Report, which includes more details on the relative ratings of each alternative and the evaluation process, is included in Appendix B.

Since the measures to be included in the nonstructural alternative have not yet been well defined, this alternative was not evaluated during the combined VE Study/Charette. However, the team qualitatively evaluated the alternative following the VE Study/Charette. The results of this evaluation are discussed below. By policy, a primarily nonstructural alternative will be included in the final array.

5.2.1 Nonstructural Alternative

5.2.1.1 Cost

In order to assess flood damage benefits, the team needs to refine the nonstructural alternative and calculate the costs of the measures that would comprise the nonstructural alternative.

5.2.1.2 Life Safety

Risk of geotechnical levee failure and subsequent flooding in the surrounding area would remain. Subsequent improvements to the levee would be done under emergency or post-failure conditions.

5.2.1.3 Flood Damage Benefits

In order to assess flood damage benefits, the team needs to refine the nonstructural alternative and calculate the benefits of the measures that would comprise the nonstructural alternative.

5.2.1.4 Critical Infrastructure Impacts

At a minimum, measure NS6 (flood warning system) and measure NS7 (evacuation plan) will be included in this alternative. These measures would not address impacts to critical infrastructure. In order to assess critical infrastructure impacts, the team needs to refine the nonstructural alternative.

5.2.1.5 Design Capacity Exceedance

In order to assess design capacity exceedance, the team needs to determine what other measures would be included in the nonstructural alternative in addition to measure NS6 (flood warning system) and measure NS7 (evacuation plan).

5.2.1.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative would likely limit growth of local communities and future regional growth.

5.2.1.7 Sustainability

In order to assess sustainability, the team needs to refine the nonstructural alternative.

5.2.1.8 Ecosystem Functionality

If measure NS1 is included in this alternative, structure removal and relocation could provide an opportunity for ecosystem restoration benefits through riparian/wetland habitat restoration and creation of open space.

5.2.1.9 Environmental Impacts

This alternative may have the least direct environmental impact compared to the other alternatives because it would involve the least amount of construction activity and would minimizes the potential for future growth. However, communities and historic structures could be impacted by certain nonstructural measures such as NS1 (relocation of structures and critical infrastructure in the floodplain), NS2 (floodproofing at isolated locations), and NS3 (elevating structures and transportation infrastructure).

5.2.2 Ring Levees Alternative

5.2.2.1 Cost

The total estimated first cost of this alternative is $582 to 1,248 million. A breakdown of approximate first cost for each ring levee is provided below:

- Measure S1 (Biggs Ring Levee): $60 to $129 million
- Measure S2 (Gridley Ring Levee): $95 to $204 million
- Measure S3 (Live Oak Ring Levee): $82 to $177 million
- Measure S4 (Yuba City Ring Levee): $313 to $671 million

5.2.2.2 Life Safety

This alternative would reduce flood risk for a majority of the concentrated population and property within Yuba City, Live Oak, Gridley, and Biggs. Locations outside of the ring

levees (non-urban areas) would not receive flood reduction benefits from the ring levees. However, these areas are relatively low in population density. The ring levee around Yuba City would include a reach of the Feather River levee system. Thus, there would only be one line of protection around Yuba City versus two lines of protection provided by the ring levees of the other communities. A drawback of this alternative is that ring levees would rely on flood gates and other measures at crossings with railroads and roadways that would need to be actively operated in order to be effective. This alternative would also require access to evacuation routes. An evacuation plan would be included as a nonstructural measure for this alternative to address life safety.

5.2.2.3 Flood Damage Benefits

This alternative provides flood risk reduction to key urban development areas, thus property damages from flood events would be minimized. The ring levees around the four urbanized communities would reduce the flood risk for much of the property within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. A breakdown of the estimated annual net benefits for each ring levee is provided below. Based on this breakdown, Yuba City is the only potentially economically justified increment.

- Measure S1 (Biggs Ring Levee): $-5 to $-2 million
- Measure S2 (Gridley Ring Levee): $-6 to $0 million
- Measure S3 (Live Oak Ring Levee): $-5 to $0 million
- Measure S4 (Yuba City Ring Levee): $-10 to $29 million

5.2.2.4 Critical Infrastructure Impacts

Ring levees would reduce flood risk for key regional facilities and other critical infrastructure within the ring levees, but would not reduce the risk of flooding of roadways and railroads outside of the ring levees.

5.2.2.5 Design Capacity Exceedance

If design capacity was exceeded, the interior of the ring levees would flood rapidly, which could result in loss of life. In addition, the ring levee around Yuba City would include a reach that is part of the Feather River levee system. Thus, there would be only one line of protection for Yuba City versus two layers from the ring levees of the other three communities.

5.2.2.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative would limit growth of local communities and future regional growth, while allowing in-fill and redevelopment within the existing developed area.

5.2.2.7 Sustainability

This alternative would require maintenance of pump stations and closure structures to ensure effective continued operation and flood risk management for the ring levees. In addition, this alternative would require maintaining the existing levees within the study area, which are currently at risk of failure due to through-seepage and underseepage. Maintenance of new ring levees would also be required. However, the maintenance requirements of new levees would be less than existing levees because they would be constructed on new foundations and to modern engineering standards.

5.2.2.8 Ecosystem Functionality

Opportunities may exist for ecosystem restoration near the reaches of levee at Yuba City that would be incorporated into the Yuba City ring levee. There are few opportunities for ecosystem restoration associated with the other ring levee locations. Constructing new ring levees may impact existing functionality.

5.2.2.9 Environmental Impacts

This alternative preserves the existing floodplain while minimizing the potential for future growth and associated adverse effects on air quality and other resources. However, this alternative has the potential to conflict with local land use plans. Construction of the ring levees would require multiple railroad crossings as well as crossings of two significant drainage canals in Yuba City. Significant borrow material would be required for construction of the new levees. Direct and indirect impacts associated with this alternative could affect environmentally and culturally sensitive areas. In addition, construction of the levees would occur in urban areas that are more susceptible to air and noise quality impacts. Ring levees would also separate the communities of Yuba City, Live Oak, Gridley, and Biggs from their surrounding supporting areas and would result in aesthetic impacts by disrupting existing viewsheds. Pump stations would have to be operated periodically, which may result in air quality and noise impacts. There may also be HTRW issues associated with new levee alignments.

5.2.3 Big "J" Alternative

5.2.3.1 Cost

The total estimated first cost of this alternative is $703 to $1,506 million.

5.2.3.2 Life Safety

This alternative would reduce flood risk to the majority of the population and property within the study area. Areas in the southern portion of the study located below the Big "J" cross-levee would be located within the 1% (1/100)ACE floodplain. No actively operated closures would be necessary to maintain this alternative. All existing evacuation routes would be maintained.

5.2.3.3 Flood Damage Benefits

This alternative would capture approximately 93% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. The benefits would be limited by the performance of the Sutter Bypass levees, which have a lower performance than the Feather River levees. As presented in Table 7, the estimated annual net benefits for this alternative range from $-35 to $26 million.

5.2.3.4 Critical Infrastructure Impacts

This alternative would provide flood risk reduction for hospitals, power plants, and other critical infrastructure within the study area, but would not reduce risk for all critical roadways within study area limits.

5.2.3.5 Design Capacity Exceedance

If design capacity was exceeded, the evacuation route on westbound Route 20 would be impacted. If the levee failed, flood depths would be greater due to the height of the southern cross levee south of Yuba City. The flood depths within the urbanized area of Yuba City would increase at a faster rate due to changes in the location of floodplain storage. Areas in the southern portion of the study area (below Sutter Bypass levee) would remain at high risk to flooding.

5.2.3.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative reduces flood risk in Yuba City and other communities, which would allow for growth in existing urbanized areas. The cost of complying with the floodplain regulations could limit growth in the study area outside the Big J levee.

5.2.3.7 Sustainability

This alternative would result in reduced maintenance on the majority of existing levees along the Feather River, which are currently at risk of failure due to through-seepage and underseepage. New cross-levees for this alternative would be constructed on new foundations and to modern engineering standards. In addition to the maintenance required for the existing levees, these new reaches would require additional maintenance.

5.2.3.8 Ecosystem Functionality

Opportunities exist for ecosystem restoration within the segments of this alternative that includes existing levees. There are few opportunities for ecosystem restoration on other segments of this alternative. Constructing cross-levees may invade existing functioning ecosystems. Preserving existing levees may allow for future ecosystem restoration projects.

5.2.3.9 Environmental Impacts

Construction of the new cross levee associated with this alternative would directly impact farmland and potential sensitive habitat areas. Construction impacts would be limited where land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. The alternative would significant borrow material to construct new levee reaches. Construction of cutoff walls could potentially disrupt groundwater flows. Potential HTRW issues exist for new levee alignments. The alternative would include construction of levee reaches in urban areas, which are more susceptible to air and noise quality impacts. These new levee reaches would result in aesthetic impacts by disrupting existing viewsheds. This alternative would also separate the agricultural areas in the southern portion of the study area from the communities located in the northern portion.

5.2.4 Little "J" Alternative

5.2.4.1 Cost

The total estimated first cost of this alternative is $560 to $1,201 million.

5.2.4.2 Life Safety

This alternative would reduce flood risk to the majority of the population and property within the study area due to the population density in Yuba City. Areas in the southern portion of the study located below the Little "J" cross-levee would remain at risk of flooding. This alternative would impact the evacuation route on westbound Route 20 and two major drainage areas in Yuba City.

5.2.4.3 Flood Damage Benefits

This alternative would capture approximately 93% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. As shown in Table 7, the estimated annual net benefits for this alternative range from $-24 to $32 million.

5.2.4.4 Critical Infrastructure Impacts

This alternative reduces the risk of flooding for hospitals, power plants, and other critical infrastructure within the study area, but does not reduce risk for certain roadways within project limits.

5.2.4.5 Design Capacity Exceedance

If design capacity was exceeded, the evacuation route on westbound Route 20 and two major drainage areas in Yuba City would be impacted. Areas in the southern portion of the study area (below Sutter Bypass levee) would remain at risk to flood. The area north of the Little "J" levee would capture flood waters from the breach resulting in greater depths and faster stage increases.

5.2.4.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative reduces flood risk in Yuba City and other communities, which would allow for growth in existing urbanized areas. It provides limited flood risk reduction in all other parts of the study area, which could limit future growth. It focuses development in areas designated or already developed in lieu of encouraging development scattered through floodplain.

5.2.4.7 Sustainability

This alternative would result in reduced maintenance on the majority of existing levees along the Feather River, which are currently at risk of failure due to through-seepage and underseepage. New levees for this alternative would be constructed on new foundations and to current engineering standards. In addition to the maintenance required for the existing levees, the new levee reaches would require additional maintenance. This alternative would also require maintenance of pump stations and closure structures to ensure effective continued operation and flood risk management.

5.2.4.8 Ecosystem Functionality

Opportunities exist for ecosystem restoration within the reaches of this alternative that include existing levees. There are few opportunities for ecosystem restoration on other reaches of this alternative. Constructing new levees may invade existing functioning ecosystems. Preserving existing levees may allow for future ecosystem restoration projects.

5.2.4.9 Environmental Impacts

Construction of the new levee associated with this alternative would directly impact farmland and potential sensitive habitat areas. Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. The alternative would also require crossing two significant drainage systems in Yuba City and significant borrow material to construct levee reaches. Construction of cutoff walls could potentially disrupt groundwater flows. Potential HTRW issues exist for new levee alignments. The alternative would include construction of levee reaches near urban areas, which are more susceptible to air and noise quality impacts. These new levee reaches would result in aesthetic impacts by disrupting existing viewsheds. This alternative would also

separate the agricultural areas in the southern portion of the study area from the communities located in the northern portion.

5.2.5 Minimal Fix-In-Place Alternative

5.2.5.1 Cost

The total estimated first cost of this alternative is $177 to $381 million.

5.2.5.2 Life Safety

This alternative would reduce flood risk to portions of Yuba City and surrounding areas, but would not reduce flood risk for the communities in the northern study area (Live Oak, Gridley, and Biggs) and some portions of Yuba City. This alternative addresses high life risk areas south of the Yuba River and Feather River confluence and in Yuba City. In the event of flooding, the eastbound SR-20 evacuation route would be accessible, but evacuation routes SR-99 and Westbound SR-20 would be cut off.

5.2.5.3 Flood Damage Benefits

This alternative would provide flood risk reduction to approximately half of Yuba City, which includes approximately 77% of the total property within the study area. It would provide some protection to agricultural lands. The alternative would capture approximately 39% of total benefits within the study area. Compared to the other structural alternatives, it would provide the least amount of flood risk reduction and expose the maximum amount of property to potential damage. As presented in Table 7, the estimated annual net benefits for this alternative range from $-8 to $9 million.

5.2.5.4 Critical Infrastructure Impacts

The alternative would not provide flood risk reduction for all key critical infrastructure (hospitals, power plants) and would not provide flood risk reduction for roadways or railroads within the study area.

5.2.5.5 Design Capacity Exceedance

Given the limited extent of levee improvements, it is anticipated that design capacity would be exceeded on a frequent basis. In the event of flooding, the eastbound SR-20 evacuation route would be accessible, but evacuation routes SR-99 and Westbound SR-20 would be cut off. The alternative would not result in the ponding issues caused by the cross-levees in the J-levee alternatives.

5.2.5.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative reduces flood risk in approximately half of Yuba City. It does not provide flood risk reduction in all other parts of the study area, which could limit future growth.

5.2.5.7 Sustainability

Compared to the other structural alternatives, this alternative would result in the minimum amount of existing levees being improved. Thus, maintenance efforts for existing levees would be greater as compared to the other alternatives. However, the alternative would not add any additional reaches of levees to be maintained.

5.2.5.8 Ecosystem Functionality

Opportunities exist for ecosystem restoration along existing levees. Preserving existing levees may allow for future ecosystem restoration projects.

5.2.5.9 Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows.

5.2.6 Fix-In-Place Thermalito to Star Bend Alternative

5.2.6.1 Cost

The total estimated first cost of this alternative is $422 to $905.

5.2.6.2 Life Safety

This alternative is estimated to provide a 0.5% (1/200) ACE with 90% assurance level of flood risk reduction to a majority of the northern areas and communities within the study area, including Yuba City. It would not provide flood risk reduction from an event in the western portion of the study area. This alternative would preserve eastbound SR-20 as an evacuation route, but would cut off SR-20 westbound and SR-113 as evacuation routes.

5.2.6.3 Flood Damage Benefits

The alternative would capture approximately 79% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. As shown in Table 7, the estimated annual net benefits range from $-17 to $29 million.

5.2.6.4 Critical Infrastructure Impacts

This alternative would reduce risk for the majority of hospitals, power plants, and other critical infrastructure within the study area, but would not reduce risk for all roadways.

5.2.6.5 Design Capacity Exceedance

It is anticipated that design capacity of unimproved reaches would be exceeded on a frequent basis. However, the levees along the northern segments of the Feather River would be improved and the probability of potential breaches would decrease. This alternative would preserve eastbound SR-20, but would cut off SR-20 westbound and SR-113 as evacuation routes. The alternative would not result in the ponding issues caused by the new levees in the J-levee alternatives. However, deep ponding in the southern portion of the study area would exist.

5.2.6.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative would provide flood risk reduction to a significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development in these areas. By reducing risk to the existing urbanized areas, it focuses development in areas designated or already developed in lieu of encouraging development scattered through the floodplain.

5.2.6.7 Sustainability

This alternative would improve reaches of existing levees that currently have issues related to underseepage and through-seepage, thus reducing maintenance requirements. The alternative would not add any additional levees to be maintained. The Sutter Bypass levees and Feather River levees below Star Bend would not be improved and maintenance requirements are anticipated to remain the same.

5.2.6.8 Ecosystem Functionality

Opportunities exist for ecosystem restoration along existing levees. Preserving existing levees may allow for future ecosystem restoration projects.

5.2.6.9 Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows.

5.2.7 Fix-In-Place Without Raising Alternative

5.2.7.1 Cost

The total estimated first cost of this alternative is $737 to $1,579 million.

5.2.7.2 Life Safety

This alternative would provide flood risk reduction to most of the study area, including Yuba City, Live Oak, Gridley, and Biggs. In comparison to the previous alternatives, it would also reduce flood risk in the southern part of the study area. This alternative would preserve SR-20 and SR-113 as evacuation routes.

5.2.7.3 Flood Damage Benefits

The alternative would capture most of the total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. As presented in Table 7, the estimated annual net benefits range from $-36 to $29 million.

5.2.7.4 Critical Infrastructure Impacts

The alternative would reduce risk for hospitals, power plants, and other critical infrastructure as well as roadways and railroads within the study area.

5.2.7.5 Design Capacity Exceedance

This alternative would provide flood risk reduction to most of the study area. Flooding from an event that exceeded the design capacity would be similar to the existing (without-project condition). This alternative would preserve SR-20 and SR-113 as evacuation routes.

5.2.7.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative would provide flood risk reduction to a significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development to these areas. However, existing building codes and land use restrictions could limit future growth.

5.2.7.7 Sustainability

This alternative would improve the majority of reaches of existing levees, thus reducing maintenance requirements. The alternative would not add any additional levees to be maintained.

5.2.7.8 Ecosystem Functionality

Opportunities exist for ecosystem restoration along existing levees. Preserving existing levees may allow for future ecosystem restoration projects.

5.2.7.9 Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows.

5.2.8 Primarily Fix-In-Place With Modest Setbacks Alternative

5.2.8.1 Cost

The total estimated first cost of this alternative is $882 to $1,900 million.

5.2.8.2 Life Safety

This alternative would provide flood risk reduction to most of the study area, including Yuba City, Live Oak, Gridley, and Biggs. This alternative would preserve SR-20 and SR-113 as evacuation routes. There would be a marginal factor of safety improvements due to setback levees being built on new foundations.

5.2.8.3 Flood Damage Benefits

The alternative would capture almost 100% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. As presented in Table 7, the estimated annual net benefits for this alternative vary from $-48 to $22 million.

5.2.8.4 Critical Infrastructure Impacts

The alternative would reduce risk for hospitals, power plants, and other critical infrastructure as well as roadways and railroads within the study area.

5.2.8.5 Design Capacity Exceedance

This alternative would provide flood risk reduction to most of the study area. It would not create the ponding issue that would be caused by the cross-levees of the Big "J" and Little "J" alternatives and would provide more area for ponding in the southern portion of the study area. In comparison to the previous alternatives, it would also reduce flood risk in the southern part of the study area. This alternative would preserve SR-20 and SR-113 as evacuation routes. There would be a marginal factor of safety improvement due to setback levees being built on new foundations.

5.2.8.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative would provide 1% (1/100) ACE with 90% assurance flood risk reduction to a significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development to these areas. However, existing building codes and land use restrictions could limit future growth.

5.2.8.7 Sustainability

This alternative would improve the majority of reaches of existing levees, thus reducing maintenance requirements. Setback levees would be constructed on new foundations and to latest engineering standards, thus reducing maintenance efforts. Setback levees would have access points and distances to allow maintenance vehicles access.

5.2.8.8 Ecosystem Functionality

Levee setbacks would create opportunities for restoration of riparian and wetland habitats within the setback areas (approximately 700 acres). A wider river channel would contribute to improvements in fish habitats.

5.2.8.9 Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows. Where setback levees are proposed, construction may require removal or relocation of structures and include conversion of farmland to upland, riparian or wetland habitats.

5.2.9 Setbacks With Ecosystem Restoration Alternative

5.2.9.1 Cost

The total estimated first cost of this alternative is $1,543 to $3,308 million.

5.2.9.2 Life Safety

This alternative would provide flood risk reduction to most of the study area, including Yuba City, Live Oak, Gridley, and Biggs. It would reduce flood risk for most of the study area. This alternative would preserve SR-20 and SR-113 as evacuation routes. Setback levees would reduce the water surface elevation. There would be a marginal factor of safety improvement due to setback levees being built on new foundations.

5.2.9.3 Flood Damage Benefits

The alternative would capture almost 100% of total benefits within the study area. However, some agricultural and some rural structures would still be exposed to flood risk. As shown in Table 7, the estimated annual net benefits for this alternative range from $-100 to $-3 million.

5.2.9.4 Critical Infrastructure Impacts

The alternative would reduce risk for hospitals, power plants, and other critical infrastructure as well as roadways and railroads within the study area.

5.2.9.5 Design Capacity Exceedance

This alternative would provide flood risk reduction to most of the study area. It would not create the ponding issue that would be caused by the cross-levees of the Big "J" and Little "J" alternatives and would provide more area for ponding in the southern portion of the study area. In comparison to the previous alternatives, it would also reduce flood risk in the southern part of the study area. This alternative would preserve SR-20 and SR-113 as evacuation routes. Setback levees would allow levees to withstand erosion during design exceedance better than fixing the existing levees in place.

5.2.9.6 Wise Use of Floodplain (Minimize Growth Inducement)

This alternative would provide flood risk reduction to a significant portion of study area, thus removing flood risk as an obstacle to future regional growth and development to these areas. However, existing building codes and land use restrictions could limit future growth.

5.2.9.7 Sustainability

This alternative would improve the majority of existing levees, thus reducing maintenance requirements. Setback levees would be constructed on new foundations and to latest engineering standards, thus reducing maintenance efforts. Setback levees would have access points and distances to allow maintenance vehicles access.

5.2.9.8 Ecosystem Functionality

Levee setbacks would create opportunities for restoration of riparian and wetland habitats within the setback areas (approximately 4,100 acres). A wider river channel would contribute to improvements in fish habitats.

5.2.9.9 Environmental Impacts

Construction impacts would be limited if land disturbance is confined to existing levee footprints. Seepage berms, canal relocations, and land requirements could impact adjacent environmentally sensitive habitats and structures. Construction of cutoff walls could potentially disrupt groundwater flows. Where setback levees are proposed, construction may require removal or relocation of structures and include conversion of farmland to upland, riparian, and wetlands habitats.

5.3 VE STUDY/CHARETTE RESULTS

Based on the discussions during the combined VE Study/Charette, the team identified alternatives with very similar functions as well as alternatives with little probability of implementation. This resulted in combining and eliminating some of the alternatives as well as refining and optimizing those that were retained by adding or removing measures in order to ensure a robust array. Following is a summary of the recommendations for the array of alternatives to be carried forward.

The existing measures establishing a flood-warning system and evacuation plan, as well as a new measure establishing floodfight pre-staging equipment and supply areas, should be the first added increments to all alternatives.

It was decided that a purely non-structural alternative was not likely feasible due to the extent and depths of probable floods. The team recommended combining Alternative 1.1 (Nonstructural) and Alternative 2.4 (Minimal Fix-In-Place) into a new alternative titled "Minimal Fix-in-Place plus Non-Structural" that would reduce residual risk. This alternative is a combination of minimal levee improvements to Feather River levees with the implementation of nonstructural measures focused on reducing risk to loss of life. A map of this alternative is provided as Plate 13.

The team determined that the costs of constructing ring levees around Biggs, Gridley, and Live Oak are significantly greater than the estimated annual benefits could support. Therefore, Alternative 2.1 (Ring Levees) should be refined by eliminating the individual ring levees around Biggs, Gridley, and Live Oak. This new alternative is titled "Yuba City Ring Levee" and consists of constructing a ring levee around Yuba City in combination with nonstructural measures focused on reducing risk in areas outside of the ring levee. A map of this alternative is provided as Plate 14.

The team recommended that Alternative 2.2 (Big "J" levee) be eliminated from further evaluation and that Alternative 2.3 (Little "J" levee) be retained. The Big "J" levee and the Little "J" levee are very functionally similar and are expected to have similar flood damage benefits. However, the Big "J" levee would be approximately 30% greater in cost based on conceptual cost estimates. In addition, if the design capacity of the Sutter Bypass reach of the Big "J" levee was exceeded, flood depths would be greater than existing conditions due to the height of the southern cross portion of the "J" levee (south of Yuba City). The flood depths would also increase at a faster rate due to less floodplain storage. Finally, the benefits associated with the Big "J" levee would be limited by the performance of the Sutter Bypass levees, which have a lower performance than the Feather River levees. The Little "J" levee does not utilize the Sutter Bypass levees and can therefore obtain a higher level of performance. A map of the Little "J" levee alternative is provided as Plate 15.

Based on an assessment of Alternative 2.5 (Fix-In-Place Thermalito to Star Bend) in relation to the evaluation criteria utilized for the combined VE Study/Charette, it was determined that this alternative should be retained. A map of the Fix-In-Place from Thermalito to Star Bend alternative is provided as Plate 16.

The team recommended that Alternative 3.1 (Fix-In-Place Without Raising) should be combined with Alternative 3.2 (Primarily Fix-In-Place with Modest Setbacks). These two alternatives were essentially the same alternative except for the optional setbacks. The setbacks can be evaluated as standalone additions to the combined alternative. This new alternative is titled "Fix in Place Feather River, Sutter Bypass, and Wadsworth Canal with Select Setbacks for Ecosystem Restoration." A map of this alternative is provided as Plate 17. The team also recommended that Alternative 4.1 (Setbacks with Ecosystem Restoration) be eliminated from further evaluation because the additional cost of this alternative compared to combined Alternatives 3.1 and 3.2

exceeds the additional restoration benefits and it has little probability of implementation. The ecosystem benefits from setbacks can be evaluated as standalone additions to the alternatives that are retained for further evaluation.

Finally, it was determined that the team should evaluate an optional measure that would provide FRM to the area south of the community of Sutter between the Sutter Bypass levee and Wadsworth Canal Levee. This was recommended to address completeness within the study area.

A matrix with the array of alternatives to be carried forward and measures associated with each of these alternatives is included in Table 8. This array will be evaluated in further detail as the team progresses toward selection of the Tentatively Selected Plan (TSP).

Table 8. Refined Alternatives to be Evaluated in Further Detail

ID	Management Measure	Primarily Nonstructural with Minimal Levee Improvement Reaches	Yuba City Ring Levee	Little "J" Levee	Fix in Place Feather River Thermalito to Star Bend	Fix in Place Feather River[1], Sutter Bypass[2], and Wadsworth Canal[3] with select setbacks for ecosystem restoration
S4	Yuba City Ring Levee		X			
S5	Fix-In-Place Feather River West Levee from Thermalito to Shanghai Bend	X SBFCA segment 4 and 5 only (Sunset Weir to Shanghai Bend)		X	X	X
S6	Southern Portion of J-Levee			X		
S7	Fix-in-Place Feather River West Levee from Shanghai Bend to Sutter Bypass; plus Wadsworth Canal East Levee; plus Sutter Bypass East Levee				X Shanghai Bend to Star Bend	X
S9	Sutter Bypass Setback Levee					O
S10	Northern Feather River Setback Levee			O	O	O
S11	Sutter Bypass and Feather River Confluence Setback Levee					O
S12	Star Bend Setback Levee	O	O	O	O	O
S13	Oroville DFG Wildlife Management Area –Degrade Land Surface and Restore Wetlands	O	O	O	O	O
S15	Southern Relief Structure	O	O	O	O	O
S23	Sunset Weir Modification	O		O		O
S26	Managed overtopping (levee superiority) on Feather River and Sutter Bypass.	O		O	O	O
S27	Improve upstream fish passage in Sutter Bypass. (Remove fish passage barriers). Dependent on					O

	S9					
S28	Sutter Bypass Sediment Removal			O	O	O
NS1	Relocate structures and critical infrastructure in floodplain.	O	O	O	O	O
NS2	Floodproof at isolated locations.	O	O	O	O	O
NS3	Elevate structures and transportation infrastructure	O	O	O	O	O
NS4	Establish flood-resistant housing	O	O	O	O	O
NS5	Secure large floatable objects	O	O	O	O	O
NS6	Flood-warning system	X	X	X	X	X
NS7	Evacuation plan	X	X	X	X	X
NS8	Construct ring levees at isolated locations	O	O	O	O	O
NS9	Floodfight pre-staging equipment and supply area	X	X	X	X	X
R1	Multi-Use Trails	O	O	O	O	O
R2	Bicycle Trails	O	O	O	O	O
R3	Equestrian Trails	O	O	O	O	O
R4	Day Use Area	O	O	O	O	O
R5	River Access	O	O	O	O	O
R6	Scenic Overlook	O	O	O	O	O
R7	Recreational parkway	O	O	O	O	O

X: Included in alternative
O: Optional to alternative

1 Feather River West Levee from Thermalito to Sutter Bypass
2 Sutter Bypass East Levee, Wadsworth Canal to Feather River
3 Wadsworth Canal East Levee, East Interceptor to Sutter Bypass

6.0 COMPARISON OF REFINED ALTERNATIVES

6.1 REFINED ARRAY OF ALTERNATIVES

Following is a summary of the refined array of alternatives that will evaluated in further detail as the team progresses toward selection of the TSP for In Progress Review (IPR) 4. The No Action Alternative is designated as Alternative SB-1.

6.1.1 Minimal Fix-in-Place plus Non-Structural SB-2

A map of this alternative including estimated residual floodplains is provided as Plate 13. This alternative consists of fixing-in-place the Feather River levees from Sunset Weir up- to and including a Star Bend set back (partial S5 and S7 measures). This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

Options:

- Other non-structural measures include relocation of structures and critical infrastructure in the floodplain; flood proofing at isolated locations; elevating structures and transportation infrastructure; establishing flood-resistant housing, securing large floatable objects, constructing ring levees at isolated locations, and incorporating a southern relief structure.

- Construct a Southern Relief Structure.
- Department of Fish and Game Wildlife Management Area (DFGWMA) Re-contour Floodplain.
- Sunset Weir Modification.

6.1.2 Yuba City Ring Levee Alternative SB-3

A map of this alternative including estimated residual floodplains is provided as Plate 14. This alternative consists of a ring levee around Yuba City. The height of the Yuba City ring levee was estimated based on the 0.5% (1/200) ACE levee breach floodplain and additional height to provide 90% reliability. The eastern flank of the Yuba City ring levee would utilize the existing Feather River levee. The ring levee was assumed to require two new pump stations to address interior drainage. This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

Options:

- Construct a Star Bend setback levee.
- DFGWMA Re-contour Floodplain.
- Construct a Southern Relief Structure

6.1.3 Little J Levee Alternative SB-4

A map of this alternative including estimated residual floodplains is provided as Plate 15. This alternative includes fixing-in-place in place Feather River levees from Thermalito to Shanghai Bend (partial S5 measure), and constructing a new levee to the south and west of Yuba City (Little J). The "J" levee was assumed to require two new pump stations to address interior drainage. This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

Options:

- Construct a Star Bend setback.
- Northern Feather River Setback.
- DFGWMA Re-contour Floodplain.
- Sunset Weir Modification.
- Construct a Southern Relief Structure.

6.1.4 Fix-In-Place Feather River, Thermalito to Star Bend Alternative SB-5

A map of this alternative including estimated residual floodplains is provided as Plate 16. This alternative consists of fixing- in -place Feather River levees from Thermalito up-to and including a Star Bend set back (partial S5 & S7 measures). This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

Options:

- Construct a Star Bend setback levee in lieu of a fix-in-place.
- Northern Feather River Setback.
- DFGWMA Re-contour Floodplain.
- Construct a Southern Relief Structure

6.1.5 Fix-In-Place Feather River, Sutter Bypass, and Wadsworth Canal Alternative SB-6

A map of this alternative including estimated residual floodplains is provided as Plate 17. This alternative consists of fixing –in- place the Feather River levees from Thermalito to the confluence with the Sutter Bypass, and fixing-in-place the east levees of the Sutter Bypass (partial S5 & S7 measures). Levees along the south side of Wadsworth Canal would also be fixed-in-place. This alternative also includes a Star Bend setback. This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

Options:

- Construct a new setback levee at the Sutter Bypass and Northern Feather River confluence.
- DFGWMA Re-contour Floodplain.
- Sunset Weir Modification.
- Improve Fish Passage- dependant on a Sutter Bypass setback.
- Construct a Southern Relief Structure.

7.0 DRAFT ARRAY OF ALTERNATIVES

Further refinement and evaluation of the of the refined array of alternatives led to the addition of two additional alternatives identified as SB-7 and SB-8 that further reduced flood risk and addresses residual risk in terms of life safety. The alternative descriptions are as follows:

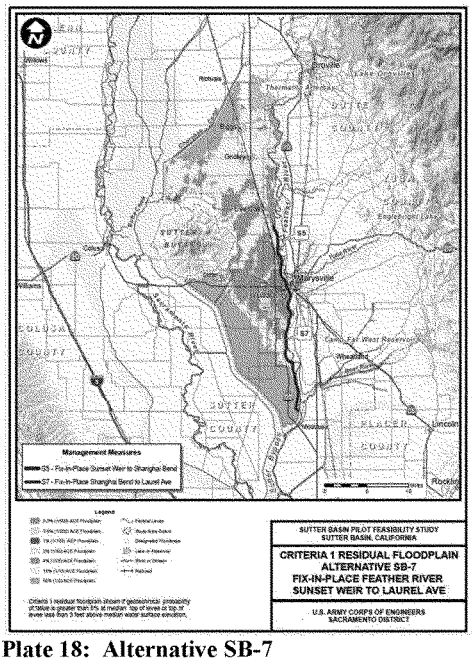

Plate 18: Alternative SB-7

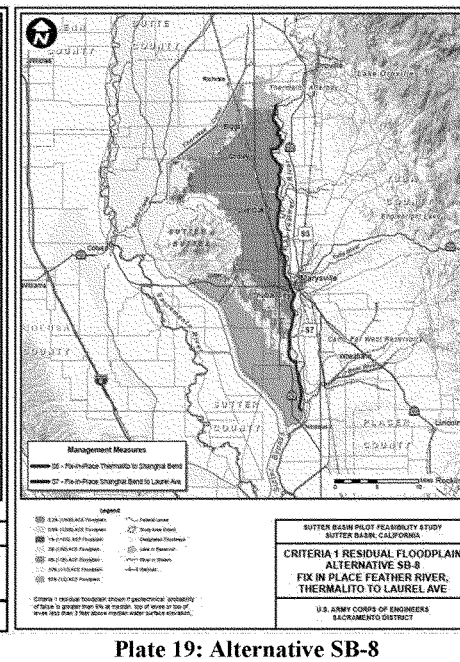

Plate 19: Alternative SB-8

Alternative SB-7: Fix-in-Place Feather River Levees, Sunset Weir to Laurel Avenue

This alternative includes SB-2 and extends Feather River fix-in-place levee improvements south of Yuba City to Laurel Ave. Reduction of flood risk includes SB-2 and additional flood risk reduction in the Yuba City southeastern areas. This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

Alternative SB-8: Fix-in-Place Feather River Levees, Thermalito Afterbay to Laurel Avenue

This alternative is inclusive of SB-7 and extends Feather River levee improvements north to Thermalito. Reduction in flood risk includes all of SB-7 and provides extensive flood risk reduction in the northern areas and communities of the Sutter Basin which includes the towns of Live Oak, Gridley, and Biggs. This alternative also includes non-structural measures of a flood warning system, evacuation plan, & flood fight pre-staging areas.

These final eight alternatives were further refined and evaluated as the Draft Array of Alternatives:

Alternative SB-1: No Action Alternative
Alternative SB-2: Minimal Fix-in-place Feather River Levees, Sunset Weir to Star Bend
Alternative SB-3: Yuba City Ring Levee
Alternative SB-4: Little "J" Levee
Alternative SB-5: Fix in Place Feather River Levees, Thermalito Afterbay to Star Bend
Alternative SB-6: Fix-in-Place Feather River Levees, Sutter Bypass, and Wadsworth Canal
Alternative SB-7: Fix-in-Place Feather River Levees, Sunset Weir to Laurel Avenue
Alternative SB-8: Fix-in-Place Feather River Levees, Thermalito Afterbay to Laurel Avenue

The final array of alternative process from this draft array are described in Decision Point 2 Report Summary document and Draft Report, Chapter that leads to the Tentatively Selected Plan.

8.0 REFERENCES

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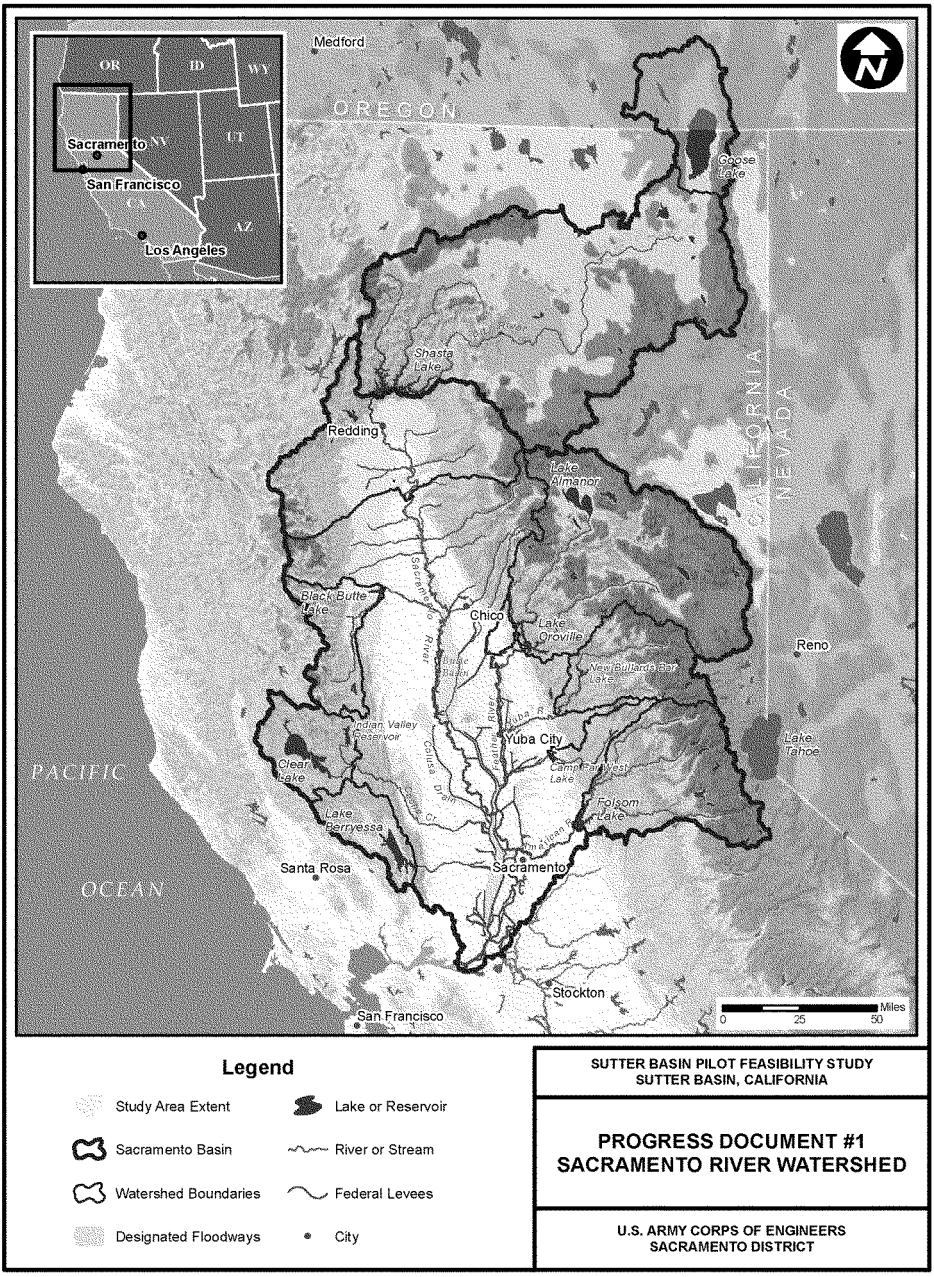
Sutter Basin Pilot Feasibility Study
Progress #1 Document:
Without Project and Alternative Development

Plates



Legend

- Study Area Extent
- Sacramento Basin
- Watershed Boundaries
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levees
- City

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

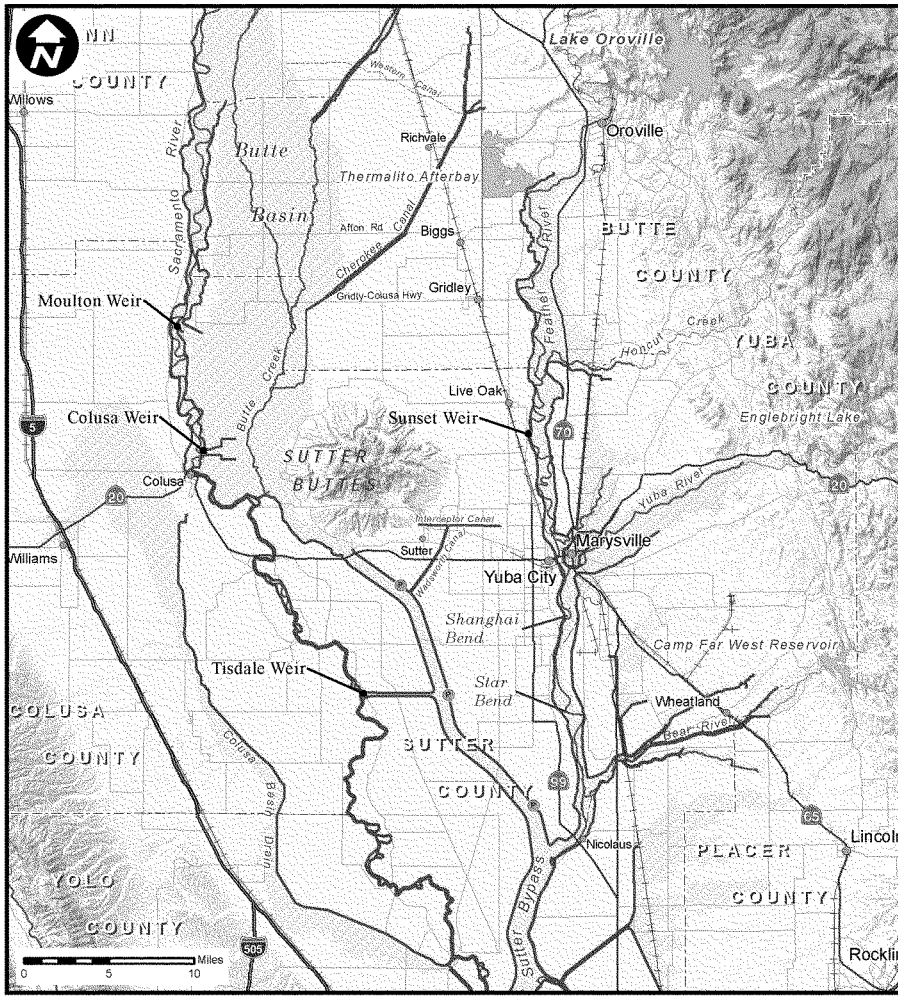
PROGRESS DOCUMENT #1
SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 1



Legend

- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- Pump Station
- Highway
- Major Road
- Railroad
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
STUDY AREA

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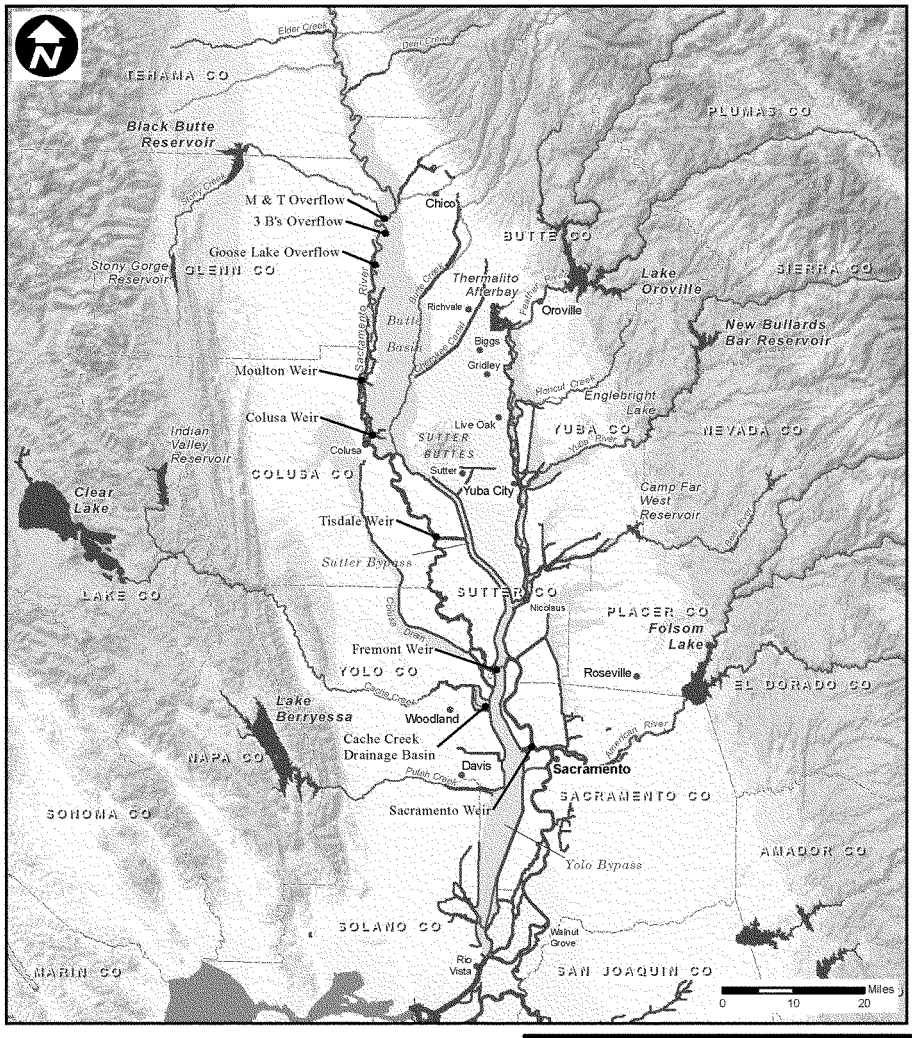
PLATE 2



Legend

- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
SACRAMENTO RIVER
FLOOD CONTROL PROJECT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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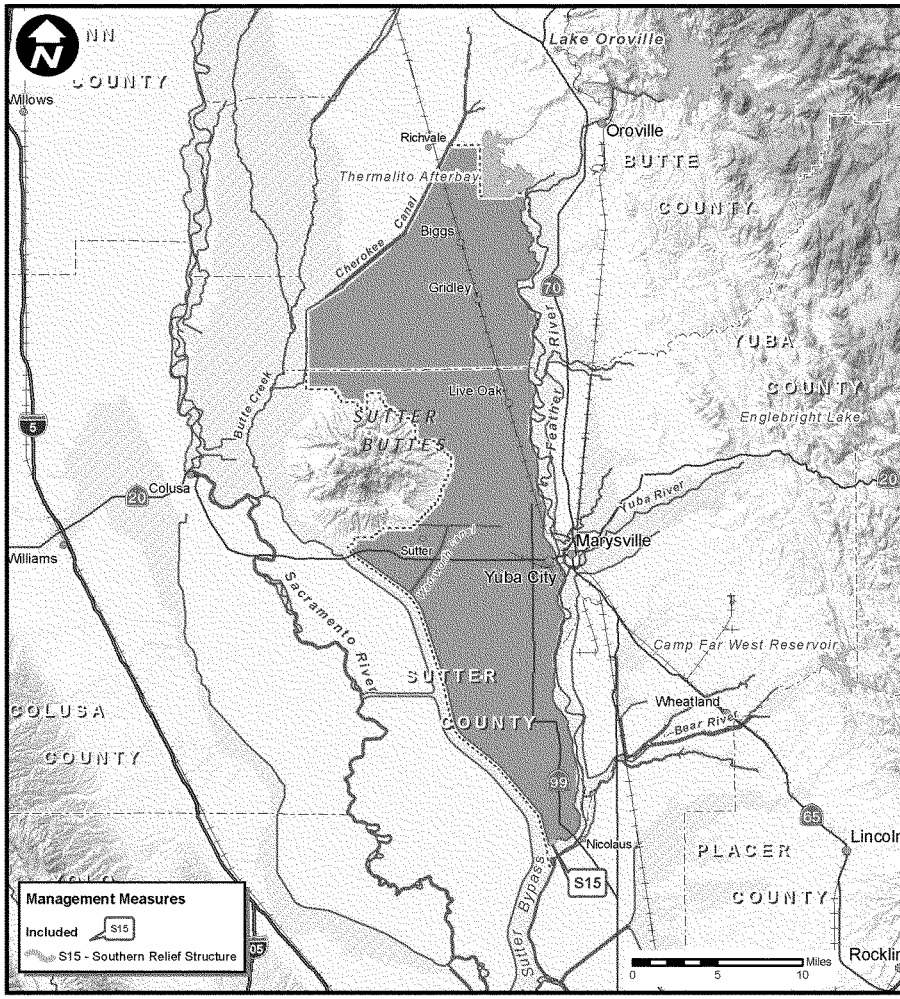
PLATE 3



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 1.1

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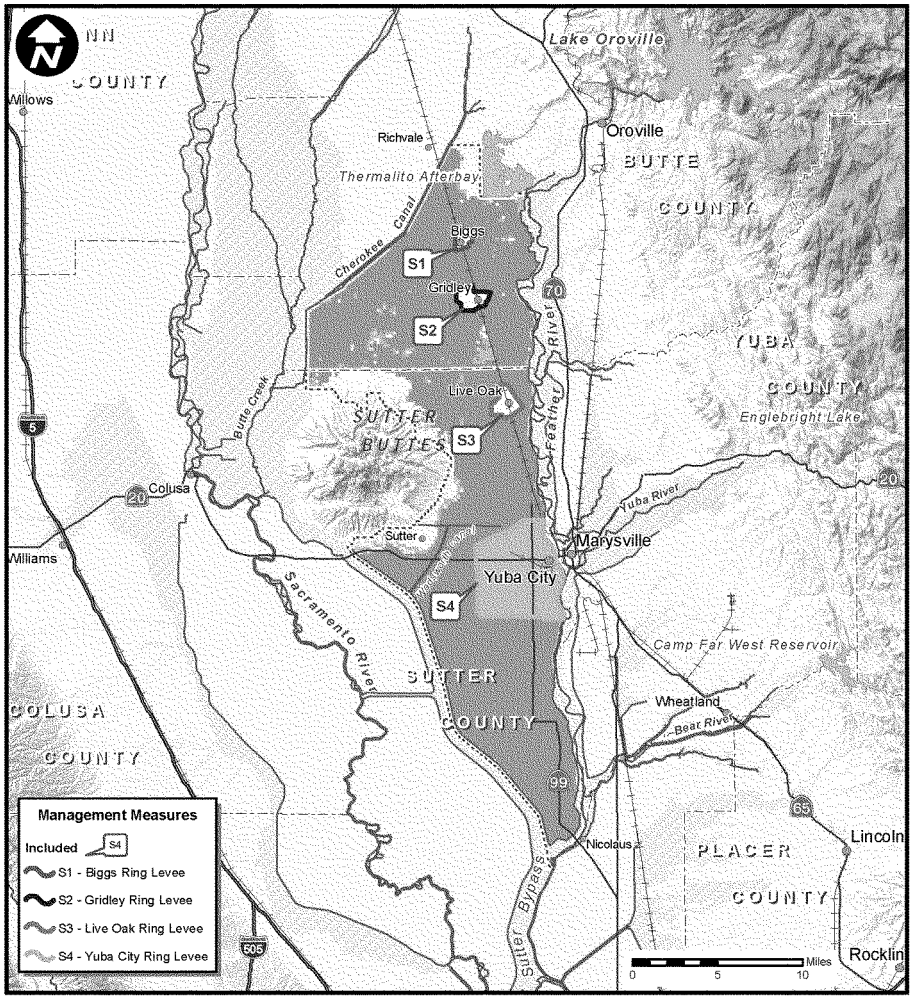
PLATE 4



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 2.1

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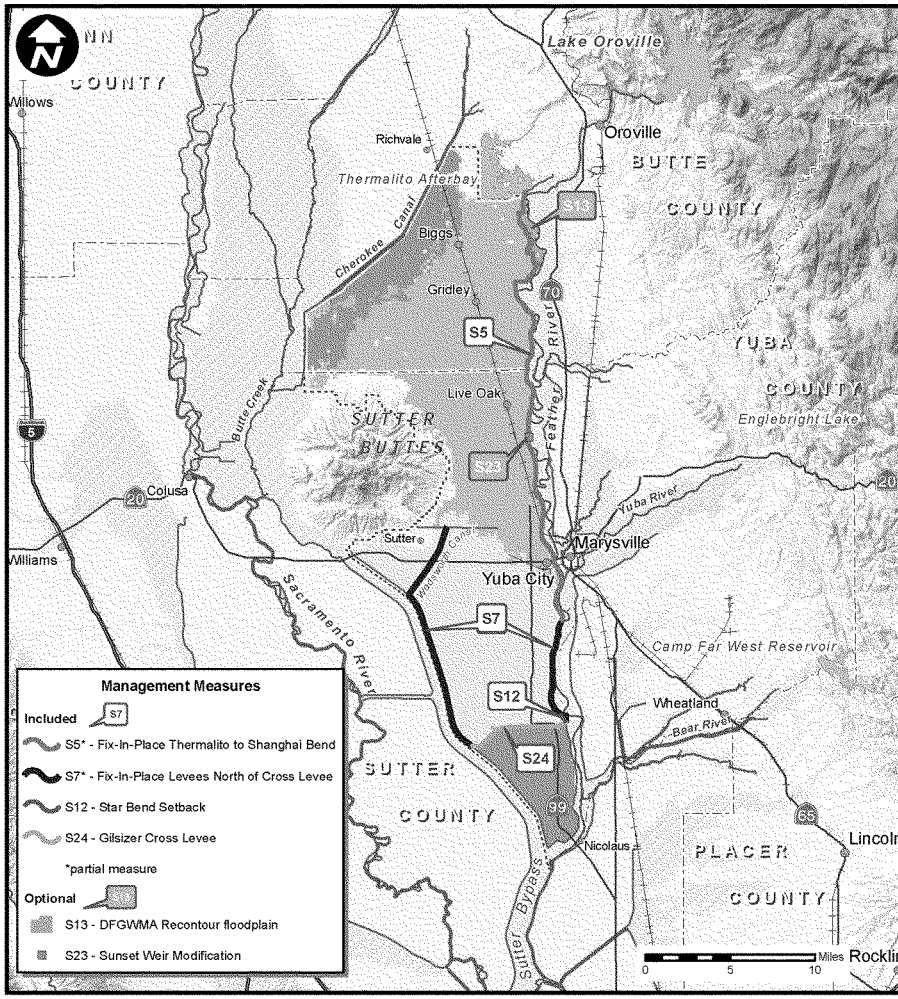
PLATE 5



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 2.2

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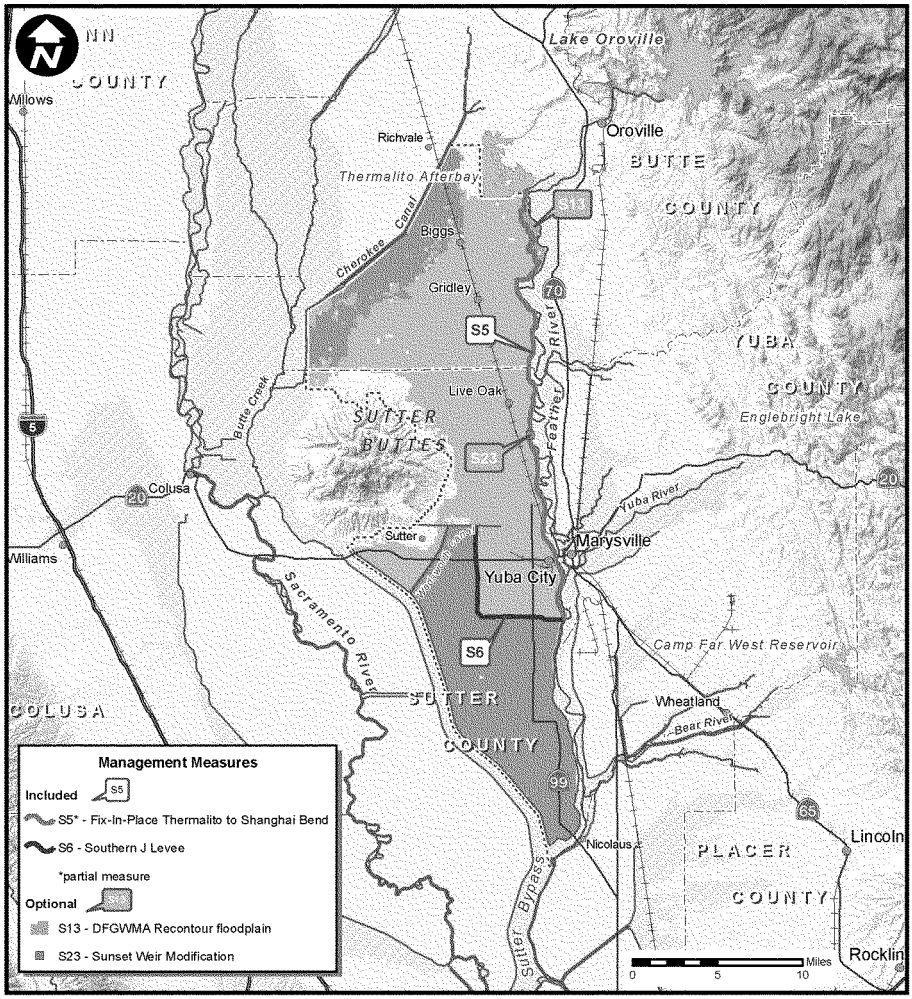
PLATE 6



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 2.3

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SACRAMENTO DISTRICT

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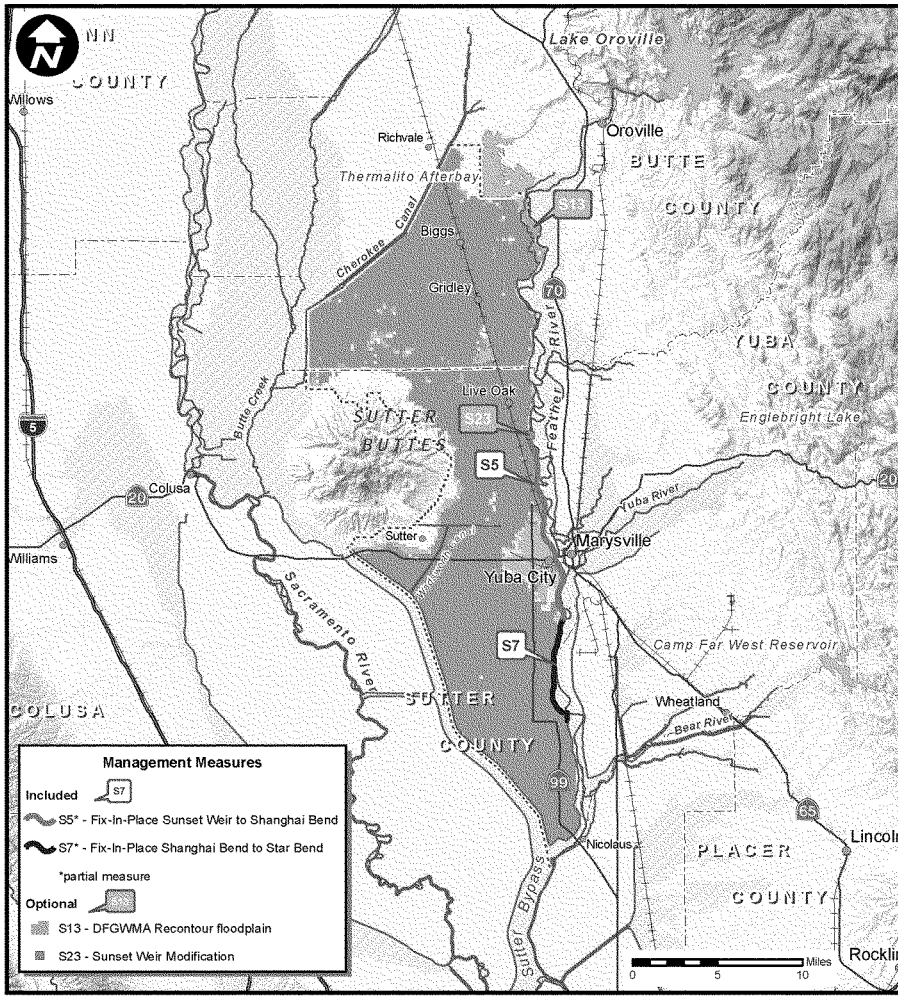
PLATE 7



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 2.4

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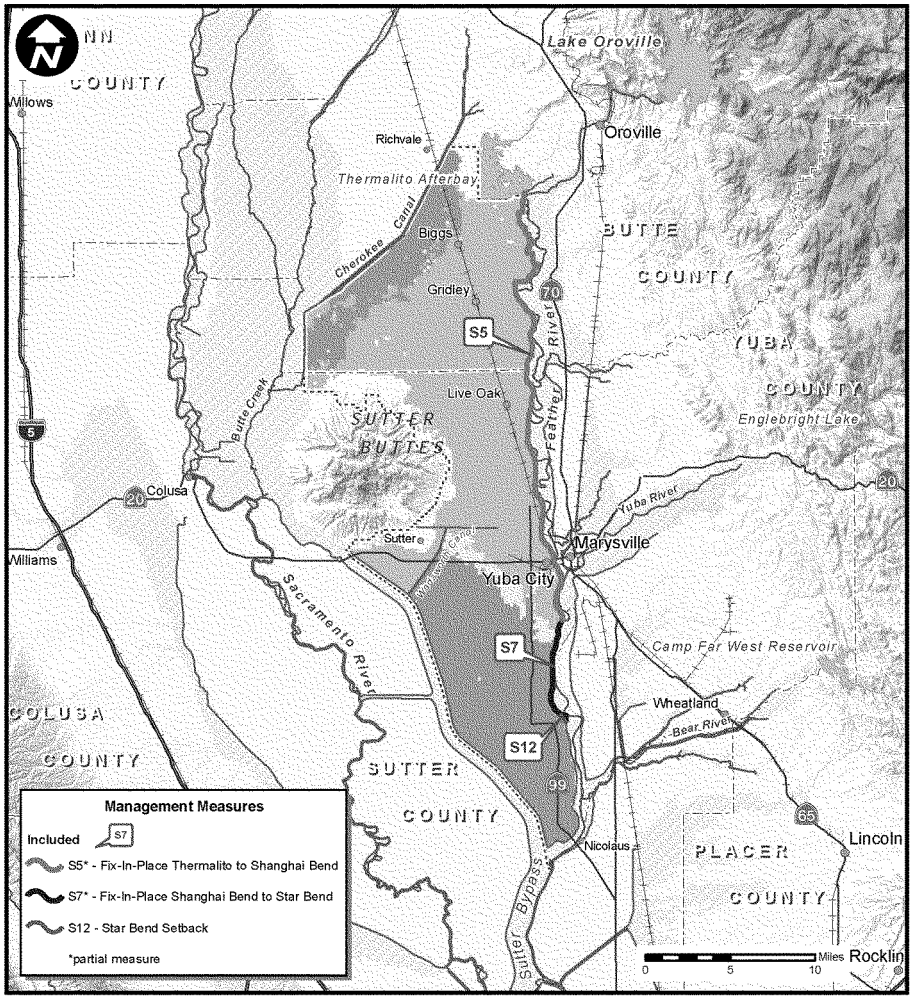
PLATE 8



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

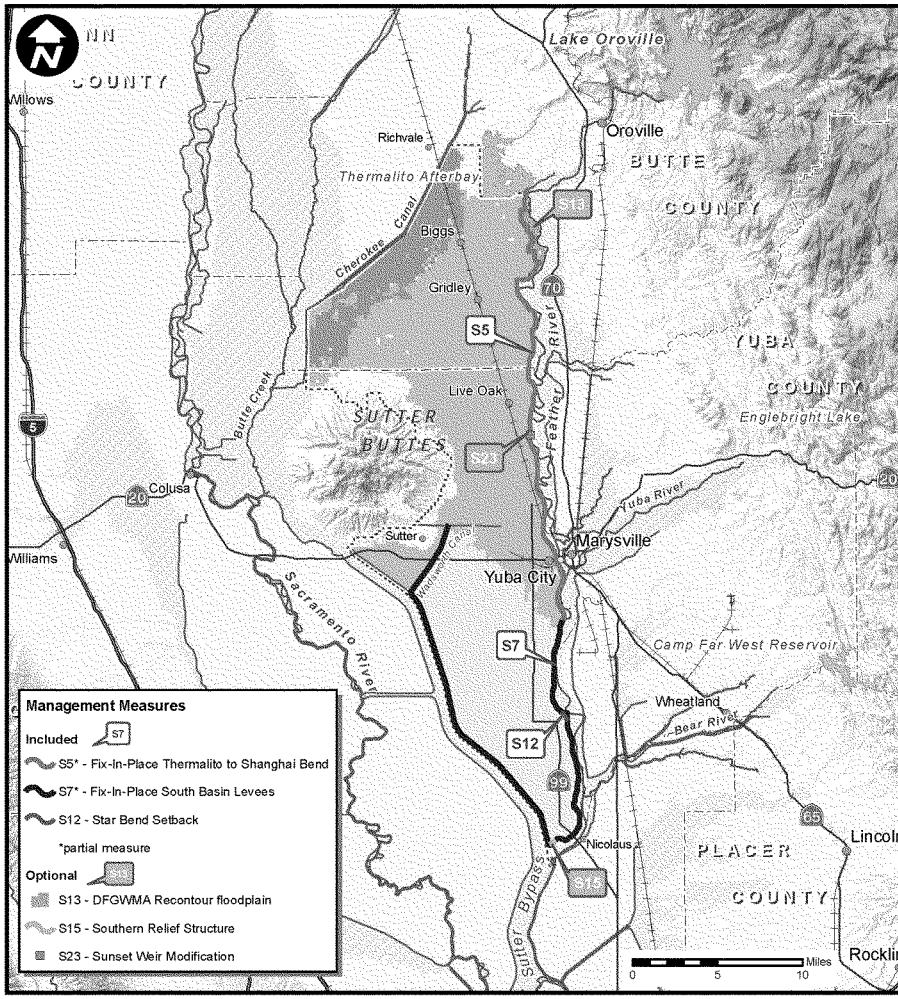
NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 2.5

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars | MAY 2012 | PLATE 9



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 3.1

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SACRAMENTO DISTRICT

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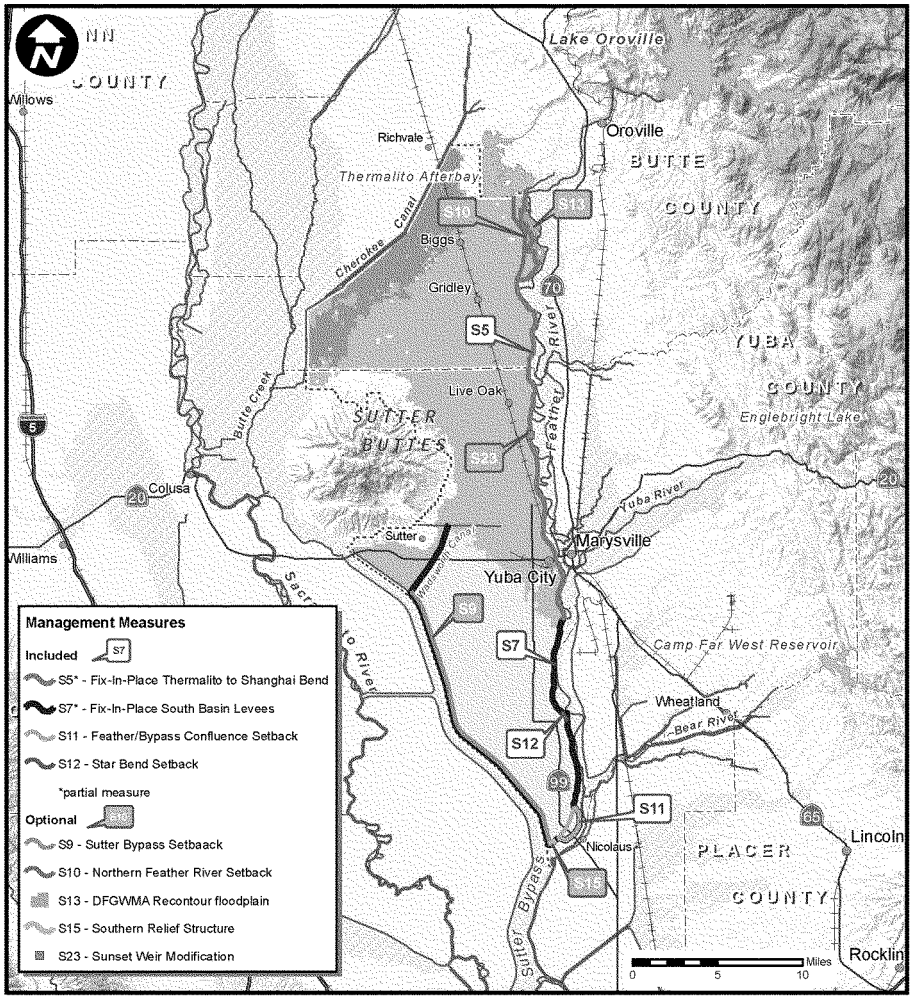
PLATE 10



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 3.2

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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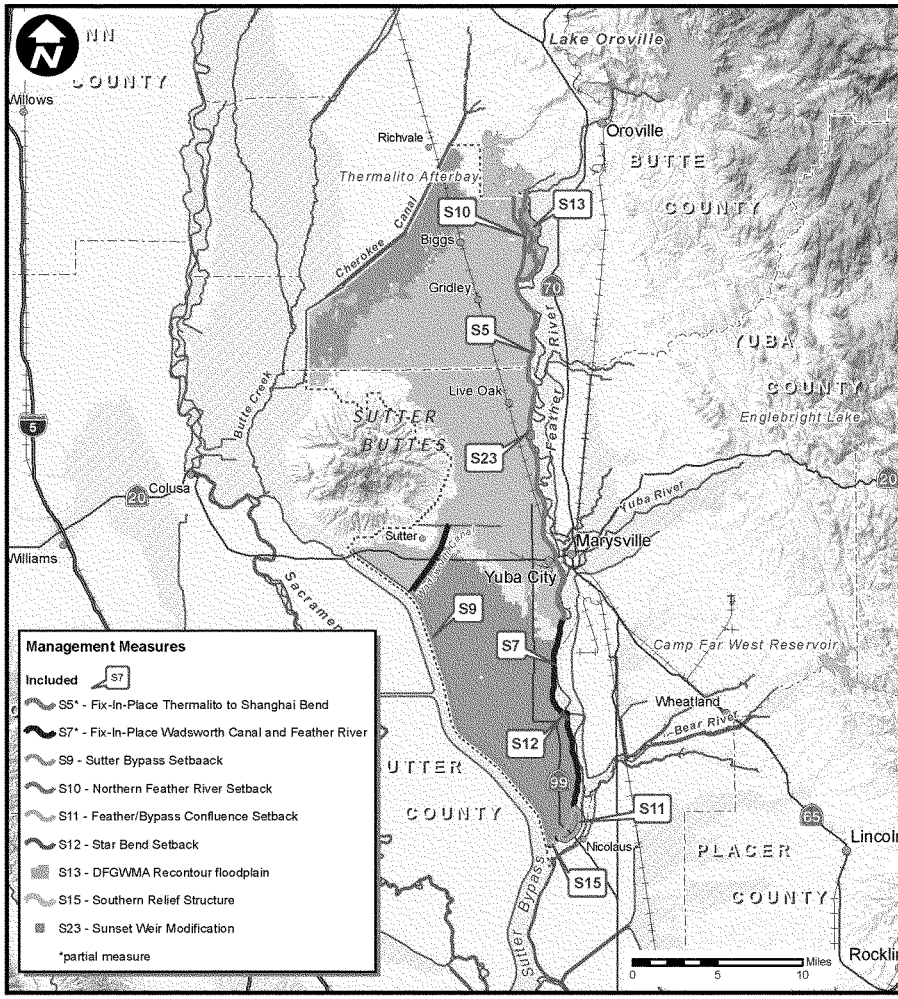
MAY 2012

PLATE 11



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

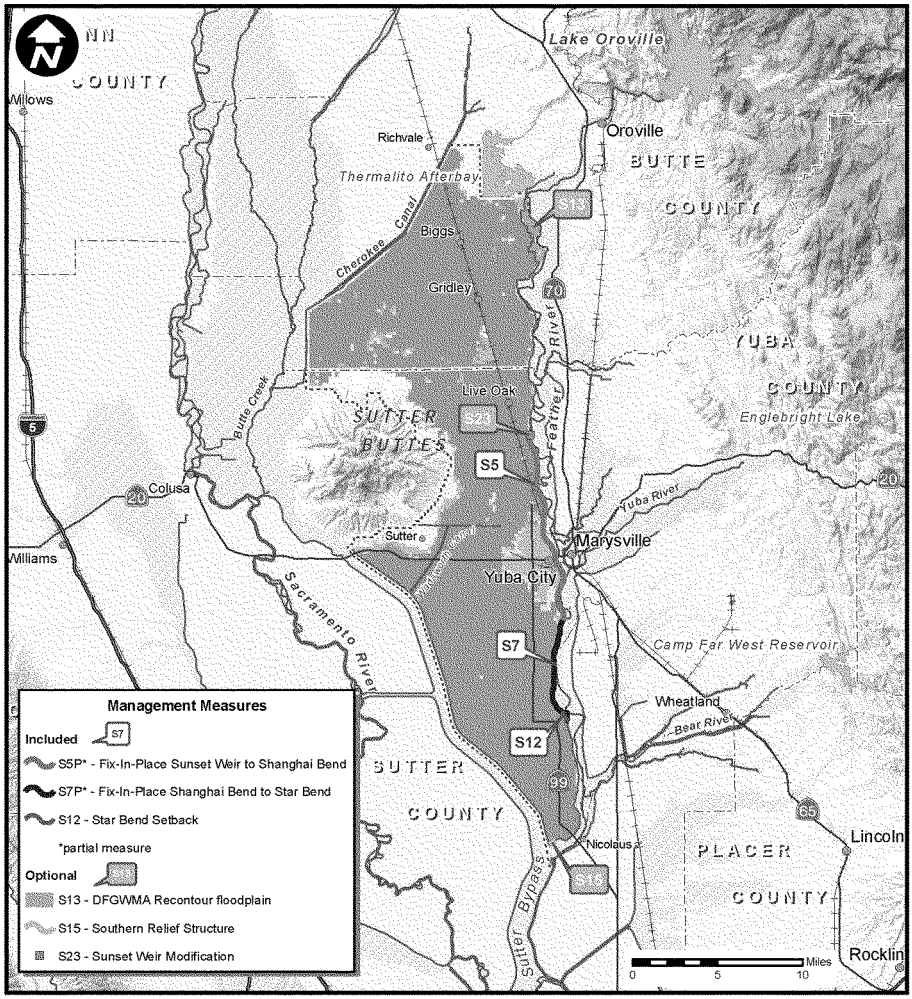
PROGRESS DOCUMENT #1
CONCEPTUAL ALTERNATIVE 4.1

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 12



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

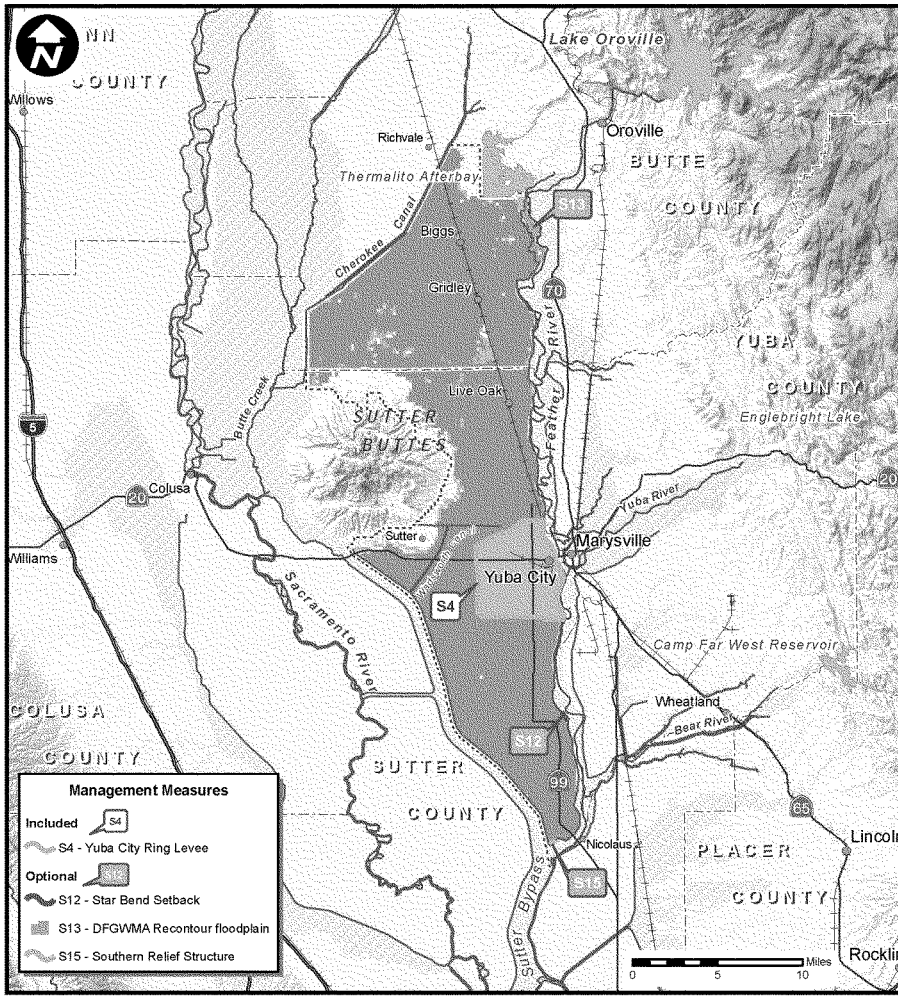
PROGRESS DOCUMENT #1
ALTERNATIVE SB-2
MINIMAL FIX-IN-PLACE
PLUS NONSTRUCTURAL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 13



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

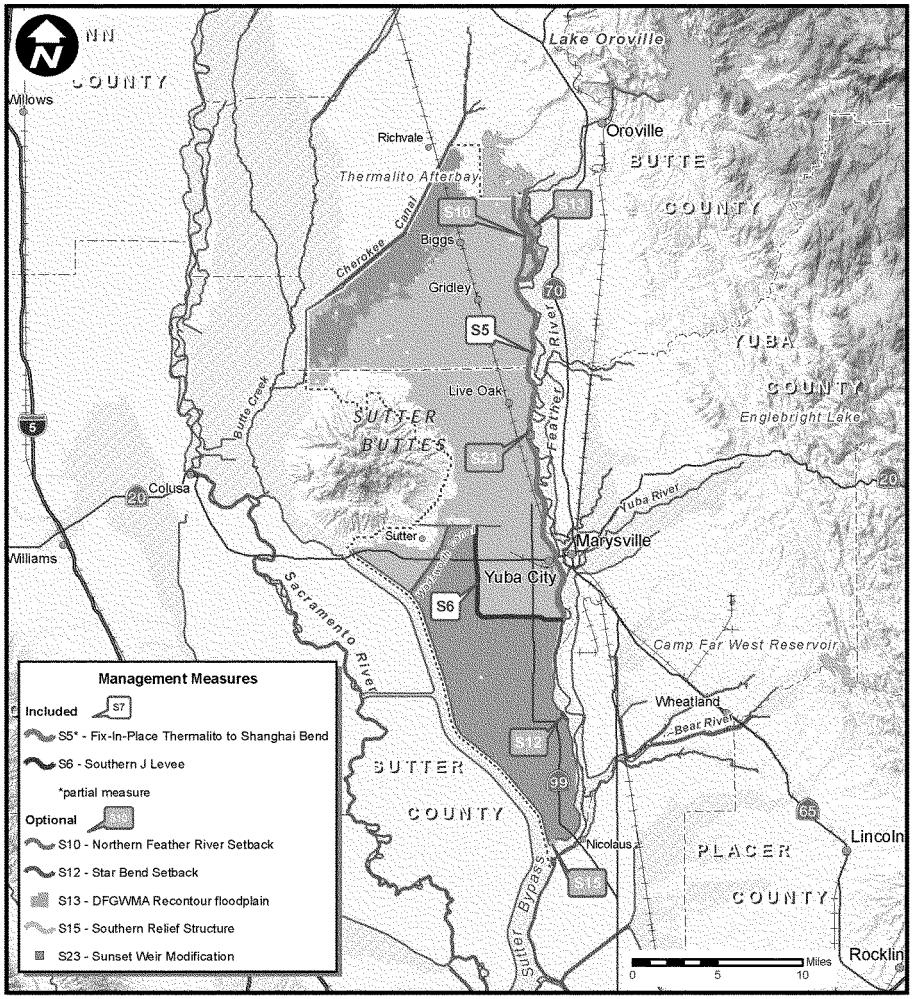
PROGRESS DOCUMENT #1
ALTERNATIVE SB-3
YUBA CITY RING LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 14



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
ALTERNATIVE SB-4
LITTLE "J" LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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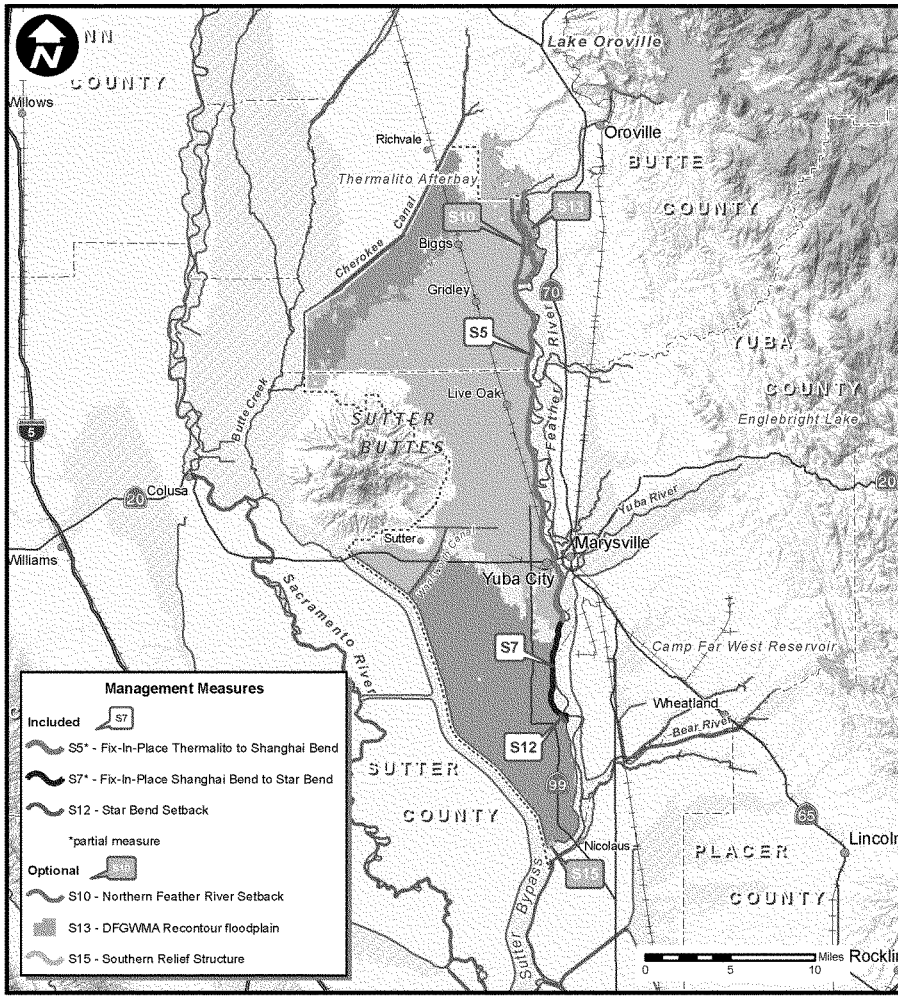
PLATE 15



Legend

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- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual models*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

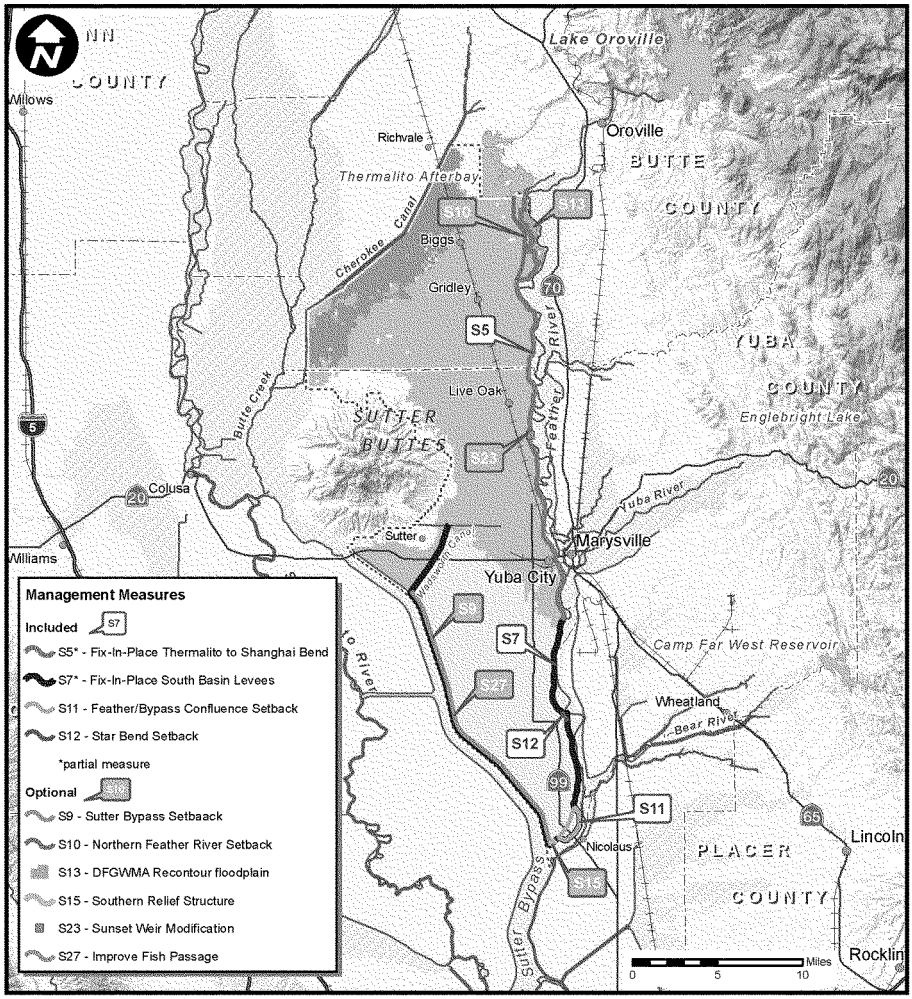
PROGRESS DOCUMENT #1
ALTERNATIVE SB-5
FIX IN PLACE FEATHER RIVER, THERMALITO TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAY 2012

PLATE 16



Legend

- 1/100 AEP Floodplain
- 1/200 AEP Floodplain
- 1/500 AEP Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: *Floodplains are based on conceptual analysis*

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

PROGRESS DOCUMENT #1
ALTERNATIVE SB-6
FIX IN PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH

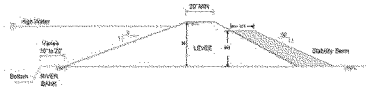
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

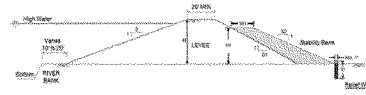
MAY 2012

PLATE 17

Stability Berm Element

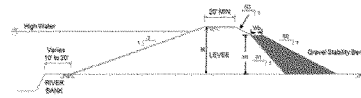


Stability Berm with Relief Wells Element

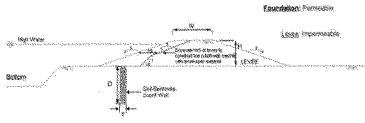


Seepage Berm Element

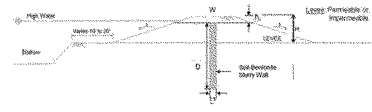
Gravel Stability Berm Element



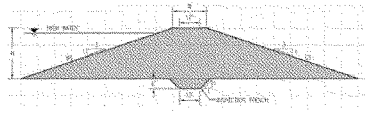
Waterside Soil-Bentonite Slurry Cutoff Wall Element



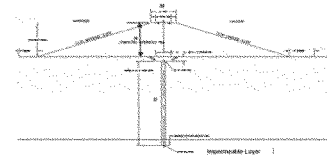
Centerline Soil-Bentonite Slurry Cutoff Wall Element



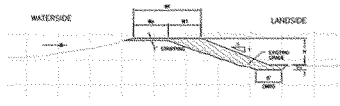
New Levee Element



New Levee with Centerline Soil-Bentonite Cutoff Wall Element



Levee Crest Widening Element



SUTTER BASIN PILOT FEASBILITY STUDY SUTTER BASIN, CALIFORNIA
PROGRESS DOCUMENT #1 LEVEE DESIGN TEMPLATES
U.S ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

Source:

MAY 2012 PLATE X

US Army Corps
of Engineers®

Sacramento District

Engineering Division

Sutter Basin Pilot Feasibility Report - Environmental Impact Report / Supplemental Environmental Impacts Statement

Butte and Sutter Counties, California

Appendix C: Engineering Appendix

October 2013

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- Geotechnical Design Appendix
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- Plan
- Cost Estimate

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ACRONYMS

ACE Annual Chance of Exceedance
ADWS Authorized Design Water Surface
ATOL Authorized Top of Levee
AEP Annual Exceedance Probability
APE Area of Potential Effect
AST Above Ground Storage Tank
BMP Best Management Practice
CCEL Cherokee Canal East Levee
CDFW California Department of Fish and Wildlife
CEQA California Environmental Quality Act
CFS Cubic Feet Per Second
COE The Corps of Engineers
CVFED Central Valley Floodplain Evaluation and Delineation
CVFPB Central Valley Flood Protection Board
CSA Cultural Site Assessment
Cy Cubic Yards
DFG California Department of Fish and Game
DWR California Department of Water Resource
DWS Design Water Surface
DWSE Design Water Surface Elevation
DSM Deep Soil Mixing
ESA Environmental Site Assessment
ETL Engineering Technical Letter
EIP Early Implementation Project
EPA Environmental Protection Agency
FDA Flood Damage Assessment
FRWL Feather River West Levee
FRM Flood Reduction Measures
HPTRM High Performance Turf Reinforced Mat
HTOL Hydraulic Top of Levee
HTRW Hazardous, Toxic and Radioactive Wastes
LEERD Land, Easements, Rights-of-way, Relocation and Disposal Areas
LiDAR Light Detection and Ranging
LMA Levee Maintenance Authorities
LD Levee District
LSO Levee Safety Officer
LSPM Levee Safety Program Manager
MEIP Modified Early Implementation Project
NMFF National Marine Fishery Service
NHPA National Historic Preservation Act
NPDES National Pollution Discharge Elimination System
OMRR&R Operation and Maintenance, Repair, Replacement and Rehabilitation
PA Programmatic Agreement
PCA Project Cooperation Agreement
PCB Polychlorinated biphenyl
PDT Project Delivery Team

PED Preconstruction Engineering and Design
REP Real Estate Plan
PFR Plan Formulation Report
PLM Project Levee Mile
ROW Right-of-Way
RWQCB Regional Water Quality Control Board
SOP Standard of Practice
SBFS Sutter Basin Feasibility Study
SBEL Sutter Bypass East Levee
SBMC Sutter Butte Main Canal
SBFCA Sutter Butte Flood Control Agency
SBFIP Star Bend Fix-in-place
SBLS Sutter Basin Levee System
SBL Sutter Bypass Levee
SHPO State Historic Preservation Office
ULE Urban Levee Evaluation
UPRR Union Pacific Railroad
USACE United States Army Corps. of Engineers
USFWS U.S. Fish and Wildlife Service
USGS U.S. Geological Survey
UST Underground Storage Tank
VFZ Vegetation Free Zone
VE Value Engineering
WPC Without Project Condition
WCEL Wadsworth Canal East Levee
WCWL Wadsworth Canal West Levee
WSEL Water Surface Elevation

CHAPTER 1 – INTRODUCTION

1.1 Project Description

The study area is located in Sutter and Butte Counties and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The existing Sutter Basin Levee System (SBLS) consists of four mainline levees : Feather River West Levee (FRWL or right levee), Sutter Bypass East Levee (SBEL or left levee), Wadsworth Canal East Levee (WCEL or left levee) and Wadsworth Canal West Levee (WCWL or right levee), and Cherokee Canal East Levee (CCEL or left levee) surrounding the communities of Yuba City, Live Oak, Gridley, Biggs and other smaller towns in Sutter and Butte Counties, California.

For this Feasibility Study, planning measures were considered and combined to form a preliminary array of conceptual alternatives. Through the plan formulation process, a draft array of eight alternatives were defined as follows:

- Alternative SB-1 – No action alternative (i.e. existing condition)
- Alternative SB-2 – Minimal Fix-in-place Feather River Levees, Sunset Weir to Star Bend

- Alternative SB-3 – Yuba City ring levee
- Alternative SB-4 – Little "J" levee, Thermalito Afterbay to south of Yuba City
- Alternative SB-5 – Fix-in –place Feather River Levees: Thermalito Afterbay to Star Bend
- Alternative SB-6 – Fix-in –place Feather River Levees: Sutter Bypass, and Wadsworth Canal
- Alternative SB-7 – Fix-in –place Feather River Levees: Sunset Weir to Laurel Avenue
- Alternative SB-8 – Fix-in –place Feather River Levees: Thermalito Afterbay to Laurel Avenue

This draft array of alternatives was analyzed and refined to a final array that includes 3 of the alternatives (Alternatives SB-1, SB-7 and SB-8). These final alternatives were further evaluated at a feasibility level of design to verify and determine the Recommended Plan for recommendation. See Plates 1-1 to 1-8 for maps of draft array of alternatives (note that the reach identifications shown in these plates were revised during the final array analysis for Alternatives SB-7 and SB-8 as shown on plate 2-2 and discussed in Paragraph 2.4).

1.2 Purpose and Scope

This Engineering Appendix provides a summary of the engineering analyses performed by the Project Delivery Team (PDT) for the draft and final alternatives, including the existing conditions. The appendix provides narrative descriptions of the final two alternatives. The objective of this appendix (along with referenced subject matter appendices) is to summarize the designs and cost estimates completed for the Feasibility Study.

1.3 Coordination

The Project Delivery Team (PDT) worked closely with the local sponsor comprised of the State of California Central Valley Flood Protection Board (CVFPB) and the Sutter Butte Flood Control Agency (SBFCA) in the preparation of this appendix. The local sponsor's design team includes Peterson Brustad, Inc., HDR, Inc., Wood Rogers, Inc., and MHM, Inc.

SBFCA is a consortium of Sutter and Butte Counties, the Cities of Yuba City, Live Oak, Gridley, and Biggs, and Levee Districts 1 and 9 of Sutter County. The agency was formed in 2007 to finance and construct regional levee improvements. The FRWL Improvement Project's goal is to improve the 44 miles of the right bank levee of the Feather River from the Thermalito Afterbay outlet to the confluence with the Sutter Bypass under a Section 408 permit. The design of the FWRL Improvement Project is being done ahead of the Feasibility Study as an Early Implementation Project (EIP) for future cost share under the Feasibility Study. The SBFCA EIP is at the 100% design level for a portion of the FRWL between Shanghai Bend and Live Oak. The remaining portion of the SBFCA EIP is at the 65% design level.

Additional contacts were also made with local authorities (e.g. the U.S. Fish and Wildlife Service, the United Auburn Indian Community and Enterprise Rancheria etc.) to obtain inputs to the final feasibility design of Alternatives SB-7 and SB-8.

CHAPTER 2 – GENERAL DESIGN CONSIDERATIONS

2.1 General

This chapter summarizes general design considerations used for evaluation of the draft array and final array of alternatives. Refer to the subject matter appendixes for further detail of the analyses. Features resulting from these analyses are provided in project descriptions of Alternatives SB-7 and SB-8, Chapters 4 and 5, respectively.

A key concept of the Pilot Feasibility Study is to utilize an appropriate level of detail to make risk informed decisions. ER 1110-2-1302 Civil Works Cost Engineering describes five levels of detail. The classes are based on ASTM E 2516-06, Standard Classification for Cost Estimate Classification System. The purpose of the classification system is to improve communication among all the stakeholders involved with preparing, evaluating, and using cost estimates (ASTM, 2011). Class definitions, as they relate to the Pilot Study are considered to also describe a level of design and engineering commensurate with the level of detail in the cost engineering classification. These class definitions are described below. Cost accuracies do not necessarily apply to engineering and design but are of a level that is consistent with those accuracies

- Class 5 is the least accurate and is the minimum required for assessing rough order of magnitude. The level of project definition is 0% to 2% of a complete definition. The expected cost accuracy (+/-) is 4 to 20 times the accuracy of the best (Class 1) estimate.

- Class 4 is the minimum required for Reconnaissance/905b Reports and alternative analysis in feasibility studies. The level of project definition is 1% to 15% of a complete definition. The expected cost accuracy (+/-) is 3 to 12 times the accuracy of the best (Class 1) estimate.

- Class 3 is the minimum required for the feasibility NED Plan and Feasibility Sponsor Preferred Plan. The level of project definition is 10% to 40% of a complete definition. The expected cost accuracy (+/-) is 2 to 6 times the accuracy of the best (Class 1) estimate.

- Class 2 is minimum required for Planning, Engineering, and Design up to 90% Plans and Specifications. The level of project definition is 30% to 70% of a complete definition. The expected cost accuracy (+/-) is 1 to 3 times the accuracy of the best (Class 1) estimate.

- Class 1 is minimum required for Planning, Engineering, and Design 100 % Plans and Specifications and the Independent Government Estimate. The level of

project definition is 50% to 100% of a complete definition. This is considered the most accurate estimate. It does not imply that all unknowns and risk are eliminated.

The analysis of the existing condition (i.e. Alternative SB-1) forms the basis of comparison to project alternatives. The analysis of the existing conditions was conducted at a Class 4 level during the screening and selection of the draft array of alternatives. The analysis of the existing condition was refined during the final analysis to a Class 3 level of detail.

Analysis of the draft array of alternatives is based on a Class 4 level of detail. The final array of alternatives (including refinements to the without project conditions) are based on a Class 3 level of detail and is referred to as Final Analysis in this report.

Another key concept in the Pilot Feasibility Study is to utilize existing information where applicable. Since the local sponsor had already completed a 65% design for their Early Implementation Project (EIP) the PDT reviewed and adopted information where applicable (specifically, civil and geotechnical designs, quantity estimates, and utility relocations) All design information was reviewed to ensure it was consistent with the planning objectives of the study. Refer to the Civil and Geotechnical Design Appendixes for the review and adoption of design information in the 65% EIP.

2.2 Datum

The North American Datum of 1983 (NAD 83) State Plane California Coordinate System Zone II (U.S. Survey Feet) was used for horizontal control. The North American Vertical Datum of 1988 (NAVD 88) was used as the vertical datum.

2.3 Alignment and Stationing

2.3.1 General

This section describes the alignment and stationing developed for the Class 4 and Class 3 analyses. Refer to the Civil Design Appendix for further details.

2.3.2 Draft Array of Alternatives SB-1 through SB-8

Alignment stationing were defined for three levee segments during the analysis of the draft array of alternatives. These include: (1) Feather River West Levee or right levee, (2) Sutter Bypass East Levee or left levee, and (3) Wadsworth Canal East Levee or left levee. The project levee alignments were developed based on surveyed data from the National Levee Data Base. The stationing of each levee segment begins with station 0+00 at the intersection with the levee segment at the downstream end, and increases in an upstream direction. See Plate 2-1 for details.

2.3.3 Final Array of Alternatives: SB-7 and Alternative SB-8

For Alternatives, SB-7 and SB-8, the project levee alignment follows the existing levee centerline of the FRWL except at Star Bend where the levee alignment follows the centerline of the setback levee. The stationing begins with station 10+00 at the confluence of the FRWL at the SBEL and increases in an upstream (north) direction. This levee stationing conforms to the existing levee centerline and accounts for recent changes in the alignment, such as the Star Bend Setback Levee (between station 478+68 and station 512+00). At locations where levee relocations (e.g. roughly between station 1432+70 and station 1754+30 etc.) are proposed, supplementary levee alignments stationing necessary for designs and analyses were established. See Plate 2-2 for details.

All tables, figures and plates are shown at the end of this Engineering Report.

2.4 Alternative Reaches

2.4.1 General

This section describes the alternative reaches developed for the analyses of the draft array and final array of alternatives. Refer to the Civil Design Appendix for further details.

2.4.2 Draft Array of Alternatives SB-1 through SB-8

The evaluation of the existing condition (SB-1) and Alternatives SB-2 through SB-8 were based on a 28 reaches (see Plate 2-1). Sixteen of these reaches are existing levee segments. The other 12 reaches are either proposed setback or new (Ring and "J") levee segments. Reaches were defined based on similarity in geotechnical and proposed structural fix.

2.4.3 Final Array of Alternatives SB-7 and SB-8

A new reach identification system was developed for the analysis of Alternatives SB-7 and SB-8 (see Plate 2-2). Alternative SB-7 is defined by 21 reaches (2A-North, 2B, 3... 21) starting from station 180+00 (approximately 2,000 linear feet south of Laurel Avenue) and ending at station 1433+83 (immediately north of Sunset Weir). Alternative SB-8 is defined by 41 reaches (2A-North, 2B, and 3 to 41) starting from station 180+00 (approximately 2,000LF south of Laurel Avenue) and ending at station 2368+00 (Thermalito Afterbay). The reaches were also tabulated and shown in Table 4-2 (for Alternative SB-7) and Table 5-2 (for Alternative SB-8). These reaches are a refinement of the reaches in 2.4.2 above based on refinement of the proposed structural fixes.

2.5 Survey Data

2.5.1 General

This section of the report describes the survey data used for this study. Refer to the Civil Design Appendix for further details.

2.5.2 Topographic Data

The project employed topographic information obtained from three sources. LiDAR data acquired in 2008 were obtained from DWR's Central Valley Floodplain Evaluation and Delineation (CVFED) Program and Urban Levee Evaluation (ULE) Program. Topographic data at 2 foot contour intervals were obtained from surveys performed for the USACE during the 2002 Sacramento and San Joaquin Basins Comprehensive Study. The 2002 topography was based on the National Geodetic Vertical Datum of 1929 (NGVD 29). The surveyed data was converted to the North American Vertical Datum of 1988 (NAVD 88) in 2010. The 2010 converted bathymetry was used throughout the study.

Land survey was completed to confirm the LiDAR topographic data. Results show that cross section profiles based on CVFED and ULE Program's LiDAR-based topographic data are comparable with land surveyed elevation.These data sets were used in hydraulic and geotechnical evaluations, site layouts and quantity estimates.

2.5.3 Bathymetric Data

Bathymetry of the Feather River was obtained from a bathymetry survey performed for the USACE during the 2002 Sacramento and San Joaquin Basins Comprehensive Study at a contour interval of 2 feet. The 2002 surveyed elevations were based on the National Geodetic Vertical Datum of 1929 (NGVD 29). The surveyed data was converted to the North American Vertical Datum of 1988 (NAVD 88) in 2010. The 2010 converted bathymetry was used throughout the study.

2.6 Hydrology

2.6.1 General

A hydrologic analysis was completed for the sources of flooding within the study area. The methodology and results are essentially identical for the analysis of the draft array and final array of alternatives.

2.6.2 Hydrologic Analysis
2.6.3 Analysis of Alternatives SB-1 through SB-8

The Wadsworth Canal flood frequency curve was developed from graphical frequency analysis of gage records at Wadsworth Canal near Sutter (DWR stream gage A05929) following Bulletin 17B guidelines.

Flood frequency curves and 30 day balanced hydrographs for Cherokee Canal were developed from gage records at Cherokee Canal near Richvale Gage (DWR stream gage A02984) following Bulletin 17B guidelines. All alternatives except Alternative SB-3 (Yuba City Ring levee) and SB-4 (Little "J" Levee) are based on the existing conditions hydrology.

Hydrology for the Sutter Bypass, Feather River and Butte Basin was based on the Sacramento-San Joaquin Comprehensive study and Lower Feather River Floodplain mapping study. The hydrologic analysis was derived from historical flood events and statistical analysis of

unimpaired or unregulated locations throughout the Sacramento River Basin. Unregulated flows were hydrologically routed through the major reservoirs to develop unregulated and regulated flows at downstream locations. The hydrographs were passed to hydraulic analysis for routing through the flood control system.

Statistical analysis was used to develop curves describing peak unregulated flow versus exceedance probability for seven exceedance events (50, 10, 4, 2, 1, 0.5, and 0.2 percent) throughout the project area. Flow frequency curves showing the unregulated flow frequency are available in the Hydrology Appendix as plates at selected locations throughout the study area. Tables of peak unregulated flows and the period of record, and design flow and peak regulated flow are provided in tables in the Hydrology Appendix. Authorized Design flows and regulated flow–frequency tabular values are shown in the Table 2-1.

2.6.4 Interior Drainage Analysis

An interior drainage analysis was performed only for Alternatives SB-3 and SB-4. An interior drainage analysis was not performed for the other alternatives because analysis of the floodplains indicated it was not a factor in the evaluation and comparison of draft alternatives would have similar hydrology as existing conditions except the for the interior drainage area. Rainfall depths were extracted from the design rainfall analysis. The analysis is based on rainfall depth-area-duration statistics. The runoff area within the alternatives was estimated from topographic mapping. The loss rate coefficient was calibrated to match the peak flows shown the West Yuba City master drainage study. A mean daily flow rate of 918 cfs was estimated for the 24.2 square mile area inside the levee using a 1-day, 10% ACE precipitation volume of 2.82 inches, and a rainfall-runoff coefficient of 0.5.

2.6.5 Final Analysis of Alternatives SB-7 and SB-8

The hydrologic analysis performed for the draft array of alternatives was adopted for use in the analysis of the final array of alternatives for Wadsworth Canal, Cherokee Canal, Feather River, and Sutter Bypass. However, a more detailed interior drainage analysis was performed to evaluate residual flooding. The analysis was performed by Peterson-Brustad Incorporated (PBI) for the Sutter Butte Flood Control Agency (SBFCA). The interior drainage analysis evaluated rainfall runoff and flood depths for 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE flood events. Storm events with 24-hour and 96 hour durations were evaluated.

The analysis utilized an HEC-HMS model to compute sub basin runoff and a FLO-2D two dimensional hydraulic model to route the runoff through the study area. A total of 16 drainage basins covering approximately 340 square miles were identified within the interior drainage boundary. The drainage basins were further divided into a total of 77 sub basins. The model included ten storm water pump stations that pump drainage water into the Feather River or Sutter Bypass. The FLO-2D model uses a 1,000-foot by1,000-foot grid size and includes the main drainage channels throughout the study area as channel elements. The resulting interior

drainage maps were reviewed and adopted for use in this study. Maps showing the residual interior drainage are provided in the Hydraulic Design Appendix.

2.7 Hydraulic Design

2.7.1 General

This section describes general hydraulic design and analysis of the draft array and final array of alternatives. Refer to the Hydraulic Design Appendix for further details.

2.7.2 Draft Array of Alternatives SB-1 through SB-8

Hydraulic analysis was conducted for design of project features and evaluation of each alternative's flood risk performance relative to the existing conditions. Based on a review of historical conditions and proposed actions, the hydrologic and hydraulic conditions in the future are assumed to be the same as existing conditions.

The flood risk performance of each alternative condition (including the existing condition) was evaluated using Risk and Uncertainty methods. Flood risk is defined as the probability of a flood event occurring and the consequences of occurrence. Flood risk was assessed using the USACE FDA (flood damage assessment) model version 1.2.5a (USACE, 2010). The FDA model combines flow-frequency, stage-discharge, geotechnical fragility, and stage-damage relationships to estimate damages. Uncertainty in each relationship is incorporated by assigning uncertainty estimates and applying a Monte Carlo type approach to combine the results.

Flow-frequency, stage discharge, and geotechnical frequency relationships reflect the exterior (probability) side of the risk calculations. Inundation depth and stage-damage relationships reflect the interior (consequence) side of the risk calculations. For the probability side of the risk calculations, the hydraulic model assumptions are based on flows contained to the channel (allowed to overtop without failure). For the consequence side of the risk calculations, the hydraulic model assumptions are based on levee breach failure or simply the depth for natural overbank (non-levee) conditions.

Hydraulic analyses were conducted using five separate hydraulic models that were adapted from existing hydraulic models utilized for studies within the Sacramento Valley. Water surface profiles for Sutter Bypass and Feather River were computed using an HEC-RAS unsteady one-dimensional flow model of the Sacramento River system. Water surface profiles for Wadsworth Canal were computed using an HEC-RAS steady one-dimensional flow model. Water surface profiles for Cherokee Canal were computed using an HEC-RAS unsteady one-dimensional flow model. Water surface elevations for Butte Basin were based on the UNET unsteady model results obtained from the Sacramento-San Joaquin Comprehensive Study. Inundation depths from levee breach simulations were evaluated using a FLO-2D 2-dimensional unsteady flow model of the study area.

The hydraulic design of project features, project performance, and description of residual floodplains for the draft array of alternatives is provided in the Hydraulic Design Appendix.

2.7.3 Final Analysis of Alternatives SB-1, SB-7 and SB-8

The final hydraulic analysis of Alternatives SB-1, SB-7 and SB-8 was based on the same approach as the evaluation of the draft array of alternatives. However, refinements were made to the Wadsworth Canal model and Sutter Bypass and Feather River hydraulic model. The Wadsworth Canal model was refined to include four bridges. The Sutter Bypass and Feather River models were revised to include a diversion weir near Thermalito Afterbay. These refinements were found to have negligible impacts on computed water surface profiles and flood risk assessment.

2.7.3.1 Current Authorization and Requirement

The Authorized Design Water Surface (ADWS) is the 1957 design water surface (DWS). The Authorized Top of Levee (ATOL) is the 1957 ADWS plus 3-foot free board.

2.7.3.2 Design Analysis

Water surface profiles were developed for use in the design of seepage measures, estimation of project performance, and economic risk analysis. The top of levee was not based on a design water surface profile. As required by ER 1105-2-101 Risk Analysis for Flood Damage Reduction Studies, freeboard or similar buffers to account for hydrologic and geotechnical uncertainties are no longer used for levee planning and design. Project performance is to be described by annual exceedance probability (AEP) and long term risk rather than level of protection. A description of the levee performance is provided at key index points in the Flood Reduction Measures (FRM) performance section of the Hydraulics Appendix.

Water surface profiles along the project reach of Alternative SB-7 and Alternative SB-8 were computed using the Sutter Bypass and Feather River HEC-RAS unsteady one-dimensional flow model of the Sacramento River system. The model was calibrated to two historic flood events that occurred in January 1997 and December 2005 - January 2006. Calibration efforts were specifically focused on the Feather River, Sutter Bypass, and Wadsworth Canal. Detailed calibration for all of the other rivers and storage areas within the HEC-RAS model was considered outside of the scope of this study. Manning's roughness values range from 0.031 to 0.07 in the main channel and 0.05 to 0.10 in the overbanks.

Mean water surface profiles were simulated for 50% (1/2) ACE, 10% (1/10) ACE, 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, and 0.2% (1/500) flood events.

2.7.3.3 Top of Levee

The levee height will be reconstructed to the existing top of levee elevation or the ATOL elevation (defined in Paragraph 2.7.3.1), whichever is higher. In no cases, will the levee height exceed these profiles. This height was selected through the plan formulation process. The selection of the levee height is described in the feasibility report and the economic appendix.

2.7.3.4 Erosion Protection/Levee Superiority and Resiliency

Levee superiority for a flood risk management system is the increment of levee height added in order to increase the likelihood that an event exceeding the design event will result in controlled flooding at the design overtopping section. To insure controlled flooding, erosion protection features are required in the reach where initial levee overtopping will most likely occur.

Based on hydraulic analysis of the levee crest and water surface profiles, erosion protections features (such as an articulated mat or anchored High Performance Turf Reinforced Mat (HPTRM) etc.) are needed for 1 location within reach 7, the first point of overtopping, and 1 location within reach 23, another initial point of overtopping (see Plate 2-2 for map of project reaches). For the purpose of this study, use of anchored HPTRM was assumed based on Sacramento District's knowledge of its performance history and familiarity with its cost. Other products such as an articulated mat could also be considered. The purpose of these erosion protection features is to increase the resiliency of the initial overtopping sections. The design objective is to increase the flood warning and evacuation time prior to overtopping failure.

2.7.3.5 Interior Drainage

The levee construction, utility improvements and other relocations will temporarily disrupt the storm drain systems; however, it is anticipated that the temporary disruption will not cause any significant impacts to interior drainage of the basin since the levee construction is expected to be within normal construction season (April through October) during which the storm drain systems won't be needed.

The project also includes removal or downsizing of six culverts for Alternative SB-8. Based on a site evaluation conducted by the local sponsors' engineers, it is estimated that interior drainage would not be impacted by the modification of these features. Further detailed analysis is recommended during preconstruction engineering and design (PED).

2.8 Geotechnical Design

2.8.1 General

This section describes general geotechnical considerations for the evaluation of the existing condition and describes the geotechnical design considerations for and recommendations resulting from the Class 4 and Class 3 analyses. Refer to the Geotechnical Design Appendix for further details.

2.8.2 Evaluation of the Existing Condition (Alternative SB-1)

The evaluation of the existing condition followed the conventional method for evaluating the without-project condition during the screening and selection of alternatives. Risk-based geotechnical analyses were performed to evaluate the existing levees. The first-order-second-moment (FOSM) method, as recommended in ETL 1110-2-556, "Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies" dated 28 May 1999, was followed during the evaluation. In this approach, the uncertainty in performance is taken to be a function of the uncertainty in model parameters. A set of conditional-probability-of-poor-performance versus floodwater-elevation graphs (also known as fragility curves) were developed for the existing levees as related to underseepage piping, stability and judgment. For all levee reaches in the study except one, the underseepage piping performance mode accounts for virtually all of the probability of poor performance, which agrees with the actual performance history of the levees.

The geotechnical analysis of the existing condition was also updated with additional information (e.g. new boring logs etc.) during the Final Analysis (Class 3).

2.8.3 Class 4 Analysis of Alternatives SB-2 through SB-8

The analysis of Alternatives SB-2 through SB-8 followed the parametric approach during the screening and selection of alternatives. The geotechnical recommendations for seepage and stability modification for fix-in-place alternatives and seepage controls for non-fix-in-place alternatives (e.g., new ring levees, setback levees, etc.) were developed based in large part using engineering judgment. The approach assumed that cutoff walls were the primary method for seepage control, and the design of the measures (e.g., length, depth, percentage of reach, etc) was selected using judgment and the principal of most likely minimum and maximum for each value. After identifying a range, an expected mean value was selected. Refer to Figures 2.1 and 2.9 of the Civil Design Appendix for templates of typical modification measures developed for the Class 4 analysis.

2.8.4 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The Final Analysis (Class 3) of Alternatives SB-7 and SB-8 was based on the conventional design approach for development of feasibility level design (35%; Class 3) using existing subsurface explorations and deterministic seepage and stability analyses. The design considerations and recommendations for the final alternatives are listed below.

2.8.4.1 Current Authorization and Requirement

USACE guidance for levee design requires geotechnical analysis (for seepage and slope stability) to be performed at the 1957 Authorized Design Water Surface (1957 ADWS, defined in Paragraph 2.7.3.1) at a minimum. The Sacramento District's standard practice requires the analyses to also be performed with the water surface at the 1957 Authorized Top of Levee (1957 ATOL, defined in Paragraph 2.7.3.1).

2.8.4.2 Design Analysis

The geotechnical analysis (for seepage and slope stability) for the design of Alternatives SB-7 and SB-8 were based on the geotechnical analysis prepared for the SBFCA EIP (SBFCA EIP was defined in Paragraph 1.3). The geotechnical analysis for the SBFCA EIP was conducted at two water surfaces: (1) the SBFCA EIP's design water surface (not the 1957 ADWS), and (2) the hydraulic top of levee (HTOL).

The SBFCA EIP's design water surface (SBFCA EIP's DWS) is defined as:

- The 0.5% (1/200) ACE for the urban area upstream of station 461+00 (Reaches 5 – 41)
- The 1% (1/100) ACE for the rural area downstream of station 461+00 (Reaches 2A – 5).

The SBFCA EIP's HTOL (SBFCA EIP's HTOL) is defined as the lowest of:

- The SBFCA EIP's DWS plus 3 feet
- The 0.2% (1/500) ACE water surface
- The existing levee crest elevation

In addition, SBFCA's analysis added an extra foot to the EIP's design water surface (SBFCA EIP's DWS + 1 foot) and to the SBFCA EIP's HTOL profiles (SBFCA EIP's HTOL + 1 foot) for SBFCA EIP's geotechnical analysis of the design of modification measures. The additional foot, which originates in DWR's Urban Levee Criteria, increases confidence in the seepage and stability design.

The "SBFCA EIP's DWS + 1 foot" and "HTOL + 1 foot" profiles were determined to be comparable (within a foot) with the "1957 ADWS" and "1957 ATOL" profiles, respectively (see Plate 2-5). The highest of the water surfaces (SBFCA EIP versus authorized) varies by location along the Feather River. The SBFCA EIP geotechnical analysis showed seepage exit gradients and slope stability factors of safety well within USACE criteria; adding an extra foot of water would not change the recommended design modification measures. Therefore, for the purpose of this Feasibility Study, the SBFCA EIP's geotechnical analysis was considered to be adequate for use as the USACE's final geotechnical analysis of Alternatives SB-7 and SB-8.

2.8.4.3 Modification Features

Where the existing levee meets the geotechnical analysis criteria, no modification is needed. Where modification is required, cutoff walls are the primary feature for addressing geotechnical deficiencies of the existing FRWL for the following reasons:

- Cutoff walls are highly effective when constructed correctly.
- Cutoff walls do not require the acquisition of additional permanent real estate.
- Cutoff walls do not require maintenance once constructed (except for monitoring activities).

- Cutoff walls constructed by the conventional open-trench method are cost-comparable to landside berms when the costs of additional permanent real estate and environmental mitigation for landside berms are included.
- Cutoff walls have minimal long-term environmental impact primarily due to their location within the existing levee footprint.

Two primary modification measures of the FRWL were evaluated. In general, the measures were a fully-penetrating soil-bentonite cutoff wall and a partially-penetrating soil bentonite cutoff wall combined with a seepage berm or relief wells. Both measures would include a partial levee degrade to obtain the needed working platform width. (A full levee degrade is proposed where the levee has a severe burrowing rodent infestation or to prevent having to use the more expensive deep soil mixing (DSM) method for cutoff wall construction due to depth). A reach-by-reach cost comparison between the two measures showed a fully-penetrating soil bentonite cutoff wall was the least-cost measure for most reaches. However, site conditions dictated selection of a different measure for some reaches or portions of reaches.

Jet grout cutoff walls are proposed at locations where it is not practical to construct a conventional soil bentonite cutoff wall (i.e. bridges, railroad crossings, and the Yuba City Water Treatment Plant). Seepage berms by themselves are proposed for the northernmost end of the FRWL because a conventional soil bentonite cutoff wall is not constructible through the cobble levee. Partially penetrating cutoff walls combined with seepage berms or relief wells are proposed for the southern end of the FRWL because fully-penetrating cutoff walls would be too deep to be cost-effective. A cutoff wall with levee relocation and a cutoff wall with Sutter Butte Main Canal (SBMC) relocation are proposed for some levee sections along the FRWL (north of Sunset Weir, where the Sutter Butte Main Canal is located adjacent to the landside levee toe) to obtain the required O&M corridors.

The recommended modification measures for Alternatives SB-7 and SB-8 are shown on Plate 2-3.

2.8.4.4 Minimum Levee Template

The minimum levee template criteria obtained from four sources (USACE EM 1110-2-1913, CESPK-ED-G-SOP-EDG-03 (SOP3), DWR Urban Levee Design Criteria, and the Code of California Regulations (Title 23 Division 1) are shown on Plate 2-4. As a levee modification project, the Sacramento District allows a narrower crest width (not less than 15 ft) for existing levees that have improvements constructed to address seepage and stability concerns. The Sacramento District has adopted the following minimum levee template criteria:

- Crest width: 15 feet minimum.
- Landside slope: 2H:1V or flatter.
- Waterside slope: 3H:1V or flatter.
- Landside easement: 15 feet minimum.
- Waterside easement: 15 feet minimum.

2.8.4.5 Levee Fill and Borrow

Type 1, Type 2 and Random fill materials are needed for levee, cutoff wall and seepage berm constructions. Type 1 levee fill material will be used primarily as a clay core for the reconstructed levee above the cutoff wall and for the cutoff wall's soil-bentonite mix. Type 2 levee fill material will be used primarily for shells for the reconstructed levee above the cutoff wall. Random fill will be used primarily for the seepage berm.

Excavated materials from the levee degrade are expected to be reusable for Type 1 and Type 2 fills. Soils meeting the Type 1 fill requirement also meet the Type 2 and Random Fill requirements. Type 2 fill can be used as Random fill. Therefore, type 1 fill could be used as Type 2 and/or Random Fill in case there are shortages of Type 2 or Random Fill. It is expected that borrow materials will be needed for construction of the project. The two primary types of borrow material for the levee and cutoff wall constructions are: Type 1 and Type 2. Source for borrow is discussed in Paragraph 2.10. Specifications for the two material types are as follows:

- Type 1 Levee Fill: USCS classification of CL, SC, or CH and maximum particle size of 2 inches, AND a minimum 35% by weight passing the #200 sieve, maximum liquid limit of 60, plasticity index between 12 and 40.

- Type 2 Levee Fill: Maximum particle size of 2 inches; minimum 12% by weight passing the #200 sieve; maximum liquid limit of 45.

Based on preliminary geotechnical investigations and standard practice, an approximately 20% increase should be applied to the total demand (to account for all material swell, loss and shrinkage during excavation, transportation and placement, respectively) when estimating the borrow amount needed. The approximate percentages of levee degrade suitable for levee fill are shown in Table 2-2.

2.9 Civil Design

2.9.1 General

This section describes general civil design considerations for and recommendations resulting from the Class 4 and Class 3 analysis.

2.9.2 Class 4 Analysis of Alternatives SB-2 through SB-8

The Class 4 civil design analysis of Alternatives SB-2 through SB-8 followed the parametric approach in which site assessments were completed based on existing information and aerial photos, and quantity estimates were completed based on typical design templates from geotechnical design recommendations. Refer to the Civil Design Appendix for further details.

2.9.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The final civil design analysis of Alternatives SB-7 and SB-8 was based on a conventional design approach for development of feasibility level design (35%; Class 3) with detailed site assessments and deterministic analyses for encroachment and utility improvements, and for quantity analysis. The design considerations are listed below. All civil design analysis was based on hydraulic and geotechnical design recommendations provided in Paragraphs 2.7 and 2.8.

2.9.3.1 Embankment Geometry

The primary feature of the project is a cutoff wall which requires reconstruction of the excavated levee embankment. The reconstructed embankment is required to meet the minimum levee template criteria or to match the existing levee prism, whichever is larger (see Paragraph 2.8.4.4). The degraded levee will be reconstructed to the existing top of levee elevation or the 1957 authorized top of levee elevation, whichever is higher (see Paragraph 2.7.3.3).

In general, the existing levee prism of the FRWL currently appears to be larger than the minimum levee template. At some locations, however, the landside slope was damaged and needs to be reconstructed to meet the minimum levee template criteria (see Paragraph 2.8.4.4). Plate G-2 shows the typical section for embankment reconstruction.

An active railroad embankment (Union Pacific Railroad) crosses the levee alignment at approximate station 1130+00. The railroad embankment is about 4 feet lower than the levee. A stop log closure structure will be provided to meet the authorized levee height without causing impacts to the UPRR's operation. This structure will be closed during flood events.

There are three locations along the FRWL alignment, between station 1434+00 and station 1957+00, where the SBMC encroaches into the proposed right-of-way. The levee will be relocated toward the river at these locations (see Paragraph 2.9.3.3). The relocated levee is required to meet the minimum levee template criteria (see Paragraph 2.8.4.4) and levee height requirement (see Paragraph 2.7.4.3).

2.9.3.2 Right-Of-Way (ROW) Requirements

Currently, the existing FRWL's right-of-way (ROW) corridor includes O&M corridors which vary in width along the alignment and are discontinuous for a significant distance at some locations. The minimum levee template criteria require the project levee to have a 15 feet minimum O&M corridor on each side of the levee, along the levee toes (see Paragraph 2.8.4.4). The O&M corridors are necessary for O&M and flood fighting purposes. Therefore, for this feasibility study, additional real estate will be acquired to provide sufficient space for the O&M corridors. Acquiring additional real estate will result in relocation of physical structures (e.g., buildings, canals, etc.) along the alignment (see Paragraph 2.3). Where it is impractical to acquire the additional real estate, the levee will be relocated toward the river (see Paragraph 2.9.3.3).

There will be one exception in regards to the minimum requirement for O&M corridor. The exception covers the area between station 1904+00 and station 1957+00 where the SBMC is

encroaching into the proposed 15ft minimum landside easement. For this area, an existing 10ft minimum natural berm, on the levee's landside slope, will be utilized for O&M purposes without any further actions (see Paragraph 2.9.3.3).

2.9.3.3 Relocations

To meet the minimum ROW requirements as stated above, acquisition of additional real estate is necessary and will require relocations of certain physical structures. Any physical structures falling within the ROW proposed will be considered potential relocations (except for the encroachment of the SBMC). These relocations will be studied in greater detail in the PED phase.

In the case of the SBMC, which encroaches into the proposed ROW at four locations along the FRWL alignment between stations 1430+00 and 1957+00 (Plate 2-3), there were four potential measures considered for each area to address the issue. The measures include: construction of retaining wall in the landside slope, construction of a flood wall, levee relocation, and canal relocation. Each measure was evaluated based on construction cost and impacts.

The proposed measures were also coordinated with the USFWS to obtain their inputs. The flood wall and retaining wall options were eliminated because these structures were deemed to create a substantial barrier for terrestrial wildlife species migration.

Levee relocation was deemed to have the least overall impact and was selected as the primary measure for addressing the issue. The relocated levee is required to meet the minimum levee template criteria (see Paragraph 2.8.4.4) and height requirement (see Paragraph 2.7.3.3). The cutoff wall will be constructed at the centerline of the relocated levee sections.

Canal relocation was selected for a small section along the alignment where the FRWL is too close to the Feather River's main channel to relocate the levee. This option was also selected for a small section of the SBMC near the Sunset Weir Pump Station, around station 1430+00, because it was deemed to be more cost effective than the levee relocation option which requires relocation of the pump station' electrical system.

At one of the four locations where the SBMC encroaches into the proposed ROW, specifically between station 1904+00 and station 1957+00, an existing 10ft minimum natural berm, on the levee's landside slope, will be utilized for O&M purposes without any further actions needed.

2.9.3.4 Encroachments

A comprehensive inventory of all encroachments (utilities, physical structures, and woody vegetation) was completed based on existing data and field investigations. The existing encroachment data came from multiple sources including the CVFPB encroachment list, the USACE Periodic Inspection report, and as-built drawings of various projects located along the FRWL alignment. Field investigations were conducted to validate and improve the existing inventories.

The final encroachment list (Table 4-3 for Alternative SB-7 and Table 5-3 for Alternative SB-8) shows numerous pipelines (both gravity and pressurized lines) and conduits (cables, electrical lines etc.) crossing the existing FRWL embankment. The record also indicates a number of utilities running parallel to the alignment (power poles, irrigation ditches, pipelines etc.), physical structures (public, residential and commercial buildings), and woody vegetation (mature trees) currently located within the proposed ROW. The encroachments were divided into 2 groups:

- Utilities and Physical Structures
- Woody Vegetations

The following Paragraphs outline the approach for addressing levee encroachment issues (see Plate 2-6 for the utility handle chart).

2.9.3.4.1 Utilities and Physical Structures

This group was subdivided into 2 categories: levee prism encroachments and ROW encroachments.

The levee prism encroachments are utility pipelines and conduits running perpendicular to the levee alignment. Most of these pipeline and conduit crossings are either dated and do not comply with the current standard for levee encroachment or will be disrupted/otherwise impacted by levee construction. These pipelines and conduits, therefore, will be removed before the cutoff wall construction begins and replaced after the cutoff wall construction completes with proper pipe materials. Gravity lines (storm drain) will be replaced in-place. Pressurized lines (irrigation and drainage discharge lines, gas pipes, water and sewer lines etc.) and conduits (electrical and communication lines, cables etc.) will be relocated above the 1957 Water Surface Elevation (WSEL) profile or 0.5% (1/200) ACE WSEL profile north of station 461+00, whichever is greater and above the 1957 WSEL profile or 1% (1/100) ACE WSEL profile south of station 461+00, which ever greater. Where it is not feasible to relocate the pressurized pipelines above the intended WSEL (e.g. at Sunset Weir pump station), these pipelines will be replaced in-place. Pipes that are known to be recent installations will remain. All pipelines and conduits crossing the levee alignment will be modified to include positive closure devices and meet the USACE design criteria for levee penetrations in accordance with EM 1110-2-1913. Abandoned pipelines and conduits will be removed. Typical improvement plans for these utility encroachments were developed and shown in Plate G-3.

ROW Encroachments are the utilities and physical structures that are outside of the levee prism but fall within the limits of the proposed ROW (see Paragraph 2.9.3.2). These structures will be relocated outside of the proposed ROW prior to levee and seepage berm constructions.

Temporary bypass systems will be provided to minimize disruption to irrigation and other utility services during the farming season. The utility improvements and relocations will disrupt the storm drain systems; however, it is anticipated that the disruption will not cause any significant impacts to interior drainage of the basin since the levee construction is expected to be

within normal construction season (April through October) during which the storm drain systems won't be needed.

Tables 4-3 and 5-3 provide detailed descriptions of all utilities, encroachments and the proposed improvement for each site within the Alternatives SB-7 and SB-8, respectively.

2.9.3.4.2 Woody Vegetation on Levee

The FRWL currently has mature trees on the both the levee slopes and within 15 feet of both the landside and waterside levee toes, with the majority of the trees being within 15 feet of the toes in some locations. USACE Engineering Technical Letter (ETL) 1110-2-571 (Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures, 10 April 2009) establishes a vegetation-free zone to provide a reliable corridor of access to, and along, levees, floodwalls, embankment dams, and apparent structures, to assure adequate access by personnel and equipment for surveillance, inspection, maintenance, monitoring, and flood-fighting, and to prevent root penetration into the levee that could compromise its structural integrity. It is, therefore, required that the O&M corridors and levee embankment will be free of all woody vegetation in accordance with the Vegetation-Free Zone (VFZ) requirements in the ETL 1110-2-571.

The local sponsor, in their EIP, proposed allowing woody vegetation to temporarily remain within the EIP's ROW and the adoption of a life cycle adaptive management approach to address noncompliant vegetation removal overtime. The Sacramento District's PDT considered two options to address this issue. The first option was to require complete compliance with the ETL by removal of all woody vegetations within the VFZ. The second option was to require removal of all woody vegetation in the upper 2/3 of the waterside levee slope, the entire landside slope, within 15 feet of the landside toe and obtaining a vegetation variance for trees in the lower 1/3 of the waterside slope and within 15 feet of the waterside toe. The estimated cost differential of ETL 1110-2-571 compliance between the options appeared to be within the overall feasibility study cost contingency.

Because there is no significant cost differential, the first option, complete compliance with the ETL 1110-2-571, is the final recommendation (with exceptions to be considered on a case-by-case basis during the design phase).

2.9.3.5 Quantity Estimate

Quantity estimates were completed for levee construction and utility improvements in accordance with ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works and ER 1110-2-1302 Civil Works Cost Engineering.

The quantity estimates were completed on a reach by reach basis. The estimates for levee excavation and backfill took into account the swell and shrinkage factors, respectively, based on the geotechnical design recommendations (see Paragraph 2.8.4.5). The excavation quantities were estimated based on a degrade level placed at half of the levee height. The backfill quantities were estimated based on the recommended levee geometry (see Paragraph 2.9.3.1). Borrow

quantities were estimated based on the total demand and the quantities of reusable levee degrade. A 20% increase was applied to the total demand, defined as the additional backfill quantities needed beyond the reusable levee degrade, to account for all material swell, loss and shrinkage during excavation, transportation and placement, respectively. The quantities of reusable levee degrade were estimated based on the recommended percentages of reusable material (see Paragraph 2.8.4.5). Cutoff wall quantities were estimated separately for each type of cutoff wall (soil bentonite cutoff wall, deep soil mix cutoff wall, and jet grouting cutoff wall).

2.10 Borrow Sites and Disposal Areas

2.10.1 General

This section describe general considerations for borrow and disposal areas for the Class 4 and Class 3 analyses. Refer to the Geotechnical and Civil Design Appendixes for further details.

2.10.2 Class 4 Analysis of Alternatives SB-2 through SB-8

Borrow sites and disposal areas were not specifically identified during the screening and selection of alternatives. For borrow, the general assumption was that suitable borrow materials could be typically found within the basin and that the borrow sites would be within 15-mile to 30-mile radius of the construction sites. It is assumed that borrow would likely become cost prohibitive if not obtained within this distance, primarily due to air quality impacts. A conservative shrinkage factor of 15% was used for estimating borrow quantities.

2.10.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

Detailed analyses of borrow sites and disposal areas were completed for the final alternatives. The considerations are detailed below.

2.10.3.1 Borrow Sites

While some of the embankment material removed during levee degrading will be re-used to reconstruct the levee, it is anticipated that borrow materials will be needed to meet the levee fill material specifications. Two primary types of borrow material needed for levee and cutoff wall construction are: Type 1 levee fill, primarily used as a clay core for the reconstructed levee above the cutoff wall and for the soil-bentonite mix, and Type 2 levee fill, primarily used for shells for the reconstructed levee above the cutoff wall. Specifications for the two material types are discussed in Paragraph 2.8.4.5.

There were 13 sites identified as potential borrow areas, five of which were eliminated as a result of a preliminary screening process completed for each of the sites. The screening criteria, detailed in the EIS, include contamination level, and relative location to the levee/seepage berm. The design teams are currently in the process of sampling and testing the sites to ensure they meet material requirements. The borrow sites are shown on Plates 4-3 and 5-3 for Alternatives SB-7 and SB-8, respectively. Sampling and testing is ongoing for these potential borrow sites. It was estimated that the borrow sites can provide up to 1,349,932 cubic yards of Type 1 fill

material, 459,796 cubic yards of Type 2 fill material, and 330,800 cubic yards of Random fill materials.

Alternative SB-8 requires the largest quantity of borrow material. That alternative may require up to 629,810 cubic yards of Type 1fill material, 809,845 cubic yards of Type 2 fill material, and 179,520 cubic yards of Random fill material. The available borrow sites have an abundance of Type 1 and Random Fills and an insufficient quantity of Type 2 fill. Type 1 fill meets the requirements of Type 2 fill, so the excess Type 1 fill will be used to make up the deficiency of Type 2 fill.

2.10.3.2 Solid Waste Disposal Areas

The nearest solid waste facilities to the project area are the Ostrom Landfill (located east of the project site, approximately 30 road miles south of the project Reach 2) and the Neal Road Landfill (located 25 miles north of the project Reach 40).

The 225 acre Class II Ostrum Landfill is permitted to accept the following types of waste: solid waste; waste water treatment sludge; construction debris; food and green waste; some types of contaminated soils; and non-friable asbestos. The landfill has a total maximum permitted capacity of 43,467,230 cubic yards. In 2007, the Ostrum Landfill was reported to have 39,223,000 cubic yards of remaining capacity (90% of total capacity).

The Neal Road Facility is permitted to accept the following types of waste: municipal solid waste, inert industrial waste, demolition materials, special wastes containing nonfriable asbestos; and septage. The landfill has a total maximum permitted capacity of 25,271,900 cubic yards. In June 2011, the Neal Road Landfill was reported to have 20,396,081 cubic yards of remaining capacity (80% of total capacity).

Implementation of Alternative SB-8 may generate up to 813,000 cubic yards of solid waste that would require disposal. Sources of solid waste related to construction activities would include levee material, structural debris from removal of residences and agricultural structures, roadway pavements, and levee material deemed unsuitable for reuse. Using a reasonable estimate for reuse of the solid waste, the required amount for disposal is reduced to about 240,000 cubic yards. Only 8 per cent of the 240,000 cubic yards of solid waste is structural debris that would be wasted at the commercial disposal sites indicated above. This further emphasizes the adequacy of the identified landfills for the project. The other 220,000 cubic yards of solid waste is to be disposed at the borrow sites.

2.11 Construction Access, Haul Routes and Staging Areas

2.11.1 General

This section describes general considerations for hauling and staging activities for the Class 4 and Class 3 analyses.

2.11.2 Class 4 Analysis of Alternatives SB-2 through SB-8

Haul routes and staging areas were not specifically identified during the screening and selection of alternatives. For cost estimating purposes, it was assumed that a typical 15-mile haul distance (30 miles round trip) would be sufficient for estimating hauling efforts from the construction sites to borrow sites and disposal areas. Refer to the Civil Design Appendix for further details.

2.11.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

A hauling and staging plan was developed for Alternatives SB-7 and SB-8 during the Final Analysis (Class 3). Plates 4-3 and 5-3 show the hauling and staging plans for the final two Alternatives SB-7 and SB-8. The plans were developed based on the following assumptions from historical/typical USACE cutoff wall construction projects:

- A 1.5-acre staging area is needed every 2,500 linear feet of levee construction.
- A 5-acre staging area is needed every 5 miles of levee construction to accommodate a job trailer and staff parking.
- The haul route will be mainly on existing public roads, from the center of the source (commercial/borrow source) to the center of the construction contract (see Plates 4-3 and 5-3).
- A 15 foot permanent road easement along the landside and water side edge of the project features (see Paragraph 2.8) is sufficient for movement of construction equipments within the construction site.
- The proposed staging areas are close to public roads for easy access and away from active farm lands, orchards and residential homes (where possible) to minimize impacts caused by construction activities.
- Permanent access to the existing levees will remain except where seepage berms are proposed. Access ramps will be constructed at the seepage berm locations to provide new maintenance access.

2.12 Real Estate Requirements

2.12.1 General

This section describes general real estate requirements determined during the Class 4 and Class 3 analyses. Additional details can be found in the Real Estate Appendix.

2.12.2 Class 4 Analysis of Alternatives SB-2 through SB-8

During the screening and selection of alternatives, the Sacramento District's Engineering Division delineated the project's footprint and identified properties impacted by the project (refer to the Civil Design Appendix for greater details). Based on this information, Real Estate Division completed the real estate cost estimate for the draft array of alternatives using the parametric approach in which the impacted properties were classified based on land use and each type of

land use was given an empirical unit cost. The preliminary real estate requirements for the levee footprint, O&M corridor, and utility corridor were estimated as fee value only.

2.12.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The real estate estimate for the Final Analysis (Class 3) of Alternatives SB-7 and SB-8 was developed based on the conventional approach for development of feasibility level design. During the Final Analysis, the Real Estate Plan was developed for Alternatives SB-7 and SB-8 in accordance with ER 405-1-12 and based on the footprints delineating project requirements developed by the Sacramento's Engineering Division. The general Land, Easements, Rights-of-way, Relocation and Disposal Areas (LERRD)'s requirements for the Real Estate Plan include: the acquisition of flood protection levee easement, permanent road easement, utility easement, drainage easement, temporary work area easement, borrow easement, and fee title. The basis for different types of acquisition is as follows:

- The flood protection levee easement is required for the construction and operation and maintenance of project features. The easement varies in width and is delineated by the toe of existing levee and seepage berms (within the project's limit), relocated levee segments and new seepage berms.
- A 15 foot permanent road easement along the landside and waterside edge of the flood protection levee easement, at a minimum, is needed for providing maintenance access to and for flood fighting purposes along the toe of the project features.
- Flood protection levee easement and permanent road easement together will be sufficient to cover the acquisition needed for the vegetation free zone and to allow for the movement of construction equipments within the construction site.
- Additional utility easement (approximately 20ft beyond the permanent road easement for O&M roads) may also be needed for obtaining utility corridors for relocation of utilities parallel to the project's alignment outside of the proposed ROW. This additional utility easement was not specifically identified for the SBFS and will be estimated as percentage of the total utility relocation costs.
- Drainage easement is required for the canal relocations.
- Temporary work area easement is required for acquiring staging areas along the 41 mile long alignment of the project.
- Borrow easement is required for potential borrow sites.
- Potential on-site mitigation areas will be acquired in fee title.

2.13 Environmental Considerations

2.13.1 General

This section describes environmental considerations for the draft and final arrays of alternatives. Refer to the main integrated report for further details.

2.13.2 Evaluation of the Existing Condition (Alternative SB-1)

An inventory and forecast of future without-project conditions was conducted for the study area using existing sources of information for the study area (e.g., county and city general plans, and prior NEPA and CEQA environmental documentation). The results are described in the Sutter Basin Feasibility Study Environmental Without-Project Conditions Report (ICF International, 2012). This report and the EIS/EIR prepared for the SBFCA EIP forms the basis for the "Affected Environment" and "No Action Alternative" sections of the Sutter Pilot Feasibility Study/EIS/EIR. (The SBFCA EIP was defined in Paragraph 1.3 of this report.)

2.13.3 Class 4 Analysis of Alternative SB-2 through SB-8

The screening of alternatives from an environmental standpoint focused on qualitatively assessing temporary and permanent impacts on the environment. The criteria include:

- Assessment of the potential for induced development in the floodplain.
- Minimization of land disturbance outside the existing levee footprint, loss of farmland, impacts to existing structures.
- Minimization and avoidance of adverse effects on air and water quality, sensitive habitat, and other resources.

Information from various data bases and existing reports was used in the evaluation. The primary sources were the Sutter Basin Feasibility Study Environmental Without-Project Conditions Report (ICF International, 2012) and the Environmental Constraints Analysis prepared for the SBFCA EIP (ICF International, August 2011). The results of public involvement, NEPA scoping, and coordination with the resource agencies were also used to assess alternatives.

2.13.4 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

For the Final Analysis (Class 3) of Alternatives SB-7 and SB-8, the study heavily relied on environmental surveys and the Draft EIS/EIR prepared for SBFCA EIP which was released for public review in December 2012. Extensive information developed for the SBFCA EIP's EIS/EIR aided the study in determining environmental impacts and developing mitigation cost estimates. The considerations are detailed below.

2.13.4.1 Significant Impacts

Alternatives SB-7 and SB-8 are anticipated to result in the following significant and unavoidable or potentially significant and unavoidable impacts. The main integrated report discusses these impacts in greater details.

1. Air Quality Impacts

Project construction would result in temporary construction-related emissions. These include:

- Exceedance of applicable thresholds for construction emissions

Emissions would be partially mitigated by reducing vehicle and equipment emissions and implementing a fugitive dust plan. Despite the mitigation measures, the temporary construction emissions are anticipated to be significant and unavoidable.

2. Noise Impacts

Implementation of any of the project alternatives would result in temporary but significant effects related to construction noise and vibration to sensitive receptors near construction areas. These might include:

- Exposure of Sensitive Receptors to Temporary Construction-Related Noise
- Exposure of Sensitive Receptors to Temporary Construction-Related Vibration

Noise-reducing mitigation measures and vibration-reducing construction practices may not be sufficient to reduce the exposure of sensitive receptors to temporary construction noise and vibration to less than significant.

3. Vegetation Impacts

Project construction is estimated to result in permanent impacts to riparian vegetation and wetlands. These might include:

- Disturbance or Removal of Riparian Trees
- Potential Loss of Special-Status Plant Populations Caused by Habitat Loss Resulting from Project Construction

Habitat compensation is proposed to mitigate losses with the goal of no net loss. Mitigation needs for Alternative SB-7 are estimated at 48 acres and for Alternative SB-8 88 acres. For SB-8, a draft mitigation and monitoring plan has been developed which proposes about 88 acres of compensation consisting of about 25 acres at the Star Bend Conservation Area and 63 acres at the proposed Three Rivers Levee Improvement Authorities Feather River Floodway Corridor Restoration Site.

4. **Visual Resources**

Construction potentially could result in significant visual effects in reaches with sensitive viewers. These might include:

- Temporary Visual Effects from Construction.
- Adverse Affects to a Scenic Vista.
- Substantial degradation of the Existing Visual Character or Quality of the Site and its Surroundings.
- Creation of a New Source of Substantial Light or Glare that would Adversely Affect Day and Nighttime Public Views.

The effect mechanisms are primarily vegetation removal and replacement of agricultural and developed land use with seepage berms. Construction activities would also have temporary visual effects.

5. Cultural Resources

Cultural resources are known to exist throughout the planning area. Cultural resources could be disturbed and destroyed under any of the project alternatives. Impacts might include:

- Effects on Identified Archaeological Sites Resulting from Construction of Levee Improvements and Ancillary Features
- Potential to Disturb Unidentified Archaeological Sites
- Potential to Disturb Human Remains
- Direct and Indirect Effects on Identified Historic Architectural/Built Environment Resources Resulting from Construction Activities

While mitigation measures have been identified, the mitigation does not reduce effects to less than significant. The cultural site assessment (CSA) is discussed in greater detail in Paragraph 2.15 of this report.

6. Hazardous, Toxic and Radioactive Wastes (HTRW)

HTRW is discussed in detail in Paragraph 2.14 of this report.

2.13.4.2 Other Impacts

Other environmental impacts are expected due to construction of the proposed Alternatives SB-7 and SB-8. These include:

1. Flood Control and Geomorphic Conditions

Construction of any of the alternatives would be a flood control benefit in the planning area although existing drainage patterns could be altered. Effects on local interior drainage would be mitigated to less than significant by coordinating with owners and operators, preparing drainage studies, and remediating effects through project design.

2. Water Quality and Groundwater Resources

Dewatering of construction areas could result in the release of contaminants to surface or groundwater. This impact would be mitigated to less than significant by implementing provisions for dewatering effluent before it is discharged.

3. Geology, Soils, Seismicity and Mineral Resources

Construction activities associated with any of the alternatives would not result in any significant impacts to geology, soils, seismicity, and mineral resources.

4. Traffic, Transportation and Navigation

Temporary increases in construction-related traffic, temporary road closures, emergency response times, and other traffic, transportation and navigation effects from project implementation were determined to be less than significant under all action alternatives.

5. Climate Change and Greenhouse Gas

Construction activity would cause a temporary and less than significant increase in greenhouse gas emissions.

6. Wildlife

Construction activities could result in potential injury, mortality, or disturbance of special-status and common species, which could affect local populations. Implementation of mitigation measures would minimize or avoid these impacts and bring effects down to a less than a significant level.

7. Fish and Aquatic Resources

No in-water construction is proposed that could directly affect fishery resources. No loss of Shaded Riverine Aquatic cover and critical habitat would occur. Some loss of floodplain riparian vegetation would occur but mitigation is proposed to offset this loss. Thus, the project is not expected to significantly effect fish and aquatic resources.

8. Agriculture, Land Use and Socioeconomics

Project implementation would permanently convert farmland to nonagricultural use where construction extends beyond the existing levee footprint. Overall, the project is intended to preserve existing land use and socioeconomic conditions, especially for agriculture. Additionally, flood control activities are typically considered public uses, which are largely consistent with the land use policies and regulations governing the project area. Construction activities would temporarily increase employment and personal income in the local area.

9. Population, Housing and Environmental Justice

Project implementation of any of the alternatives will require displacement of existing housing units. Permanent acquisition, relocation, and compensation services will be conducted in compliance with Federal and State relocation laws. In cases where project construction is temporarily disruptive to nearby residents, assistance would be provided for residents to relocate temporarily during construction activities and provide compensation to residents for reasonable rent and living expenses incurred as a result of relocation.

The alternatives would not result in disproportionately high and adverse effects on minority populations and low-income populations from acquisition of homes because plenty of vacant homes exist within the affected area to serve as replacement housing.

10. Recreation

The alternatives would not have any permanent effects on recreation in the project area. Temporary access to recreational facilities along the Feather River would be an impact and addressed by providing notification of construction area closures to protect public safety.

11. Utilities and Public Services

Construction of the project may damage drainage and irrigation systems and public utility infrastructure, resulting in temporary disruptions to service. Coordination with drainage and irrigation systems users, consultation with service providers, and implementation of appropriate protection measures would minimize the possibility of any significant effects.

12. Public Health and Environmental Hazards

Project implementation has the potential to slightly increase risks to the public during construction through use of equipment and fuels, but the increased risk is temporary. These risks are minimized by implementation of a stormwater pollution prevention plan and the best management practices (BMPs) it contains to control accelerated erosion, sedimentation, and other pollutants during and after project construction.

2.13.4.3 Environmental Commitments

The following environmental commitments are proposed as part of the project to avoid and minimize construction-related effects.

- Avoidance measures for valley elderberry longhorn beetle.
- Avoidance measures for giant garter snake.
- Avoidance measures for Swainson's hawk.
- Avoidance measures for raptors.
- Measures to minimize loss riparian vegetation.
- Invasive plant species prevention measures.
- Construction limitations near residences.
- Soil borrow site reclamation plan.
- Post-construction operations and maintenance.
- Stormwater pollution prevention plan.
- Bentonite slurry spill contingency plan spill prevention, control and counter-measure plan.
- Monitoring of turbidity in adjacent water bodies.

2.13.4.4 Fish and Wildlife Mitigation Facilities

Mitigation facilities required for fish and wildlife compensation consists of: (1) 24.5 acres at the existing 49-acre Star Bend Conservation Area, located on the west levee of the Feather River, approximately 6 miles south of Yuba City and (2) 63 acres at the proposed Three Rivers Levee Improvement Authorities Feather River Floodway Corridor Restoration Project site located on the opposite east bank of the Feather River. These sites would serve as a valley elderberry longhorn beetle elderberry transplant/compensation site and riparian habitat compensation area for both Alternatives SB-7 and SB-8.

The Star Bend Conservation Area site was created in 2009. LD 1 of Sutter County constructed the Feather River Setback Levee and Habitat Enhancement Project at Star Bend to replace a portion of existing levee that poses a high risk of failure in order to decrease the flood stage, velocity, and scour potential; increase and improve floodplain habitat; and improve habitat connectivity between the Abbot Lake and O'Connor Lakes Units of CDFW's Feather River Wildlife Area. The Star Bend project created approximately 55 acres of floodplain habitat within which to implement mitigation for impacted elderberry and riparian habitat.

For the loss of jurisdictional wetlands and giant garter snake habitat, compensation would be provide by the purchase of credits from local mitigation banks. A detailed mitigation and monitoring plan accompanies the main report in the environmental appendix. The plan describes in greater detail the proposed design for mitigation and monitoring to ensure success.

2.14 Hazardous, Toxic and Radioactive Wastes (HTRW)

2.14.1 General

This section describes HTRW considerations during the Class 4 and Class 3 analyses for the project area.

2.14.2 Class 4 Analysis of Alternatives SB-1 through SB-8

The project area consists of urban, suburban, and rural areas. Potential sources of hazardous materials and waste may exist in the urbanized as well as agricultural areas adjacent to the levees. The following hazardous materials may be present in the project area in a variety of common contexts.

- Pesticides, herbicides, and fertilizers associated with agricultural lands.
- Petroleum hydrocarbons.
- Underground storage tanks.
- Contaminated debris including asbestos.
- Lead associated with paints and structures.
- Wastewater.
- Pits or ponds.
- Stormwater runoff structures.
- Transformers that may contain PCBs.

2.14.2.1 Preliminary Site Assessment

A Preliminary Environmental Site Assessment was conducted by USACE in June–July of 2009. The Preliminary Environmental Site Assessment was conducted to identify recognized environmental conditions, including presence or likely presence of any hazardous substance or petroleum products under conditions that indicate an existing release, a past release, or the material threat of a release into structures, the ground, groundwater, or surface waters of the property. As part of the assessment, a database record search was conducted to identify any known HTRW in the project area. Results of the Preliminary Environmental Site Assessment included:

- 51 registered underground storage tanks and 3 aboveground storage tanks.
- Five sources are listed as small and large generators of U.S. Environmental Protection Agency (EPA)-regulated hazardous waste.
- Five sites that had leaking underground storage tanks, two of which have or had affected public drinking water.
- Six known or potential hazardous substance sites under investigation or cleanup.
- Two waste discharge systems.
- Two landfills.
- 12 suspected drug labs.
- One pesticide-producing facility.

One additional site not included in the Preliminary Environmental Site Assessment was a SuperFund site (Onstott Dusters, Inc.). For the majority of the sources, no records were found to indicate that these potential sources have actually caused major contamination, although investigations are still on-going. Several areas of concern were revealed during the investigation. Most of these areas of concern involve registered underground storage tanks, hazardous waste generators, minor tank leaks, underground storage tank removal and remediation, and accidental releases.

During records research, no known contamination due to HTRW was confirmed within the construction zone. In conclusion, no evidence was found to indicate that any other potential sources of contamination would interfere with any planned construction of the levees. However, implementation of Alternatives SB-7 and SB-8 would potentially result in effects on public health and environmental hazards related to construction activity. These effects are judged to be insignificant when mitigated by various plans and measures to be implemented before construction including Stormwater Pollution and Prevention Plan, Phase I/Phase II Environmental Site Assessment, Toxic Release Contingency Plan, Construction Site Safety Measures, and Emergency Response Plan.

2.14.2.2 Storm Water Pollution Prevention Plan (SWPPP)

Because ground disturbance for the project would be greater than 1 acre, coverage would be obtained under the EPA's National Pollutant Discharge Elimination System (NPDES) general construction activity stormwater permit. The Central Valley Regional Water Quality Control Board administers the NPDES storm water permit program in Sutter and Butte counties. Obtaining coverage under the NPDES general construction activity permit generally requires that the project applicant prepare a stormwater pollution prevention plan (SWPPP) that describes the best management practices that would be implemented to control accelerated erosion,

sedimentation, and other pollutants during and after project construction. The SWPPP would be prepared prior to commencing earth-moving construction activities.

The specific best management practice that would be incorporated into the erosion and sediment control plan and SWPPP would be site-specific and would be prepared by the construction contractor in accordance with the Central Valley Regional Water Quality Control Board Field Manual. However, the plan likely would include one or more of the following standard erosion and sediment control best management practices.

- **Timing of construction**. The construction contractor would conduct all construction activities during the typical construction season to avoid ground disturbance during the rainy season.
- **Staging of construction equipment and materials**. To the extent possible, equipment and materials would be staged in areas that have already been disturbed.
- **Minimize soil and vegetation disturbance**. The construction contractor would minimize ground disturbance and the disturbance/destruction of existing vegetation. This would be accomplished in part through the establishment of designated equipment staging areas, ingress and egress corridors, and equipment exclusion zones prior to the commencement of any grading operations.
- **Stabilize grading spoils**. Grading spoils generated during construction would be temporarily stockpiled in staging areas. Silt fences, fiber rolls, or similar devices would be installed around the base of the temporary stockpiles to intercept runoff and sediment during storm events. If necessary, temporary stockpiles may be covered with an appropriate geotextile to increase protection from wind and water erosion.
- **Install sediment barriers**. The construction contractor may install silt fences, fiber rolls, or similar devices to prevent sediment-laden runoff from leaving the construction area.
- **Stormwater drain inlet protection**. The construction contractor may install silt fences, drop inlet sediment traps, sandbag barriers, and/or other similar devices.
- **Permanent site stabilization**. The construction contractor would install structural and vegetative methods to permanently stabilize all graded or otherwise disturbed areas once construction is complete. Structural methods may include the installation of biodegradable fiber rolls and erosion control blankets. Vegetative methods may involve the application of organic mulch and tackifier and/or the application of an erosion control seed mix. Implementation of a SWPPP would substantially minimize the potential for project-related erosion and associated adverse effects on water quality.

2.14.2.3 Discovery of Potential HTRW Sites During Construction

If any evidence of potential HTRW is found during construction, all work would cease, and USACE would be notified by the contractor for further evaluation of the potential contamination. Any unanticipated hazardous materials encountered during construction would be handled according to applicable Federal, State, and local regulations. USACE would require that a contingency plan that outlines steps to be taken before and during construction activities to document soil conditions, as well as procedures to be followed if unexpected conditions are encountered, be prepared by the contractor. The non-Federal sponsor is responsible for 100 percent of the cost to develop the clean-up procedures (remedial action plan) and to treat the contamination in place or relocate the material (ER 1110-2-1150).

2.14.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The HTRW considerations from the screening and selection of alternatives apply to the Final Analysis (Class 3) of Alternatives of SB-7 and SB-8. A Phase I Environmental Site Assessment of HTRW for Alternative SB-7 or Alternative SB-8 would be complete in PED.

2.15 Cultural Impact Assessment

2.15.1 General

This section describes the CSA during the Class 4 and Class 3 analyses. Refer to the EIS for further details.

2.15.2 Class 4 Analysis of Alternatives SB-1 through SB-8

The cultural resources impacted by the proposed conceptual alternatives were not specifically identified during the screening and selection of alternatives. A statutory level set aside of 1% of the federal share of construction costs (set by the Archeological and Historical Preservation Act of 1974, Public Law 93-271) was applied and used as the cost estimate for the draft array of Alternatives SB-1 through SB-8.

2.15.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The construction of Alternative SB-8 would result in impacts to the levee itself, the Sutter Butte Canal, historic buildings and neighborhoods in Yuba City, other built environment resources identified in the FRWLP EIS/EIR, and several known prehistoric archaeological sites (CA-SUT-5, CA-SUT-10, CA-SUT-20, CA-SUT-77, CA-BUT-52, CA-BUT-53, CA-BUT-496, CA-BUT-1123, and the unnamed site identified by UAIC). The geographically smaller Alternative SB-7 would result in similar impacts, but would avoid the known prehistoric sites in Butte County (CA-BUT-52, CA-BUT-53, CA-BUT-496, CA-BUT-1123).

Additional impacts may be identified as cultural resources inventories are completed, including the borrow areas and utility relocations. These could result in further costs that would be included in the cost estimate developed during PED.

In light of this analysis, USACE will continue to use the 1% of the federal share of construction costs set aside for data recovery of impacted cultural resources as a gross means of estimating cost. USACE would only cost-share the project up to the cost of Alternative SB-7, the Federal costs associated with both alternatives would be the same. Increased cultural resources costs associated with the larger Alternative SB-8 including data-recovery investigations, would be borne by the local sponsor.

2.16 Operation and Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

2.16.1 General

This section describes the OMRR&R considerations during the Class 4 and Class 3 analyses.

2.16.2 Class 4 Analysis of Alternatives SB-2 through SB-8

OMRR&R related activities were not specifically identified during the screening and selection of alternatives. A brief investigation of OMRR&R costs was done by the local sponsor by soliciting information from various levee districts (LDs) and State maintenance agencies (MAs) within the Sutter Basin. The costs reflect a ratio of base costs to the summation of yearly OMRR&R budgets for the various LDs and MAs. For estimating purposes, the assumed 8.5% of construction cost for OMRR&R related activities for each of the alternatives were deemed to be reasonable.

2.16.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The OMRR&R requirements, activities and costs were identified during the Final Analysis (Class 3) of Alternatives SB-7 and SB-8.

2.16.3.1 General Requirements

The non-Federal sponsors (CVFPB and SBFCA) will be responsible for all OMRR&R related activities upon transfer of the project which will in turn be delegated to the individual levee maintenance authorities. The OMRR&R costs represent average cost to maintain the project improvements throughout the project life. The OMRR&R for flood control features would be performed in accordance with provisions of Title 33, Flood Control Regulation, Maintenance and Operation of Flood Control Work, approved by Secretary of the Army , 9 August 1944, published 17 August 1944, Federal Register. The general intent of the regulations is expressed as follows: "The structures and facilities constructed by the United States for flood protection shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits."

USACE's resident engineer schedules and conducts joint acceptance inspections, monitors correction of deficiencies, schedules and monitors OMRR&R training, ensures that all as-built drawings are complete and accurate, and provides information/support for USACE to prepare and distribute property transfer documentation.

Prior to final acceptance of the project or an increment of the project, pre-final inspections will be conducted on an area-by-area basis or may be conducted on a functional basis. The purpose of these inspections is to ensure transfer of a complete, functional and maintainable project, constructed fully in accordance with contract specifications and drawings. Upon final acceptance of an area or the project, USACE will prepare and transfer an amended OMRR&R manual for the project features and the non-Federal sponsor will assume OMRR&R.

2.16.3.2 Typical OMRR&R Activities

Typical OMRR&R activities both with and without project are considered to be::

- Vegetation removal and control in compliance with Corps of Engineers ETL 1110-2-571, 10 April 2009.
- Rodent control and repair of rodent damage.
- Slope re-grading and reseeding.
- Repair of waterside erosion.
- Maintenance of relief wells and collection ditches.
- Maintenance and repair of flap gates to minimize internal drainage.
- Patrol road/ramp maintenance.
- Inspection/patrolling including participation in Federal and State inspection programs, routine patrolling to identify maintenance needs and to assure flood worthiness, and continuous patrolling during high water conditions.
- Flood fighting
- Closure of the gap in the levee crown for passage of the railroad during high water conditions to prevent flooding of Yuba City and vicinity.

Project implementation will likely result in increased cost /effort for some of these activities and decreased cost/effort for others. Net change in OMRR&R cost/effort is considered to be minimal.

A comparison of the estimated without project O&MRR&R and with project costs in 2012 dollars for the levees to be repaired under Alternatives SB-7 and SB-8 is shown in Table 2-3.

2.16.3.3 Vegetation

The without-project maintenance requirements for vegetation within the project area are not altered by the USACE ETL 1110-2-571. The requirements remain as identified in the Sacramento River Flood Control Project standard manual which states: "clearing of bushes, trees, and other wild growth from the levee crown and slopes. Bushes and small trees may be retained on the waterside slope where desirable for the prevention of erosion and wave wash. Where practicable, measures shall be taken to retard bank erosion by the planting of willows or other suitable growths on areas riverward of the levees."

Under USACE policy, it is expected that any potential levee project will be required to fully comply with the USACE ETL 1110-2-571, unless a variance is obtained. The USACE ETL 1110-2-571 requires that no vegetation (with the exception of grasses) be allowed to grow within the Vegetation-Free Zone (VFZ), defined in Paragraph 2.9.3.4.2) to assure adequate access by personnel and equipment for surveillance, inspection, maintenance, monitoring, and flood-fighting, and to prevent root penetration into the levee that could compromise its structural integrity.

USACE guidance defines a variance as "alternative vegetation management standards to be applied to a levee system or portion thereof that provide for the same levee functionality as intended in ETL 1110–2–571" (Federal Register, February 17, 2012). Variances may only be granted to allow the preservation of waterside vegetation below the upper third of the waterside

slope. Per the draft variance request procedure published in the Federal Register (February 17, 2012), no variance requests will be approved for noncompliant landside vegetation.

For the case of the Sutter Basin project, it is anticipated that the local sponsor will be seeking a vegetation variance. However, attempting to obtain a variance during the feasibility phase would require substantial time and cost and would be inconsistent with the USACE SMART planning modernization effort. Therefore, the issue of ETL variance will be addressed during the PED phase. Also during the PED phase, further consideration can be given to avoiding and minimizing the removal of vegetation that provides significant habitat for endangered species and other wildlife. Levee design modifications (overbuilding, etc) may be implemented to avoid the loss of trees that are determined regionally significant, such as heritage oak trees. Vegetation outside the construction footprint would be retained if it conforms to established USACE vegetation policy at the time of PED, during detailed design and preparation of construction plans and specifications. Vegetation removal requirements would be based on full compliance with vegetation management guidelines in ETL 1110-2-571, or another approach approved by USACE.

2.17 Cost Engineering

2.17.1 General

This section describes general considerations for the development of the cost estimates during the Class 4 and Class 3 analyses. Refer to the Cost Engineering Appendix for further details.

2.17.2 Class 4 Analysis of Alternatives SB-2 through SB-8

During the screening and selection of alternatives, the cost estimate for Alternatives SB-2 through SB-8 was developed using the parametric approach in which historical and unit costs were employed. The Parametric Cost Estimating MII Toolbox (spreadsheet format) was used to prepare the cost estimate.

2.17.3 Final Analysis (Class 3) of Alternatives SB-7 and SB-8

The cost estimate, prepared by the Sacramento District's Cost Engineering Section, for the final feasibility design of Alternatives SB-7 and SB-8 followed the conventional approach for developing cost estimates for feasibility level design (35%; Class 3). The cost estimate was prepared in accordance with ER 1110-2-1302 and ETL 1110-2-573 for Cost Estimating. The cost estimate was based on the quantity estimates provided by the Sacramento District's Engineering Division (see Paragraph 2.9.3.5 for quantity development). The construction contracts for each of Alternatives, SB-7 and SB-8, were sequenced based on the approximated funding availability and appropriation (see Tables 4-4 and 5-4).

2.18 Value Engineering

2.18.1 General

A combined Value Engineering (VE) Study and Planning Charette was held from 31 October to 4 November 2011. The VE methodology was incorporated into the planning process at an early stage of the study to compare, refine, and optimize alternatives based on multiple criteria. This process also provided an opportunity to validate the array of preliminary alternatives and to ensure that significant alternatives had not been overlooked. The VE Study/Charette was attended by the PDT and non-Federal sponsors, the SPK VE Officer and SPD VE Program Manager, the SPD Plan Formulation Lead, and representatives from the National Pilot Program 17+1 Team.

2.18.2 Methodology

The team reviewed initial alternative evaluation criteria and expanded these criteria based on inputs from the group.The following are the final criteria that were used to assess each alternative in combination with the conceptual level cost estimates for each alternative.

- Life Safety
- Flood Damage Benefits
- Critical Infrastructure Impacts
- Design Capacity Exceedance
- Wise Use of Floodplain
- Sustainability
- Ecosystem Functionality
- Environmental Impacts

Based on the discussions during the combined VE Study and Planning Charette, the team identified alternatives with very similar functions as well as alternatives with little probability of implementation. This resulted in combining and eliminating some of the alternatives as well as refining and optimizing those that were retained by adding or removing measures in order to ensure a robust array. A draft array of potential alternatives was identified for further evaluation.

2.18.3 Results

Following is a summary of the recommendations for the draft array of 8 alternatives to be carried forward for further evaluation.

- Alternative SB-1 – No action alternative (i.e. existing condition)
- Alternative SB-2 – Minimal fix-in-place Feather River Levees, Sunset Weir to Star Bend
- Alternative SB-3 – Yuba City ring levee
- Alternative SB-4 – Little "J" levee, Thermalito Afterbay to South of Yuba City
- Alternative SB-5 – Fix-in –place Feather River Levees: Thermalito Afterbay to Star Bend
- Alternative SB-6 – Fix-in –place Feather River, Sutter Bypass, and Wadsworth Canal Levees

The VE Study and Planning Charette Report, which includes details on the relative ratings of each of the original alternatives and the evaluation process, is included in Appendix B of the Sutter Basin, CA Pilot Study, Progress Document#1 (30 May 2012).

Following the VE study, through additional plan formulation, two additional alternatives were added to the draft array (because the economic net benefit analysis determined that extending the fix-in-place reach further south increased the net benefits), these include:

- Alternative SB-7 – Fix-in-place Feather River Levees: Sunset Weir to Laurel Avenue
- Alternative SB-8 – Fix-in-place Feather River Levees: Thermalito Afterbay to Laurel Avenue

CHAPTER 3 – EXISTING CONDITION

3.1 General

The purpose of this chapter is to provide an overview of the existing levee system delineating the perimeter of the Sutter Basin. The discussion will focus on describing the existing features. Hydraulic and geotechnical analyses of the existing condition and performance of the levee system are discussed in Paragraphs 2.3 and 2.4 of this report. Refer to the Hydraulic and Geotechnical Appendixes for greater details.

3.2 Existing Sutter Basin Levee System

The existing Sutter Basin Levee System (SBLS) consists of four mainline levees which are Feather River West Levee (FRWL), Sutter Bypass East Levee (SBEL), Wadsworth Canal East Levee (WCEL) and Cherokee Canal East Levee (CCEL) surrounding the communities of Yuba City, Live Oak, Gridley, Biggs and other smaller towns in Sutter and Butte Counties, California.

These Local Maintenance Authority (LMA) entities include Levee District (LD) 1 of Sutter County, LD 9 of Sutter County, and California Department of Water Resources Maintenance Areas (MA 3, 7, 13, 16, Wadsworth Canal, and Sutter Bypass). These entities maintain all levees within the study area. Plate 1-1 shows the existing SBLS and LMAs. The levee segments in the study area are as follows:

- Feather River West Levee – MA 3: Right levee (on the west bank) of the Feather River from Project Levee Mile (PLM) 0.00 at the Sutter Bypass confluence upstream to PLM 5.19 at the downstream boundary of the LD 1 segment.

- FRWL – LD 1: Right levee (on the west bank) of the Feather River from PLM 0.00 at the boundary of MA 3 upstream to PLM 16.65 at the downstream boundary of the LD 9 segment.

- FRWL – LD 9: Right levee (on the west bank) of the Feather River from PLM 0.00 at the LD 1 boundary upstream to PLM 6.24 at the downstream boundary of the MA16 segment

- FRWL – MA 16: Right levee (on the west bank) of the Feather River from PLM 0.00 at the LD 9 boundary upstream to PLM 4.09 at the downstream boundary of the MA 7 segment.

- FRWL – MA 7: Right levee (on the west bank) of the Feather River from PLM 0.00 at the MA 16 boundary upstream to PLM 12.07 at the downstream boundary of the Hamilton Bend segment.

- FRWL – Hamilton Bend Area: Right levee (on the west bank) of the Feather River from PLM 0.00 at the MA 7 boundary upstream to PLM 1.20 at the Thermalito Afterbay outlet channel.

- SBEL – Downstream of Wadsworth Canal: Left levee (on the east bank) of the Sutter Bypass from the confluence with the Wadsworth Canal at PLM 4.40 downstream boundary to PLM 22.11 at the confluence with the Feather River.

- SBEL –Upstream of Wadsworth Canal: Left Levee (on the east bank) of the Sutter Bypass from the confluence with the Wadsworth Canal at PLM 4.40 downstream boundary to PLM 0.00.

- WCEL: Left levee (on the south east bank) of the Wadsworth Canal from PLM 0.00 at the confluence with the Sutter Bypass upstream to PLM 4.66 at the East Interceptor Canal.

- WCEL: Right levee (on the north west bank) of the Wadsworth Canal from PLM 0.00 at the Sutter Bypass confluence upstream to PLM 4.66 at the West Interceptor Canal

- CCEL – MA 13: Left levee (on the south east bank) of the Cherokee Canal from PLM 9.90 at the Southern Pacific Railroad Bridge upstream to PLM 6.10 at the Western Canal crossing (this partial segment is not part of the ULE program).

The following Paragraphs provide more details for reach of these levee segments.

3.2.1 Feather River West Levee – MA3

The MA 3 levee segment extends north (upstream) along the right bank of the Feather River from PLM 0.00 at the Sutter Bypass left bank levee to PLM 5.19.

The levee crest elevation varies between 52 feet NAVD88 at the downstream end to 66 feet about half a mile downstream of the upstream end of the segment. The levee height varies between 18 and 26 feet, with an average height of 22 feet. The crest width varies between 20 and 30 feet. The waterside slope varies between 1.6H:1V and 2.5H:1V. The landside slope varies between 1.5H:1V and 3H:1V.

The levee soils consist mostly of alternating layers of silty sand and silt, with lesser amounts of lean clay and sandy clay. The foundation consists of a sandy clay/clay/sandy silt blanket 1 to 50 feet thick. In general, the blanket layer thickness decreases moving upstream along the segment. There is no hardpan within the blanket layer. The underlying pervious layer consists of sand, silty sand, and gravel.

After the 1997 flood, pervious toe drains with overlying stability berms were constructed by USACE between PLM 2.28 and 2.43 (Sacramento River Flood Control Project Phase II Levee Reconstruction, Site 11) and between PLM 3.46 and 3.83 (PL84-99 rehabilitation).

3.2.2 Feather River West Levee – LD 1

The LD 1 segment of the Feather River extends north (upstream) along the right bank of the Feather River from PLM 0.00 at the upstream end of the MA 3 segment to PLM 16.65 at the downstream end of the LD 9 segment. Yuba City is adjacent to the upstream 6 miles of this segment.

The crest elevation varies between 62 feet NAVD88 at the downstream end and 88 feet NAVD88 about 200 feet downstream of the upstream end of the segment. The levee height varies between 19 and 25 feet, with an average height of 22 feet. The crest width varies between 15 and 22 feet. The waterside slope varies between 2H:1V and 3.5H:1V. The landside slope varies between 1.8H:1V and 3.1H:1V. The waterside bench between the levee toe and the riverbank varies from about 30 to 4,500 feet wide.

The levee soils consist of sandy silt, sandy clay, and clay with occasional zones of silty sand downstream of Star Bend (PLM 0.00 to 5.7) and sand, silty sand, and clayey sand with some zones of sandy silt and sandy clay upstream of Star Bend. The foundation soils are highly variable and consist of a clay, sandy clay and sandy silt blanket between 2 and 62 feet in thickness. Occasional, discontinuous zones of the blanket are cemented into hardpan. The blanket layer overlies a sand and gravel pervious layer that is up to 45 feet thick.

Relief wells were installed by USACE in 1955-1957. The City of Yuba City installed additional relief wells between the old relief wells in the southern portion of the relief well area in 1991. USACE installed new relief wells between the original relief wells in the northern portion of the relief well area in 2000. The Shanghai Bend setback levee with a 25-foot deep cutoff wall through the foundation was constructed by USACE after the 1997 flood under a PL84-99 action. A permanent stability berm was constructed by LD 1 after the 1986 flood (approximate PLM 14.00 to 15.5). After the 1997 flood USACE constructed a cutoff wall 40 to 55 feet deep between PLM 12.76 and 14.54. Riprap protection was installed near the Fifth Street Bridge in Yuba City (PLM 14.27 to 14.57) after the 1997 flood. USACE installed relief wells just north of Star Bend (PLM 4.56 to 5.42) after the 1997 flood. LD 1 constructed a setback levee with a 40 to 65-foot deep soil-bentonite cutoff wall through the foundation in 2008 at Star Bend (PLM 3.76 to 4.58). The without–project-condition assumes Star Bend setback levee was not constructed. At PLM 1.5, USACE constructed a stability berm under a PL84-99 rehabilitation action after the 1997 flood.

3.2.3 Feather River West Levee – LD 9

The LD 9 segment extends north (upstream) along the right bank of the Feather River from PLM 0.00 at the upstream end of the LD 1 segment to PLM 6.24 at the downstream end of the MA 16 segment.

The levee crest elevation varies between 83 feet NAVD88 at the downstream end and 91 feet NAVD88 near the upstream end of the segment. The levee height varies between 11 and 21 feet, with an average height of 19 feet. The crest width varies between 16 and 25 feet. The waterside slope varies between 1.9H:1V and 3H:1V. The landside slope varies between 1.4H:1V and 2.6H:1V. The SBMC (about 30 feet wide at the bottom and between 5 and 8 feet deep) is adjacent to the landside levee toe over a portion of this segment. Smaller, localized drainage ditches are at the landside levee toe in some areas where the SBMC is not adjacent to the toe. Width of the waterside bench between the levee toe and the riverbank varies between 5 and 3,800 feet.

The levee soils consist of silt, sandy silt, and sandy lean clay with occasional silty sand. The clay soils predominate at the downstream end of the segment and the silty and sandy soils predominate towards the upstream end of the segment. The foundation soils consist of a sandy clay/sandy silt blanket of variable thickness (average thickness 12 feet), sometimes cemented into a hardpan, overlying a sand/silty sand pervious layer. The pervious layer has some gravel lenses in the downstream half of the segment.

An active railroad embankment crosses the levee alignment at the LD1/LD 9 boundary. The railroad embankment is about 4 feet lower than the levee. This opening is sandbagged during flood events. Trench drains were placed at the landside levee toe between PLM 3.0 and 3.83 and between PLM 4.33 and 4.9 by LD 9 in 1992. The trenches were 4-5 feet deep and 2 feet wide and consisted of a geotextile lining around drain rock, with a perforated PVC pipe near the bottom of the trench. USACE constructed a toe drain with a concrete V-ditch collector between PLM 2.43 and 2.59 in 1998.

3.2.4 Feather River West Levee – MA 16

The MA 16 segment extends north (upstream) along the right bank of the Feather River from PLM 0.00 at the upstream end of the LD 9 segment to PLM 4.09 at the downstream end of the MA 7 segment.

The levee crest elevation varies between 91 feet NAVD88 at the downstream end to 96 feet NAVD at the upstream end. The levee height varies between 7 and 14 feet, with an average height of 10 feet. The crest width varies between 15 and 25 feet. The waterside slope varies between 1.9H:1V and 3.2H:1V. The landside slope varies between 1.3H:1V and 3H:1V. The SBMC is adjacent to the landside levee toe over a portion of this segment. The waterside bench between the levee toe and the riverbank varies between 30 and 3,100 feet wide.

The levee soils consist mostly of sandy silt, with some zones of sandy clay. The foundation consists of a clay/sandy silt blanket, at some locations cemented into hardpan, between 0 and 50 feet thick (average thickness about 20 feet) overlying a pervious sand layer. The pervious layer contains gravel in the upstream half of the segment.

3.2.5 Feather River West Levee – MA 7

The MA 7 segment extends north (upstream) along the right bank of the Feather River from PLM 0.00 at the upstream end of the MA 16 segment to PLM 12.07 at the downstream end of the Hamilton Bend segment.

The levee crest elevation varies between 96 feet NAVD88 at the downstream end and 135 feet NAVD88 at the upstream end. The levee height varies between 5 and 22 feet, with an average height of 15 feet. The crest width varies between 15 and 25 feet. The waterside slope varies between 1.9H:1V and 3.2H:1V. The landside slope varies between 1.3H:1V and 3H:1V. The SBMC is adjacent to the landside levee toe over a portion of this segment. The waterside bench between the levee toe and the riverbank varies between 5 and 4,800 feet wide.

The levee soils consist mostly of sandy silt, with some zones of sandy clay and occasional lenses of sand. The foundation consists of a blanket of clay/sandy clay in the southern portion of the segment and silt/silty sand in the northern portion of the segment. Thickness of the blanket varies between 0 and greater than 80 feet; the average thickness is about 15 feet, and in general the thickness decreases moving upstream along the segment. The pervious layer consists of sand and gravel. The pervious layer is almost entirely gravel upstream of PLM 3.2. Dredge tailings, consisting primarily of cobbles and gravel, have been placed on the waterside bench over the upstream 4 miles of the segment.

USACE constructed a 50-foot deep cutoff wall between PLM 2.68 and 2.82 after the 1986 flood.

3.2.6 Feather River West Levee – Hamilton Bend Area

The Hamilton Bend segment extends north (upstream) along the right bank of the Feather River from PLM 0.00 at the upstream end of the MA 7 segment to PLM 1.20 at the Thermalito Afterbay outlet channel.

The levee crest elevation varies between 134 feet NAVD88 at the downstream end and 139 feet NAVD88 at the upstream end. The levee height varies between 3 and 24 feet, with an average height of 14 feet. The crest width is 15-20 feet upstream of the headgate structure and 60-70 feet downstream of the headgate structure. The waterside slope varies between 2H:1V and 2.5H:1V. The landside slope varies between 1.5H:1V and 3H:1V. The waterside bench between the levee toe and the riverbank varies between 50 and 1,100 feet wide.

The levee is constructed of clay upstream of the headgate structure and silty sand, gravel, and cobbles (dredge tailings) downstream of the headgate structure. There is a thin clay blanket underlying less than half of this levee segment. The pervious layer consists of silty sand, gravel, and cobbles (dredge tailings) about 80 feet thick. The downstream 0.8 miles of the segment was built through dredge tailings piles. The dredge tailings consist of silty sand, gravel, and cobbles and are higher than the levee crest elevation at some locations.

The SBMC crosses the levee alignment at PLM 1.05-1.06. A concrete headgate structure was built across the canal alignment. The headgate structure is 36 feet tall, 50 feet long, and 13.5 feet wide. The headgate structure was abandoned after construction of the upstream Oroville Dam in 1968. The SBMC headgate structure's crest elevation is lower than the crest elevation of the adjacent levee.

3.2.7 Sutter Bypass East Levee

3.2.7.1 Downstream of Wadsworth Canal

The Sutter Bypass levee extends from the confluence with the Wadsworth Canal left bank levee at PLM 4.4 to the south (downstream) along the left bank of the Sutter Bypass to the confluence with the Feather River right bank levee at PLM 22.12.

The levee crest elevation varies from 52 feet NAVD88 at the downstream end to 60 feet NAVD88 at the upstream end. The levee height varies between 14 and 22 feet with an average height of 19 feet. The crest width varies between 17 and 30 feet. The waterside slope varies between 3H:1V and 4H:1V and the landside slope varies between 2.7H:1V and 4H:1V.

The levee soils consist mostly of lean and fat clays with occasional lenses of silt, sand, and silty sand up to 4 feet thick. Subsurface soil conditions are variable over the Bypass alignment, due to the geomorphology of the levee alignment cutting across numerous historic small drainage channels at approximately 90 degree angles. The foundation consists of a clay blanket 10-60 feet thick, with the layer thickness generally lower towards the downstream end of the segment. A portion of the clay blanket is cemented at some locations, locally called "hardpan". There are pockets of sand and silty sand within the clay blanket, varying between 4 and 20 feet thick. The top of some of these pockets is 6 feet below the top of the impervious blanket layer. A widespread sand, silty sand, and gravel layer is underneath the clay blanket.

There is a 1-foot high, 50-foot wide berm at the landside levee toe, with a drainage ditch located at the toe of the berm over most of this segment. In addition, in this area USACE has previously constructed:

- A 2-foot wide, 15-foot deep toe drain trench between PLM 5.4 and 13 (McClatchy Road to Gilsizer Slough) after the 1958 flood.
- A pervious toe drain and overlying stability berm between PLM 12.7 and 14.6 (Gilsizer Slough to Everglade Road) after the 1986 flood.

- A toe drain trench and berm between PLM 4.4 and 5.4 (Wadsworth Canal to McClatchy Road) after the 1997 flood.

- A 2-foot wide, 5-foot deep pervious toe trench with an overlying stability berm at PLM 17.6 in 2001.

- A pervious vertical drain in an abandoned railroad embankment on the landside of the levee between PLM 21.88 and 22.07 (Feather River confluence to 1,000 feet upstream) in 2001.

3.2.7.2 Upstream of Wadsworth Canal

This levee segment extends along the right bank of the Sutter Bypass from PLM 0.00 at high ground at the Sutter Buttes to the southeast (downstream) to the confluence of the right bank levee of the Wadsworth Canal at PLM 4.31.

The levee height varies between 15 feet at the upstream end and 23 feet at the downstream end. The crest width is 20 feet. The waterside slope varies between 3.5H:1V and 4H:1V and the landside slope varies between 2.5H:1V to 3H:1V.

There are no existing soil explorations on this levee segment

A project pump plant at PLM 2.7 pumps interior drainage water over the levee into the Bypass There is also a drainage canal on the landside of the levee. The canal is located 15 to 50 feet from the landside toe and is about 5 feet deep and 12 feet wide at the bottom. USACE constructed a pervious toe drain and overlying stability berm between PLM 3.7 to 4.3 after the 1997 flood.

3.2.8 Wadsworth Canal Levees

3.2.8.1 East (Left) Levee

The left levee of the Wadsworth Canal extends to the northeast (upstream) from PLM 0.00 at the confluence with the Sutter Bypass to PLM 4.66 at the East Interceptor Canal.

The levee crest elevation varies between 60 feet NAVD88 at the downstream end to 65 feet NAVD88 at the upstream end. The levee height varies between 6 feet at the upstream end and 26 feet at the downstream end. The crest width varies between 12 feet at the upstream end and 27 feet at the downstream end. The waterside slope varies between 3H:1V and 3.5H:1V. The landside slope varies between 2H:1V and 2.5H:1V. There is a relatively flat bench 10 to 35 feet wide between the waterside levee toe and the excavated canal sideslopes.

The levee soils consist of interbedded lean clay, fat clay, sand, and silty sand. Sand and silty sand are the dominant soils over the downstream 1.4 miles of the levee segment. Clay soils dominate in the upstream 3.3 miles of the levee. The levee is founded on Basin deposits, generally 4 to 9 feet thick, consisting mostly of lean and fat clay with occasional lenses of silt

and sand. The Modesto Formation underlies the Basin deposits. The upper contact of the Modesto Formation is characterized by very stiff to hard clays, called "hardpan" locally. Below the hardpan, the Modesto Formation consists of silt, lean clay, and fat clay, with 1 to 9 foot thick layers of sand and silty sand.

USACE constructed a soil-cement-bentonite cutoff wall between PLM 0.00 and PLM 0.57 in 2008. The depth of the cutoff wall varied between 42 and 63 feet.

3.2.8.2 West (Right) Levee

This levee segment extends from PLM 0.00 at the confluence with the right bank levee of the Sutter Bypass to the northeast (upstream) along the right bank of the Wadsworth Canal to PLM 4.66 at the West Interceptor Canal.

The levee height varies between 20 feet at the downstream end to 5 feet at the upstream end. The crest width is 10-20 feet. The waterside slope varies between 3H:1V and 3.5H:1V. The landside slope varies between 2H:1V and 2.5H:1V.

There are no known soil explorations in this levee segment. Since the canal is fairly small (about 300 feet from levee crest centerline to levee crest centerline), it is anticipated that soil conditions along the west bank levee would be similar to the left bank levee of the Wadsworth Canal.

A small drainage canal is located at the landside levee toe over most of this segment.

3.2.9 Cherokee Canal East Levee – MA 13

The Cherokee Canal is located in the northwest portion of the project area. The Canal discharges water into the Butte Sink, a low-lying area between the Sacramento River and the Sutter Buttes. The entire canal is 23.1 miles long. The SBFS only includes the left bank levee from PLM 9.90 at the Southern Pacific Railroad bridge to the northeast (upstream) to PLM 6.10 at the Western Canal confluence.

The levee height is 6-10 feet and the crest width is 10-20 feet. The waterside slope varies between 3H:1V and 3.5H:1V and the landside slope varies between 2.5H:1V and 3H:1V.

The levee is constructed of lean and fat clay, silt, and elastic silt. The foundation soils consist of a silt and sandy silt blanket between 3 and 19 feet thick, overlying a pervious layer of silty sand, clayey sand, and clean sand. Where the pervious layer consists of clean sand, it generally contains silt lenses that are 2-4 feet thick.

An irrigation ditch is present at the landside toe.

CHAPTER 4 – ALTERNATIVE SB-7

4.1 General

Alternative SB-7 includes 21 reaches (2A-North to 21) along the FRWL alignment, beginning at station 180+00 (approximately 2,000 feet south of Laurel Avenue) and ending at station 1433+83 (Sunset Weir/Pumping Plant). The levee reaches are shown on Table 4-2 and Plates 2-2 (for Alternative SB-7).

The following Paragraphs describe the project features and measures proposed for this alternative. The proposed project features and measures for this alternative include:

- Soil-Bentonite Cutoff Walls
- Deep Soil Mix Cutoff Walls
- Jet Grouting Cutoff Walls
- Seepage Berms
- Levee Relocations
- Canal Relocations
- Embankment Reconstruction/Landside Toe Fill
- Seepage Interceptor System (Relief Wells, Drain Ditch and Pump Station)
- Erosion Protections
- Closure Structure
- Utility Improvements
- Utility Relocations
- Structural Relocations

These proposed features and measures will rehabilitate, replace, or tie in and function in junction with the existing system. The existing system (see Chapter 3) includes the following features:

- Existing Embankment
- Existing Cutoff Walls
- Existing Stability Berms
- Existing Seepage Interceptor System (Relief Wells, Drain Ditch and Pump Station)
- Existing Relief Wells
- Existing Closure Structures
- Existing Toe Drains

Table 4-1A and 4-1B and Plate 2-3 summarize different combinations of the existing and proposed features for Alternative SB8 along its alignment. See the Engineering Plan drawings for more details.

4.2 Feature Description

This section provides general descriptions for each of the combinations listed in Table 4-1. Refer to Table 4-2 and Plates G-1 and G-2 for levee improvements. Refer to Table 4-3 and Plate G-3 for utility improvements.

4.2.1 No Modification Required

There are 4 levee sections along the FRWL alignment in SB-7 where modification is not required. These sections are between: (1) 831+50 and 844+50, (2) 923+75 and 1006+24, (3) 1007+70 and 1024+00, and (4) 1027+50 and 1078+00, approximately (see Table 4-2 for more details). Existing cutoff walls (30 to 50 feet in depth) are present within the first four levee sections.

4.2.2 Cutoff Wall Only

There are 7 levee sections along the FRWL alignment in SB7 where cutoff wall is the only modification feature required. These sections are between: (1) 231+00 and 453+00, (2) 478+68 and 512+00, (3) 570+00 and 831+50, (4) 1078+00 and 1096+00, (5) 1098+10 and 1107+00, (6) 1125+70 and 1129+99, and (7) 1130+20 and 1429+00, approximately (see Table 4-2 for more details).

4.2.3 Jet Grouting Cutoff Wall Only

There are 3 levee sections along the FRWL alignment in Alternative SB-7 where jet grouting cutoff wall is the only modification feature required. These levee sections are between: (1) 1006+04 and 1007+90, (2) 1095+80 and 1098+30, and (3) 1129+50 and 1130+67, approximately (see Table 4-2 for more details).

4.2.4 Seepage Berm Only

There is 1 levee section along the FRWL alignment in Alternative SB-7 where seepage berm is the only modification feature required. These levee sections are between: (1) 1024+00 and 1027+50, approximately (see Table 4-2 for more details).

4.2.5 Cutoff Wall with Full Levee Degrade and Relief Wells

The levee section between 844+50 and 897+50 along the FRWL alignment will be fully degraded and reconstructed with a cutoff wall along the levee centerline. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 52 relief wells, drain ditch and pump stations).

4.2.6 Cutoff Wall with Relief Wells

A cutoff wall is required for the area between station 512+00 and station 570+00. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 24 relief wells, A drainage ditch, and pump stations) between station 512+00 and station 545+00. New seepage collector system (including 22 relief wells and a 2,500-foot long concrete lined V-ditch) will be installed between station 545+00 and station 570+00 at 120-foot interval. The new seepage interceptor system will be tied in with the existing one at station 545+00.

A cutoff wall is also required for the area between station 897+50 and station 923+75. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 24 relief wells, drain ditch and pump stations).

4.2.7 Cutoff Wall with Seepage Berm

There are 2 levee sections where both a cutoff wall and a seepage berm are required. These levee sections are approximately between: (1) 180+00 and 231+00, and (2) 453+00 and 478+68 (see Table 4-2 for more details).

4.2.8 Cutoff Wall with Levee Relocation

None of the levee sections within the limit of Alternative SB-7 requires levee relocation.

4.2.9 Cutoff Wall with Canal Relocation

The SBMC will be relocated away from the existing levee toe between 1429+00 and 1432+70. The existing canal section will be backfilled. A cutoff wall is required at this location and will be constructed along the levee centerline.

4.2.10 Cutoff Wall with Landside Toe Fill

Cutoff wall is required for the area between 1107+00 and 1125+70. The landside toe depression in this area will be filled.

4.2.11 Soil- Bentonite versus Deep Soil Mix (DSM) Cutoff Wall

The proposed cutoff walls vary in depth along the project alignment. At locations where a cutoff wall is required (except for the jet grouting sites), the cutoff wall will be: soil bentonite cutoff wall (if the wall is less than 75 feet in depth) or DSM cutoff wall (if the wall is greater than 75 feet in depth). There are 4 levee sections along the FRWL alignment where DSM cutoff walls are required. These sections are between: (1) 230+00 and 250+00, (2) 1125+00 and 1129+99, (3) 1130+20 and 1151+50, and (4) 1224+00 and 1248+00, approximately (see Table 4-2 for more details). The wall's depth at these locations varies between 75 and 120 feet. Between 844+50 and 897+50, an 85-foot deep soil bentonite cutoff wall is considered adequate for this area.

4.2.12 Erosion Protection

An anchored HPTRM is required on the landside slope for the initial overtopping section located in reach 7 between 547+00 and 604+60 in order to increase the sections resiliency and enhance flood warning and evacuation time prior to overtopping failure from events that exceed the design event.

4.2.13 Closure Structure

Stop log closure structure or equivalent is required at station 1130+00, where the UPRR crosses the FRWL alignment.

4.2.14 Modification of Existing Utilities and Encroachments

Table 4-4B summarizes the number of utilities and encroachments to be modified by construction of Alternative SB-7. A total of 123 utility/encroachment items will be removed, modified (to meet the USACE standard for levee penetrations) or relocated outside of the proposed ROW. Refer to Table 4-3 for more detailed descriptions.

4.3 Environmental Mitigation Measures

The main report described in detail mitigation measures to avoid, minimize and compensate for environmental impacts.

A Mitigation and Monitoring Plan accompanies the main report in the environmental appendix (Appendix D). For direct effects on woody riparian trees that cannot be avoided, compensation is proposed for the loss of riparian habitat to ensure no net loss of habitat functions and values. For elderberry shrubs and riparian habitat, about 48 acres of mitigation acreage would be established at the Star Bend Conservation Area and the TRLIA Feather River Floodway Corridor Restoration Site.

4.4 Cultural Mitigation Measures

USACE negotiated a programmatic agreement (PA) with the California State Historic Preservation Officer (SHPO) that outlines the specific processes that USACE will follow to identify and treat cultural resources. The PA took effect after it was signed by USACE and the SHPO on June 8, 2012, and was subsequently transmitted to the Advisory Council on Historic Preservation.

Following the terms of the PA, before construction begins, the following will occur:

- USACE and the SHPO would formally agree upon a final area of potential effect (APE) for the project. The APE comprises the entirety of the area where cultural resources could potentially be affected by the project.
- USACE, in consultation with the SHPO, would fully inventory the APE for cultural resources. This inventory would include both the pedestrian survey efforts conducted to date by ICF, as well as subsurface prospection efforts.
- In consultation with the SHPO, USACE would evaluate all cultural resources in the APE for their eligibility for listing in the National Register of Historic Places (NRHP). Work necessary for these evaluations may include detailed recordation, background research, and test excavation.

- USACE; in consultation with the SHPO, the public, interested Native American Tribes, or other identified stakeholders; would provide adequate mitigation to resolve any adverse effects to NRHP eligible cultural resources (historic properties).

Alternative SB-7 is a subset of Alternative SB-8 and would impact fewer cultural resources. Based on available information, it is possible to anticipate that construction of Alternative SB-7 could affect known cultural resources including the levee, the historic buildings and neighborhoods in Yuba City, other built environment resources identified in the FRWLP 408 EIS/EIR, and several prehistoric archaeological sites (CA-SUT-5, CA-SUT-10, CA-SUT-20, CA-SUT-77, and the unnamed site identified by UAIC). USACE would follow the processes outlined in the PA to resolve adverse effects to these resources.

Proposed borrow areas have not yet been surveyed. The records and literature search indicates that one of the proposed borrow locations at Star Bend would impact a fourth prehistoric archaeological site, CA-BUT-17. Inventories of the remaining borrow sites, and other sites that may be defined in the future, could result in the identification of more impacts.

Any unknown cultural resources found in the course of further inventory work would be evaluated for NR eligibility, and effects to those resources would be resolved as necessary, following the processes outlined in the PA.

4.5 Borrow, Borrow Sites and Disposal Areas

Type 1, Type 2 and Random fill materials are needed for levee, cutoff wall and seepage berm constructions. Type 1 levee fill material will be used primarily as a clay core for the reconstructed levee above the cutoff wall and for the cutoff wall's soil-bentonite mix. Type 2 levee fill material will be used primarily for shells for the reconstructed levee above the cutoff wall. Random fill is used primarily for seepage berms.

Excavated materials from levee degrade are expected to be reusable for Type 1 and Type 2 fills. Type 1 fill can be used as Type 2 and Random Fill. Type 2 fill can be used as Random fill. It is expected that borrow materials will be needed for construction of the project.

The two primary types of borrow material for the levee and cutoff wall constructions are: Type 1 and Type 2. Specifications for the two material types are as follows:

- Type 1 Levee Fill: USCS classification of CL, SC, or CH and a maximum particle size of 2 inches; minimum 35% by weight passing the #200 sieve; maximum liquid limit of 60; plasticity index between 12 and 40.

- Type 2 Levee Fill: Maximum particle size of 2 inches; minimum 12% by weight passing the #200 sieve; maximum liquid limit of 45.

The borrow areas are sites 5, 7, 8 and 12 shown in Plate 4-3. The source for borrow is discussed in Paragraph 2.10.3.1. A material balance analysis was completed for borrow

quantities based on the preliminary information and the results are shown cubic yards (cy) in Tables 4-5 and 4-6.

Implementation of Alternative SB-7/SB-8 may generate up to 813,000 cubic yards of solid waste that would require disposal. Sources of solid waste related to construction activities would include levee material, structural debris from removal of residences and agricultural structures, roadway pavements, and levee material deemed unsuitable for reuse.

The nearest solid waste facilities to the project area are the Ostrom Landfill (located east of the project site, approximately 30 road miles from the southern end of the project at Reach 2) and the Neal Road Landfill (located 25 miles north of the project Reach 40).

Assuming all of the estimated 813,000 cubic yards of waste material would require permanent disposal, Alternative SB7/SB8 implementation would represent 2% of the Ostrom Road Landfill and 4% of the Neal Road Landfill remaining capacities. However, the option of beneficial reuse is likely to reduce the cubic yards of soil that require permanent disposal as discussed in paragraph 2.10.3.2 above.

4.6 Construction Access, Haul Routes and Staging Areas

Haul route will be mainly on existing public roads (see Plate 4-3).

4.7 Real Estate Requirements

A total of 27 physical structures fall within the proposed ROW and, therefore, will be demolished for construction of this alternative. All of these structures are within reach 16 (Yuba City).

Approximately 2,110 acres will be acquired and 292 parcels will be impacted (refer to the Real Estate Appendix for more details).

4.8 Operation and Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

4.8.1 Flood Damage Reduction Features

OMRR&R activities for flood control works are generally the same with and without the project. However the cost and effort associated with each activity may increase or decrease as a result of the project. These increases or decreases are considered to be roughly offsetting and net change in overall OMRR&R effort is judged to be insignificant. Expected impacts of the project on these activities are as follows:

1. Construction activities including reconstruction of the upper half of the levee, regarding of side slopes vegetation removal, rodent disruption and crown road reestablishment will reduce maintenance costs in the short term.

2. Vegetation removal/control. For the purpose of this feasibility study it is assumed that, absent the project, the State will gradually bring levees into compliance with USACE ETL 1110-2-571 using a life cycle approach to vegetation management. Under this assumption, the immediate compliance with the ETL required by the project will result in an interim increase in cost and effort required for vegetation removal and control which will be offset initially by clearing during construction. Net increase in OMRR&R cost is anticipated.

3. Rodent control/damage repair. Increase in embankment volume resulting from the addition of seepage and stability berms could result in a slight increase in rodent related maintenance activity.

4. Slope maintenance. Reduction in OMRR&R will occur due to reduction in seepage. The VFZ required by USACE ETL 1110-2-571 the project area will reduce the need for periodic levee toe regrading previously caused by farming operations.

5. Repair of waterside erosion. No additions or significant changes to erosion are anticipated.

6. Maintenance of relief wells and collection ditches. Relief wells north of Shanghai Bend will be converted to observation wells due to slurry wall taking over seepage control function. These actions result in a net reduction in OMRR&R effort.

7. Maintenance and repair of flap gates and closure structures to minimize internal drainage. A stop log closure structure for the railroad crossing at SBFCA station 1130+47, reach 17 is a project feature added to prevent over topping at this location. This accomplished without the project by sandbagging. The stop log structure will significantly reduce the effort to close this gap. However, it remains a flood control feature that requires human intervention to implement. This structure must remain functional to prevent flooding of Yuba City and vicinity.

8. Encroachments. Wet penetration encroachments will be improved or eliminated all along the length of the project. Dry encroachments, such as power poles and vegetation will be reduced. Result will be a decrease in OMRR&R costs.

9. Road/ramp maintenance. The addition of an O&M road at the toe of the levee for the entire length of the levee in addition to the existing road on the levee crown will essentially double the cost and effort associated with road maintenance. However, the added road will enhance the efficacy of virtually all OMRR&R activities including inspections, patrolling and flood fighting.

10. Inspection/patrolling including participation in Federal and State inspection programs, routine patrolling to identify maintenance needs and to assure flood worthiness, and continuous patrolling during high water conditions. The added landside O&M toe road will significantly enhance inspection and patrolling activities.

11. Flood fighting. The project flood control features (seepage berms, stability berms, and cutoff walls) are intended to eliminate seepage and stability issues during high water. The added

O&M road at the landside levee toe should dramatically improve identification of any issues that may develop during high water and facilitate their rapid repair.

4.8.2 Mitigation Features

For Alternative SB-7 an estimated 56 acres are designated for mitigation of habitat loss due to project construction. An estimated 35 acres are available at the Star Bend mitigation site. Additional mitigation needs will be accomplished with additional mitigation sites and/or mitigation bank credits. USACE will enter into a contract to preserve the plantings for a term of three years following completion of construction. At the end of this term the areas will be turned over to the local sponsor who will maintain the areas to accomplish predetermined levels of re-vegetation success targeted for 5 years from planting.

4.8.3 Estimated Annual OMRR&R Cost

The estimated cost of OMRR&R for Alternative SB-7 in 2012 dollars is $ 277,000 as compared to $ 264,000 for the same levee reaches without the project. See Table 2-3.

4.9 Cost Estimate and Construction Schedule

The total first cost for alternative SB-7 is $390,240. The estimated fully funded cost is $438,800. Details are shown in the Cost Engineering Appendix.

The project is divided into 5 construction contracts: A, B, C1, C2 and Star Bend Fix-in-place (SBFIP). Table 4-4 summarizes the extent, year of construction and project features for each of the construction contracts. For more information on construction contracts and their sequencing, refer to the Cost Engineering Appendix.

CHAPTER 5 – ALTERNATIVE SB-8

5.1 General

Alternative SB-8 includes 41 reaches (2A-North to 41) along the FRWL alignment, beginning at station 180+00 (approximately 2,000 feet south of Laurel Avenue) and ending at station 2368+00 (Thermalito Afterbay). The levee reaches are shown on Table 5-2 and Plate 2-2 (for Alternative SB-8).

The following Paragraphs describe the project features and measures proposed for this alternative. The proposed project features and measures for this alternative include:

- Soil-Bentonite Cutoff Walls
- Deep Soil Mix Cutoff Walls
- Jet Grouting Cutoff Walls
- Seepage Berms
- Levee Relocations
- Canal Relocations

- Embankment Reconstruction/Landside Toe Fill
- Seepage Interceptor System (Relief Wells, Drain Ditch and Pump Station)
- Erosion Protections
- Closure Structure
- Utility Improvements
- Utility Relocations
- Structural Relocations

These proposed features and measures will rehabilitate, replace, or tie in and function in junction with the existing system. The existing system (see chapter 3) includes the following features:

- Existing Embankment
- Existing Cutoff Walls
- Existing Stability Berms
- Existing Seepage Interceptor System (Relief Wells, Drain Ditch and Pump Station)
- Existing Relief Wells
- Existing Closure Structures
- Existing Toe Drains

Table 5-1A and 5-1B and Plate 2-3 summarize different combinations of the existing and proposed features for Alternative SB-8 along its alignment. See the engineering plan drawings for more details.

5.2 Feature Descriptions

This section provides general descriptions for each of the combinations listed in Table 5-1. Refer to Table 5-2 and Plates G-1 and G-2 for levee improvements. Refer to Table 5-3 and Plate G-3 for utility improvements.

5.2.1 No Modification Required

There are 7 levee sections along the FRWL alignment where modification is not required. These sections are between: (1) 831+50 and 844+50, (2) 923+75 and 1006+24, (3) 1007+70 and 1024+00, (4) 1027+50 and 1078+00, (5) 1625+00 and 1673+00, (6) 1769+40 and 1813+30, and (7) 2303+00 and 2331+00, approximately (see Table 5-2 for more details). Existing cutoff walls (30 to 50 feet in depth) are present within the first four levee sections.

5.2.2 Cutoff Wall Only

There are 14 levee sections along the FRWL alignment where cutoff wall is the only modification feature required. These sections are between: (1) 231+00 and 453+00, (2) 478+68 and 512+00, (3) 570+00 and 831+50, (4) 1078+00 and 1096+00, (5) 1098+10 and 1107+00, (6) 1125+70 and 1129+99, (7) 1130+20 and 1429+00, (8) 1451+50 and 1455+00, (9) 1461+00 and 1608+50, (10) 1624+70 and 1625+00, (11) 1673+00 and 1673+30, (12) 1766+00 and 1769+40,

(13) 1813+30 and 1900+50, and (14) 1903+50 and 2290+00, approximately (see Table 5-2 for more details).

5.2.3 Jet Grouting Cutoff Wall Only

There are 4 levee sections along the FRWL alignment where jet grouting cutoff wall is the only modification feature required. These levee sections are between: (1) 1006+04 and 1007+90, (2) 1095+80 and 1098+30, (3) 1129+50 and 1130+67, and (4) 1900+00 and 1904+00 approximately (see Table 5-2 for more details).

5.2.4 Seepage Berm Only

There are 3 levee sections along the FRWL alignment where seepage berm is the only modification feature required. These levee sections are between: (1) 1024+00 and 1027+50, (2) 2290+00 and 2303+00, and (3) 2331+00 and 2368+00, approximately (see Table 5-2 for more details).

5.2.5 Cutoff Wall with Full Levee Degrade and Relief Wells

There are 2 levee sections along the FRWL alignment where the levee will be fully degraded and reconstructed with a cutoff wall along the levee centerline These levee sections area between: (1) 844+50 and 897+50, and (2) 1455+00 and 1461+00.

The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 52 relief wells, a drainage ditch and pump stations) between station 844+50 and station 897+50.

5.2.6 Cutoff Wall with Relief Wells

Cutoff wall is required for the area between station 512+00 and station 570+00. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 24 relief wells, a drainage ditch and pump stations) between station 512+00 and station 545+00. A new seepage collector system (including 22 relief wells and a 2,500-foot long concrete lined V-ditch) will be installed between station 545+00 and station 570+00 at 120-foot interval. The new seepage interceptor system will be tied in with the existing one at station 545+00.

A cutoff wall is also required for the area between station 897+50 and station 923+75. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 24 relief wells, drain ditch and pump stations).

5.2.7 Cutoff Wall with Seepage Berm

There are 2 levee sections where both a cutoff wall and a seepage berm are required. These levee sections are between: (1) 180+00 and 231+00, and (2) 453+00 and 478+68, approximately (see Table 5-2 for more details).

5.2.8 Cutoff Wall with Levee Relocation

The existing levee will be relocated 20 feet toward the river at three locations, between: (1) 1432+70 and 1451+50, (2) 1608+50 and 1624+70, and (3) 1673+30 and 1754+30. A cutoff wall is required at these locations and will be constructed along the relocated levee alignment.

5.2.9 Cutoff Wall with Canal Relocation

The SBMC will be relocated away from the existing levee toe at two locations: (1) between 1429+00 and 1432+70, and (2) between 1754+30 and 1766+00. The existing canal sections will be backfilled. A cutoff wall is required at these locations and will be constructed along the levee centerline.

5.2.10 Cutoff Wall with Landside Toe Fill

A cutoff wall is required for the area between 1107+00 and 1125+70. The landside toe depression in this area will be filled.

5.2.11 Soil- Bentonite versus Deep Soil Mix (DSM) Cutoff Wall

The proposed cutoff walls vary in depth along the project alignment. At locations where a cutoff wall is the required (except for the jet grouting sites), the cutoff wall will be: soil bentonite cutoff wall (if the wall is less than 75 feet in depth) or DSM cutoff wall (if the wall is greater than 75 feet in depth). There are 10 levee sections along the FRWL alignment where DSM cutoff walls are required. These sections are between: (1) 230+00 and 250+00, (2) 1125+00 and 1129+99, (3) 1130+20 and 1151+50, (4) 1224+00 and 1248+00, (5) 1987+25 and 2002+00, (6) 2016+75 and 2036+75, (7) 2067+00 and 2088+00, (8) 2137+00 and 2148+00, (9) 2182+00 and 2196+50, (10) 2245+75 and 2292+00, approximately (see Table 5-2 for more details). The wall's depth at these locations will vary between 75 and 120 feet. Between 844+50 and 897+50, an 85-foot deep soil bentonite cutoff wall is considered adequate for this area.

5.2.12 Erosion Protection

An anchored HPTRM is required on the landside slope for two initial overtopping levee sections located in reaches 7 and 23 between: (1) 547+00 and 604+60, and (2) 1582+00 and 1601+00 to increase the sections' resiliency and enhance flood warning and evacuation time prior to overtopping failure from events that exceed the design event.

5.2.13 Closure Structure

A stop log closure structure or equivalent is required at station 1130+00, where the UPRR crosses the FRWL alignment.

5.2.14 Modification of Existing Utilities and Encroachments

Table 5-4B summarizes the number of utilities and encroachments to be modified by construction of Alternative SB-8. A total of 223 utility/encroachment items will be removed, modified (to meet the USACE standard for levee penetrations) or relocated outside of the proposed ROW. Refer to able 5-3 for more detailed descriptions.

5.3 Environmental Mitigation Measures

As described for SB-7, the main report described in detail mitigation measures to avoid, minimize and compensate for environmental impacts.

SB-8 would have similar impacts as SB-7 but would result in a greater loss of riparian habitat and impact on listed species. A Mitigation and Monitoring Plan accompanies the main report in the environmental appendix (Appendix D). For direct effects on woody riparian trees that cannot be avoided, compensation is proposed for the loss of riparian habitat to ensure no net loss of habitat functions and values. For elderberry shrubs and riparian habitat, about 88 acres of mitigation acreage would be established at the Star Bend Conservation Area and the TRLIA Feather River Floodway Corridor Restoration Site.

For the loss of jurisdictional wetlands and giant garter snake habitat, compensation would be provide by the purchase of credits from local mitigation banks as described in the Mitigation and Monitoring Plan.

5.4 Cultural Mitigation Measures

USACE negotiated a programmatic agreement (PA) with the California State Historic Preservation Officer (SHPO) that outlines the specific processes that USACE will follow to identify and treat cultural resources. The PA took effect after it was signed by USACE and the SHPO on June 8, 2012, and was subsequently transmitted to the Advisory Council on Historic Preservation.

Following the terms of the PA, before construction begins, the following will occur:

- USACE and the SHPO would formally agree upon a final area APE for the project. The APE comprises the entirety of the area where cultural resources could potentially be affected by the project.
- USACE, in consultation with the SHPO, would fully inventory the APE for cultural resources. This inventory would include both the pedestrian survey efforts conducted to date by ICF, as well as subsurface prospection efforts.
- In consultation with the SHPO, USACE would evaluate all cultural resources in the APE for their eligibility for listing in the National Register of Historic Places (NRHP). Work necessary for these evaluations may include detailed recordation, background research, and subsurface test excavations.

- USACE; in consultation with the SHPO, the public, interested Native American Tribes, or other identified stakeholders; would provide adequate mitigation to resolve any unavoidable adverse effects to NRHP eligible cultural resources (historic properties).

Alternative SB-8 could result in impacts to the levee itself, the Sutter Butte Canal, historic buildings and neighborhoods in Yuba City, other built environment resources identified in the FRWLP EIS/EIR, and several known prehistoric archaeological sites (CA-SUT-5, CA-SUT-10, CA-SUT-20, CA-SUT-77, CA-BUT-52, CA-BUT-53, CA-BUT-496, CA-BUT-1123, and the unnamed site identified by UAIC). USACE would follow the processes outlined in the PA to resolve adverse effects to these resources.

Proposed borrow areas have not yet been surveyed. Inventories of the borrow sites, utility relocations, and other sites that may be defined in the future, could result in the identification of more impacts.

Any unknown cultural resources found in the course of further inventory work or during construction would be evaluated for NR eligibility, and effects to those resources would be resolved as necessary, following the processes outlined in the PA.

5.5 Fill, Borrow, Borrow Sites and Disposal Areas

Type 1, Type 2 and Random fill materials are needed for levee, cutoff wall and seepage berm constructions. Type 1 levee fill material will be used primarily as a clay core for the reconstructed levee above the cutoff wall and for the cutoff wall's soil-bentonite mix. Type 2 levee fill material will be used primarily for shells for the reconstructed levee above the cutoff wall. Random fill is used primarily for seepage berms.

Excavated materials from levee degrade are expected to be reusable for Type 1 and Type 2 fills. Type 1 fill can be used as Type 2 and Random Fill. Type 2 fill can be used as Random fill. It is expected that borrow materials will be needed for construction of the project.

The two primary types of borrow material for the levee and cutoff wall constructions are: Type 1 and Type 2. Specifications for the two material types (see Paragraph 2.4.4.3) are as follows:

- Type 1 Levee Fill: USCS classification of CL, SC, or CH and maximum particle size of 2 inches; minimum 35% by weight passing the #200 sieve; maximum liquid limit of 60; plasticity index between 12 and 40.

- Type 2 Levee Fill: Maximum particle size of 2 inches; minimum 12% by weight passing the #200 sieve; maximum liquid limit of 45.

The borrow areas are sites 2 to 5, 7, 8, 11 and 12 shown in Plate 5-3. Source for borrow is discussed in Paragraph 2.6. A material balance analysis was completed for borrow quantities based on the preliminary information and the results are show in Tables 5-5 and 5-6.

Implementation of Alternative SB-7/SB-8 may generate up to 813,000 cubic yards of solid waste that would require disposal. Sources of solid waste related to construction activities would include levee material, structural debris from removal of residences and agricultural structures, roadway pavements, and levee material deemed unsuitable for reuse.

The nearest solid waste facilities to the project area are the Ostrom Landfill (located east of the project site, approximately 30 road miles from the southern end of the project at Reach 2) and the Neal Road Landfill (located 25 miles north of the project Reach 40).

Assuming all of the estimated 813,000 cubic yards of waste material would require permanent disposal, Alternative SB7/SB8 implementation would represent 2% of the Ostrom Road Landfill and 4% of the Neal Road Landfill remaining capacities. However, the option of beneficial reuse is likely to reduce the cubic yards of soil that require permanent disposal as discussed in paragraph 2.10.3.2 above.

5.6 Construction Access, Haul Routes and Staging Areas

Haul route will be mainly on existing public roads (see Plate 5-3).

5.7 Real Estate Requirements

A total of 34 physical structures fall within the proposed ROW and, therefore, will be demolished for construction of this alternative. 27 of these structures are within reach 16 (Yuba City). The remaining structures are in reaches 26 to 31.

Approximately 2,196 acres will be acquired and 468 parcels will be impacted (refer to Real Estate Appendix for more details).

5.8 Operation and Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

5.8.1 Flood Damage Reduction Features

OMRR&R Activities for flood control works are generally the same with and without the project. However the cost and effort associated with each activity may increase or decrease as a result of the project. These increases or decreases are considered to be roughly offsetting and net change in overall OMRR&R effort is judged to be insignificant. Expected impacts of the project on these activities are as follows:

1. Construction activities including reconstruction of the upper half of the levee, regrading of side slopes vegetation removal, rodent disruption and crown road reestablishment will reduce maintenance costs in the short term.

2. Vegetation removal/control. For the purpose of this feasibility study it is assumed that, absent the project, the State will gradually bring levees into compliance with USACE ETL 1110-2-571 using a life cycle approach to vegetation management. Under this assumption, the immediate compliance with the ETL required by the project will result in an interim increase in

cost and effort required for vegetation removal and control (Offset initially by clearing during construction). Net increase in OMRR&R cost anticipated.

3. Rodent control/damage repair. Increase in embankment volume resulting from the addition of seepage and stability berms could result in a slight increase in rodent related maintenance activity.

4. Slope maintenance. Reduction in OMRR&R will occur due to reduction in seepage. The VFZ required by USACE ETL 1110-2-571 for the project area will reduce the need for periodic levee toe regrading previously caused by farming operations.

5. Repair of waterside erosion. No additions. No significant change.

6. Encroachments. Wet penetration encroachments will be improved or eliminated throughout the length of the project. Dry encroachments, such as power poles and vegetation will be reduced. The result will be a decrease in OMRR&R costs.

7. Road/ramp maintenance. The addition of an O&M road at the toe of the levee for the entire length of the levee in addition to the existing road on the levee crown will essentially double the cost and effort associated with road maintenance. However, the added road will enhance the efficacy of virtually all OMRR&R activities including inspections, patrolling and flood fighting.

8. Encroachments. Wet penetration encroachments will be improved or eliminated all along the length of the project. Dry encroachments, such as power poles and vegetation will be reduced. Result will be decrease in OMRR&R costs.

9. Road/ramp maintenance. The addition of an O&M road at the toe of the levee for the entire length of the levee in addition to the existing road on the levee crown will essentially double the cost and effort associated with road maintenance. However, the added road will enhance the efficacy of virtually all OMRR&R activities including inspections, patrolling and flood fighting.

10. Inspection/patrolling including participation in Federal and State inspection programs, routine patrolling to identify maintenance needs and to assure flood worthiness, and continuous patrolling during high water conditions. The added landside O&M toe road will significantly enhance inspection and patrolling activities.

11. Flood fighting. The project flood control features (seepage berms, stability berms, and cutoff walls) are intended to eliminate seepage and stability issues during high water. The added O&M road at the landside levee toe should dramatically improve identification of any issues that may develop during high water and facilitate their rapid repair.

5.8.2 Mitigation Features

For Alternative SB-8 an estimated 90 acres are designated for mitigation of habitat loss due to project construction. An estimated 35 acres are available at the Star Bend mitigation site. Additional mitigation needs will be accomplished with additional mitigation sites and/or mitigation bank credits. USACE will enter into a contract to preserve the plantings for a term of three years following completion of construction. At the end of this term the areas will be turned over to the local sponsor who will maintain the areas to accomplish predetermined levels of re-vegetation success targeted for 5 years from planting.

5.8.3 Estimated Annual OMRR&R Cost

The estimated cost of OMRR&R for Alternative SB-8 in 2012 dollars is $ 454,000 as compared to $ 432,000 for the same levee reaches without the Project. See Table 2-3.

5.9 Cost Estimate and Construction Schedule

The total first cost for alternative SB-8 is $694,010. The estimated fully funded cost is $797,700. Details are shown in the Cost Engineering Appendix.

The project is divided into 7 construction contracts those are A, B, C1, C2, D1, D2 and Star Bend Fix-in-place (SBFIP). Table 5-4 summarizes the extent, year of construction and project features for each of the construction contracts. For more information on construction contracts and their sequencing, refer to the Cost Engineering Appendix.

TABLES

Table 2-1 1957 Design Flows compared to Regulated Peak Flows

Stream and Reach	1957 Authorized Design Flow (CFS)	Regulated Peak Flows (CFS)						
		50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Sacramento River								
Colusa to Tisdale Weir	66,000	44,000	48,000	50,000	53,000	55,000	59,000	68,000
Tisdale Weir to Sutter Bypass	30,000	28,000	30,000	31,000	32,000	34,000	36,000	41,000
Feather River								
Oroville to Honcut Creek	210,000	60,000	100,000	150,000	150,000	150,000	174,000	320,400
Honcut Creek to Yuba River	210,000	49,000	107,000	157,000	159,600	163,000	182,000	293,600
Yuba River to Bear River	300,000	71,000	192,000	256,000	281,000	283,000	360,000	534,000
Bear River to Sutter Bypass	320,000	78,000	211,000	288,000	321,000	336,000	409,000	574,000
Sutter Bypass								
Meridian to Wadsworth Canal	150,000	57,000	102,000	126,000	155,000	184,000	228,000	327,000
Wadsworth Canal to Tisdale Weir	155,000	58,000	103,000	127,000	156,000	185,000	229,000	327,000
Tisdale Weir to Feather River	180,000	71,000	117,000	141,000	163,000	197,000	237,000	329,000
Feather River to Sacramento River	380,000	141,000	283,000	393,000	436,000	490,000	581,000	799,000
Wadsworth Canal								
Tributary Specific Storm Centering	1,500	820	2,550	3,200	3,980	4,830	5,750	7,070
Cherokee Canal								
Nelson Shipee Road to Western Canal	8,500							
Western Canal to Afton Road	11,500	6,000	10,300	12,100	13,200	14,300	15,200	16,300
Afton Road to Gridley – Colusa Road	12,500							

Table 2-2 Percentages of Levee Degrade Suitable for Levee Fill

Reach ID	Percentage for Levee Core (Type 1)	Fraction	Percentage for Levee Shell (Type 2)	Fraction
2A-North	5	0.05	95	0.95
2B	5	0.05	95	0.95
3	5	0.05	95	0.95
4	5	0.05	95	0.95
5	5	0.05	95	0.95
6	5	0.05	95	0.95
7	40	0.4	60	0.6
8	0	0	85	0.85
9	0	0	55	0.55
10	0	0	70	0.7
11	0	0	100	1
12	NA	NA	NA	NA
13	0	0	95	0.95
14	NA	NA	NA	NA
15	NA	NA	NA	NA
16	NA	NA	NA	NA
17	0	0	100	1
18	15	0.15	85	0.85
19	30	0.3	70	0.7
20	0	0	100	1
21	0	0	100	1
22	15	0.15	85	0.85
23	0	0	90	0.9
24	0	0	100	1
25	0	0	100	1
26	0	0	100	1
27	80	0.8	20	0.2
28	15	0.15	85	0.85
29	NA	NA	NA	NA
30	0	0	95	0.95
31	30	0.3	70	0.7
32	0	0	100	1
33	0	0	100	1
34	0	0	100	1
35	0	0	100	1
36	0	0	100	1
37	0	0	100	1
38	0	0	100	1
39	NA	NA	NA	NA
40	60	0.6	0	0
41	60	0.6	0	0

Table 2-3 OMRR&R Cost Estimates

Alternative	W/O Project	With Project	Difference (Increase)
SB-7	$ 264,000	$ 277,000	$ 13,000
SB-8	$ 432,000	$ 454,000	$ 22,000

Table 4-1A Summary of Project Features for Alternative SB-7

	Feature Description	Quantity
Alternative SB7 Reach 2A-North to 21 180+00 to 1433+83 2017 - 2021	No Modification Required	16,230LF
	Cutoff Wall Only	84,700LF
	Jet Grouting Cutoff Wall Only	560LF
	Seepage Berm Only	350LF
	Cutoff Wall with Full Levee Degrade and Existing Relief Wells	5,300LF
	Cutoff Wall with Full Levee Degrade	N/A
	Cutoff Wall with Existing Relief Wells	5,930LF
	Cutoff Wall with New Relief Wells (22 Wells)	2,500LF
	Cutoff Wall with Seepage Berm	7,670LF
	Cutoff Wall with Levee Relocation	N/A
	Cutoff Wall with Sutter Butte Canal Relocation	370LF
	Cutoff Wall with Landside Toe Fill	1,870LF
	DSM Cutoff Wall (subpart of the Cutoff Wall Only area)	7,030LF
	Erosion Protection	5,760LF
	Utilities and Encroachments (Total)	269
	Utilities and Encroachments (To be modified)	123
	Land Acquisition	2,110AC
	Impacted parcels	292
	Potential structural demolitions	27
	Closure Structures (stop logs)	1

Table 4-1B Summary of Project Features for Alternative SB7

Engineering Appendix Paragraph	Measure	Typical Section (Plate)	Segment	Contract	Beg. STA of Measure	End. STA of Measure	Length per Segment (LF)	Length per Contract (LF)	Length per Measure (LF)
4.2.1	No Rehabilitation Required	-	1	B	831+50	844+50	1,300	1,300	
	No Rehabilitation Required	-	2	C1	923+75	1006+24	8,249		
	No Rehabilitation Required	-	3	C1	1007+70	1024+00	1,630		
	No Rehabilitation Required	-	4	C1	1027+50	1078+00	5,050	14,930	16,230
4.2.2	Cutoff Wall Only	G-2A	1	A	231+00	453+00	22,200	22,200	
	Cutoff Wall Only	G-2A	2	SBFIP	478+68	512+00	3,332	3,340	
	Cutoff Wall Only	G-2A	3	B	570+00	831+50	26,150	26,150	
	Cutoff Wall Only	G-2A	4	C1	1078+00	1096+00	1,800		
	Cutoff Wall Only	G-2A	5	C1	1098+10	1107+00	890		
	Cutoff Wall Only	G-2A	6	C1	1125+70	1129+99	429		
	Cutoff Wall Only	G-2A	7	C1	1130+20	1213+85	8,365	11,490	
	Cutoff Wall Only	G-2A	7	C2	1213+85	1429+00	21,515	21,520	84,700
4.2.3	Jet Grouting Cutoff Wall Only	G-2A	1	C1	1006+04	1007+90	186		
	Jet Grouting Cutoff Wall Only	G-2A	2	C1	1095+80	1098+30	250		
	Jet Grouting Cutoff Wall Only	G-2A	3	C1	1129+50	1130+67	117	560	560
4.2.4	Seepage Berm Only	G-2B	1	C1	1024+00	1027+50	350	350	350
4.2.5	Cutoff Wall with Full Levee Degrade and Existing Relief Wells	G-2D	1	C1	844+50	897+50	5,300	5,300	5,300
4.2.5	Cutoff Wall with Full Levee Degrade	G-2D	-	-	0+00	0+00	0	0	0
4.2.6	Cutoff Wall with Existing Relief Wells	G-2C	1	B	512+00	545+00	3,300	3,300	
	Cutoff Wall with Existing Relief Wells	G-2C	3	C1	897+50	923+75	2,625	2,630	5,930
4.2.6	Cutoff Wall with New Relief Wells	G-2C	2	B	545+00	570+00	2,500	2,500	2,500
4.2.7	Cutoff Wall with Seepage Berm	G-2C	1	A	180+00	231+00	5,100		
	Cutoff Wall with Seepage Berm	G-2C	2	A	453+00	478+68	2,568	7,670	7,670
4.2.8	Cutoff Wall with Levee Relocation	G-2E	-	-	0+00	0+00	0	0	0
4.2.9	Cutoff Wall with Sutter Butte Canal Relocation	G-2F	1	C2	1429+00	1432+70	370	370	370
4.2.10	Cutoff Wall with Landside Toe Fill	G-2G	1	C1	1107+00	1125+70	1,870	1,870	1,870
4.2.11	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	1	A	230+00	250+00	2,000	2,000	
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	2	C1	1125+00	1129+99	499		
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	3	C1	1130+20	1151+50	2,130	2,630	
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	4	C2	1224+00	1248+00	2,400	2,400	7,030
4.2.12	Erosion Protection	-	1	B	547+00	604+60	5,760	5,760	5,760
4.2.13	Closure Structure (Stop Log)	-	1	C1	1130+00	1130+00	-	-	-

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
2A North	180+00 to 202+50	2,250	Cutoff wall with undrained seepage berm	180+00 to 202+50: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 180+00 to 202+50: Cutoff wall extending to an elevation of 25 ft.	
2B	202+50 to 218+66	1,616	Cutoff wall with undrained seepage berm	180+00 to 218+66: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 202+50 to 218+66: Cutoff wall extending to an elevation of 25 ft.	
3	218+66 to 300+66	8,200	Cutoff wall Cutoff wall with undrained seepage berm	218+66 to 231+00: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 218+66 to 230+00: Cutoff wall extending to an elevation of 25 ft. 230+00 to 250+00: Cutoff wall extending to an elevation of -35 ft. 250+00 to 289+00: Cutoff wall extending to an elevation of -20 ft. 289+00 to 300+66: Cutoff wall extending to an elevation of -12 ft.	
4	300+66 to 410+67	11,001	Cutoff wall	300+66 to 312+00: Cutoff wall extending to an elevation of -12 ft. 312+00 to 349+00: Cutoff wall extending to an elevation of 15 ft. 349+00 to 368+00: Cutoff wall extending to an elevation of 10 ft. 368+00 to 410+67: Cutoff wall extending to an elevation of 20 ft.	

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
5	410+67 to 478+68	6,801	Cutoff wall Cutoff wall with undrained seepage berm	453+00 to 478+00: 300 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 410+67 to 417+00: Cutoff wall extending to an elevation of 20 ft. 417+00 to 425+00: Cutoff wall extending to an elevation of 10 ft. 425+00 to 456+00: Cutoff wall extending to an elevation of 15 ft. 456+00 to 475+35: Cutoff wall extending to an elevation of 15 ft. 475+35 to 478+68: Cutoff wall extending to an elevation of 15 ft.	
6 FIP	478+68 to 512+00	3,332	Cutoff wall	478+68 to 512+00: 65ft deep (from degrade line) cutoff wall.	
7	512+00 to 596+00	8,563	Cutoff wall Cutoff wall with existing and new relief wells Erosion Protection	512+00 to 514+00: 65ft deep (from degrade line) cutoff wall. 514+00 to 526+00: Cutoff wall tip elevation +15 feet 526+00 to 570+00: Cutoff wall tip elevation -5 feet 545+00 to 570+00: 22 new relief wells at 120 feet spacing and 50 feet depth (including new concrete lined V-ditch). 570+00 to 575+00: Cutoff wall tip elevation -5 feet 575+00 to 595+00: Cutoff wall tip elevation -10 feet 595+00 to 596+00: Cutoff wall tip elevation +15 feet 547+00 to 596+00: High Performance Turf Reinforce Mat (HPTRM)	512+00 to 545+00: existing seepage interceptor system (24 relief wells, ditch and pump station) are to remain.
8	596+00 to 654+75	5,875	Cutoff wall Erosion Protection	596+00 to 654+75: Cutoff wall tip elevation +15 feet 596+00 to 604+60: High Performance Turf Reinforce Mat (HPTRM)	

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Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
9	654+75 to 706+50	5,175	Cutoff wall	654+75 to 670+00: Cutoff wall tip elevation +15 feet 670+00 to 697+00: Cutoff wall tip elevation +20 feet 697+00 to 706+50: Cutoff wall tip elevation -10 feet	
10	706+50 to 774+00	6750	Cutoff wall	706+50 to 726+00: Cutoff wall tip elevation -10 feet 726+00 to 746+00: Cutoff wall tip elevation -5 feet 746+00 to 754+50: Cutoff wall tip elevation +5 feet 754+50 to 774+00: Cutoff wall tip elevation +25 feet	
11	774+00 to 830+00	5,600	Cutoff wall	774+00 to 784+50: Cutoff wall tip elevation +25 feet 784+50 to 827+50: Cutoff wall tip elevation -5 feet 827+50 to 830+00: Cutoff wall tip elevation +25 feet	
12	830+00 to 845+00	1,500	No proposed rehabilitation measure with exception below Cutoff wall (transition only, at both ends of this reach)	830+00 to 831+50: Cutoff wall tip elevation +25 feet (transition only) 844+50 to 845+00: Cutoff wall tip elevation -26 feet (transition only)	829+85 to 845+25: existing cutoff wall (23.5ft deep, tip elevation 30.5)
13	845+00 to 927+00	8,200	Cutoff wall Cutoff wall with full levee degrade and existing relief wells	844+50 to 897+50: Full levee degrade and re-construction 844+50 to 849+00: Cutoff wall tip elevation -20' to -29' 848+00 to 863+00: Cutoff wall tip elevation -29' 863+00 to 877+00: Cutoff wall tip elevation -30' 877+00 to 887+00: Cutoff wall tip elevation -31' 887+00 to 893+00: Cutoff wall tip elevation -30' 893+00 to 897+50: Cutoff wall tip elevation -29' 897+50 to 923+75: Cutoff wall tip elevation +25'	844+50 to 897+50: Existing seepage interceptor system (52 relief wells, ditch and pump stations) are to remain. 897+50 to 923+75: Existing seepage interceptor system (29 relief wells, ditch and pump stations) are to remain. 923+23 to 927+00: existing cutoff wall (32.5ft deep, tip elevation 42.5)

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
14	927+00 to 954+40	2,740	No proposed rehabilitation measure	---	927+00 to 954+40: existing cutoff wall (32.5ft deep, tip elevation 42.5) No as-built drawing available for the existing cutoff wall.
15	954+40 to 968+50	1,410	No proposed rehabilitation measure	---	954+40 to 968+50: existing cutoff wall (32.5ft deep, tip elevation 42.5) No as-built drawing available for the existing cutoff wall.

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
16	968+50 to 1080+00	11,150	Jet grouting cutoff wall at 5th Street bridge crossing. Toe berm at 10th Street bridge crossing. Cutoff wall (transition only, at the end of Reach 16 to overlap existing cutoff wall).	1006+04 to 1007+90 (5th Street bridge crossing): Jet grouting cutoff wall tip elevation +40 feet 1023+90 to 1027+50 (10th Street bridge crossing): Toe berm, 23 feet wide, approximately 7 feet thick at the levee toe, 4H:1V slope at toe berm. 1077+85 to 1080+00: Cutoff wall tip elevation +30 feet and backfill landside toe depression (transition only).	968+50 to 983+23: existing cutoff wall (32.5ft deep, tip elevation 42.5) 983+23 to 996+23: existing cutoff wall (22.5ft deep, tip elevation 52.5) 996+23 to 1006+24: existing cutoff wall (32.5ft deep, tip elevation 42.5) 1007+90 to 1015+70: existing cutoff wall (32.5ft deep, tip elevation 42.5) 1015+70 to 1024+42: existing cutoff wall (43ft deep, tip elevation 35) 1026+99 to 1079+66: existing cutoff wall (39ft deep, tip elevation 38)

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
17	1080+00 to 1130+86	5,086	Cutoff wall Jet grouting cutoff wall at Yuba city water treatment plant Jet grouting cutoff wall at Railroad North of Yuba City Landside toe depression filled Closure Structure	1107+00 to 1125+70: Backfill landside toe depression 1080+00 to 1089+00: Cutoff wall tip elevation +30 feet 1089+00 to 1096+00: Cutoff wall tip elevation +35 feet 1095+80 to 1098+30: Jet grouting cutoff wall tip elevation +35 feet 1098+10 to 1125+00: Cutoff wall tip elevation +35 feet 1125+00 to 1129+99: Cutoff wall tip elevation +0 feet 1129+50 to 1130+67: Jet grouting cutoff wall tip elevation +0 feet 1130+20 to 1130+86: Cutoff wall tip elevation +0 feet 1130+00: Stoplog closure structure or equivalence	
18	1130+86 to 1213+85	8,299	Cutoff wall	1130+86 to 1151+50: Cutoff wall tip elevation +0 feet 1151+50 to 1159+50: Cutoff wall tip elevation +30 feet 1159+50 to 1169+50: Cutoff wall tip elevation +25 feet 1169+50 to 1189+50: Cutoff wall tip elevation +30 feet 1189+50 to 1209+50: Cutoff wall tip elevation +40 feet 1209+50 to 1213+85: Cutoff wall tip elevation +35 feet	
19	1213+85 to 1297+83	8,398	Cutoff wall	1213+85 to 1219+75: Cutoff wall tip elevation +35 feet 1219+75 to 1224+00: Cutoff wall tip elevation +5 feet 1224+00 to 1238+00: Cutoff wall tip elevation -28 feet 1238+00 to 1248+00: Cutoff wall tip elevation -42 feet 1248+00 to 1268+75: Cutoff wall tip elevation +3 feet 1268+75 to 1297+83: Cutoff wall tip elevation +35 feet	
20	1297+83 to 1374+33	7,650	Cutoff wall	1297+83 to 1298+75: Cutoff wall tip elevation +35 feet 1298+75 to 1359+00: Cutoff wall tip elevation +50 feet 1359+00 to 1369+00: Cutoff wall tip elevation +40 feet 1369+00 to 1374+33: Cutoff wall tip elevation +32 feet	

Table 4-2 Summary of Project Features for Alternative SB7

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
21	1374+33 to 1433+83	5,950	Cutoff wall Levee relocation with cutoff wall (transition only) Canal relocation	1374+33 to 1386+50: Cutoff wall tip elevation +32 feet 1386+50 to 1408+50: Cutoff wall tip elevation +55 feet 1408+50 to 1433+83: Cutoff wall tip elevation +40 feet 1429+00 to 1433+83 Sutter Butte Main Canal relocation.	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
183	21	1430+55	2,216,425.27	6,664,383.06	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. There is a 60 Inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	15.6
184	21	1430+47	2,216,417.64	6,664,382.64	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. There is a 60 Inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	15.6
185	21	1430+40	2,216,410.86	6,664,382.27	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. There is a 36 Inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	15.6
186	21	1430+40			To construct and operate a vertical-perforated plate fish screen with a power operated brush on the right bank of Feather River. Located at Sunset Pump Plant.	Cutoff wall with Sutter Butte canal relocation		IR	
187	21	1430+00			36" CM pipe crossing through levee. The O&M manual indicates this pipeline is located 30 feet south of Sunset Pump Station but it appears this pipeline is the same pipeline addressed in Permit 4556 and 4719 located at Station 1465+80. The pipeline at Station 1465+50 was a 36 inch CMP installed in 1913 and removed in 1964. It should have shown on the O&M manual.	Cutoff wall with Sutter Butte canal relocation	There is no documentation of proper abandonment of the pipeline. We believe this pipeline was actually located at 1465+50 and removed per permit 4719. The type and size appear to match the Reclamation Board Permit. **Replace in accordance with USACE Standard.**	IR (G)	
188	21	1429+98	2,216,368.25	6,664,376.98	12 KV OH Power	Cutoff wall with Sutter Butte canal relocation		EL	OH
189	21	1429+68	2,216,338.71	6,664,376.58	12 KV OH Power	Cutoff wall with Sutter Butte canal relocation		EL	OH
190	21	1429+50			Existing rubble coffer dam constructed with Reclamation Board Permit 3610. Repair coffer dam.	Cutoff wall with Sutter Butte canal relocation		IR	
191	21	1428+50			Sutter Butte Main Canal Begin (Station 1428+50 to 1433+83)-Main Irrigation Canal approx 420 cfs	Cutoff Wall	**Recommended Relocation between station 1429+00 to 1433+83**	IR	
192	21				To construct a 12 KV pole line extension adjacent to the levee and across the floodway of the Feather River. The pole line will be located 30 feet from the waterside toe of the levee and will parallel the levee for a distance of 792 feet, thence across the floodway for a distance of 834 feet. The pole line extension will consists of three 264 foot spans and three 278 foot spans.	Cutoff Wall		EL	OH
193	21	1399+27	2,213,450.77	6,664,966.80	To install a 12 kv pole line across and along the right bank levee of the Feather River.	Cutoff Wall		EL	OH
194	21				To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. End Seepage Interceptor Trench	Cutoff Wall	No work proposed and the seepage drain can remain.	struc	
195	21				Plant 9 acres of Kiwi plants on waterside of levee between Bridgeford and Hermanson Avenues.	Cutoff Wall		Trees	
196	21				Plant 14 acres of Kiwi plants on waterside of levee upstream of Hermanson Avenue	Cutoff Wall		Trees	
197	21				To construct a well and septic tanks for 2 mobile homes and to extend electrical service to well on right bank overflow area of Feather River	Cutoff Wall		Struc	

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Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
198	21				To plant 8 acres of kiwi plants, a submersible pump, and underground sprinkler system on the right bank overflow area of the Feather River	Cutoff Wall		Trees	
199	~~21~~				~~To pump storm water from landward drainage ditch over the right bank levee of the Feather River from one separate location for approximately size at the end of Hermansen Road.~~ **~~Pipe has been removed~~**	~~Cutoff Wall~~		~~SD(P)~~	
200	21	1391+96	2,212,767.43	6,665,226.86	To extend a 12 kv pole line out into the right bank levee and overflow area of the Feather River	Cutoff Wall		EL	OH
201	21	1375+35	2,211,296.56	6,665,968.34	Sutter Extension Sutter Lateral Begin (Station 1375+35 to 1428+50) Open irrigation ditch 15 feet from landside toe	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	Struc	
202	21	1374+94	2,211,260.36	6,666,016.66	To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. Begin Seepage Interceptor Trench	Cutoff Wall		Struc	
203	21	1375+00			To level and plant 13 acres Peach Orchard on the right bank overflow area of the Feather River	Cutoff Wall		Trees	
	20/21	1374+33			Reach 20/21 Transition				
204	20	1350+00			To plant peach trees and to establish two wells and install pumping plants in right bank overflow of the Feather River	Cutoff Wall		struc	
205	20	1350+00			To extend 12 kv pole line parallel to the water ward toe of levee for a distance of approximately 1,500 feet north from Koch Lane, on the right bank overflow area of the Feather River/	Cutoff Wall		EL	OH
206	20				Excavation into toe of levee from 1 to 3 feet high and ground is tilled adjacent to the landside toe. The CVFPB sent an encroachment violation notice on August 17, 2011 to Julie M. Filter-Correll.	Cutoff Wall		Struc	
207	20	1347+37	2,208,612.74	6,666,676.45	To install a 60 foot pole 86 feet from the landward toe of the levee, a 60 foot pole 10 feet from the water ward toe of the levee and 6 additional poles on the right bank overflow of the Feather River. The 12kv electrical service will be extend across the levee to serve a pump installed under Permit 6380. The span across the levee will be 234 feet. The clearance between the overhead wires and the top of the levee will be 31 feet.	Cutoff Wall		EL	OH
208	20	1347+00	2,208,582.82	6,666,680.19	Missile Communication Cable System. Installation of an underground cable at a minimum depth of 3 feet, a corrugated metal cutoff wall is located on each cable, from Beale Air Force Base to the vicinity of Chico Airport, crossing several channels in Butte, Placer, Sutter, and Yuba Counties. In 1968 the USACE requested approval to abandon the cable in-place and cut	Cutoff Wall	The cable does not meet title 23 requirements. According to email from US Government to WR, the cable is no longer in use and can be disposed. **Replace in accordance with USACE standard**	TL	4.0
209	20	1345+00			To plant prune orchard on the right bank overflow area of the Feather River, downstream from Koch Road	Cutoff Wall		Trees	
210	20	1345+00			To retain walnut orchard on the right bank overflow area of the Feather River, downstream from Koch Road	Cutoff Wall		Trees	
211	~~20~~	~~1328+10~~			~~To install 3 temporary discharge pipelines across the right bank levee of the Feather River. The proposed pipeline will be as installed in three separate locations at LM 2.52, 2.72, and 3.78. The pipelines will be exposed on the levee slopes and will have a pad constructed over them across the levee crown.~~ **~~Pipe has been removed.~~**	Cutoff Wall		~~SD(P)~~	

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Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
212	20	1328+00			To construct a 12 kv aerial power line on the right bank overflow area of the Feather River	Cutoff Wall		EL	OH
213	20	1327+00	2,206,597.56	6,666,928.33	12KV overhead power line crossing	Cutoff Wall		EL	OH
~~214~~	~~20~~	~~1317+15~~			~~To install 3 temporary discharge pipelines across the right bank levee of the Feather River. The proposed pipeline will be in installed in three separate locations at LM 3.53, 3.72, and 3.78. The pipelines will be exposed on the levee slopes and will have a pad constructed over them across the levee crown.~~ **Pipe has been removed.**	~~Cutoff Wall~~		~~SD(P)~~	
215	20	1315+03	2,205,398.45	6,666,943.63	To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. End Seepage Interceptor Trench	Cutoff Wall		Struc	
216	20	1314+80	2,205,375.80	6,666,944.25	Micheli Storm Drainage Pump Station. To install a pump with 20 inch steel discharge pipe through the right bank of the Feather River for the removal of stormwater.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(P)	2.0
217	20	1312+08			To plant an orchard and grade the land on the right bank overflow area of the Feather River. The project is located north of Yuba City approximately 5.5miles.	Cutoff Wall		Trees	
~~218~~	~~20~~	~~1305+30~~			~~To pump storm water from landward drainage ditch over the right bank levee of the Feather River from one separate location for approximately size at the end of Hornmanson Road.~~ **Pipe has been removed**	~~Cutoff Wall~~		~~SD(P)~~	
	19/20	1297+83			Reach 19/20 Transition				
219	19	1295+00			To plant an orchard and grade the land on the right bank overflow area of the Feather River. The project is located north of Yuba City approximately 1.3 miles upstream (north) of the intersection of Eager Road and Live Oak Boulevard.	Cutoff Wall		Trees	
220	19	1293+66	2,203,266.22	6,666,867.99	End Concrete Lined Ditch on landside toe of levee	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	struc	
221	19	1293+66	2,203,266.22	6,666,867.99	12 KV Overhead Power line crossing of levee. One pole 6 feet from levee toe.	Cutoff Wall		EL	OH
222	19				To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. Begin Seepage Interceptor Trench	Cutoff Wall		struc	
223	19	1284+91	2,202,406.21	6,666,705.08	Begin Concrete Lined Ditch on landside toe of levee	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	struc	
224	19	1266+71	2,200,600.09	6,666,626.50	12KV overhead power line crossing	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
225	19	1265+59	2,200,487.69	6,666,648.86	Sullivan Pump Station. 18 inch steel pipe through the levee. Pump and Gate valve in pump house on the channel bank. Concrete well on the bank. Siphon breaker in CMP riser on landside slope. (Sullivan Pump Station)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and anti-siphon device on waterside hinge of levee. The pipe line is pressurized and need to be installed above the design water surface. The current installation is at-grade. **Replace in accordance with Title 23**	IR(P)	18.3

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Location (NAD 83) Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
226	19	1229+41	2,197,325.05	6,668,184.53	Kewal Singh IR PS. A 16 inch steel pipe through levee. Pump in pump house on channel bank. Gate valve on the waterside end. Concrete standpipe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and anti-siphon device on waterside hinge of levee. The pipeline is pressurized and will need to be installed about the design water surface. **Replace in accordance with USACE standard**	IR(P)	3.0 or deeper through levee?
227	19	1226+06	2,197,092.42	6,668,425.99	12 KV power pole located in landside slope	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
	18/19	1213+85			Reach 18/19 Transition				
228	18				Excavation into the toe of levee on waterside 0.5 to 3 feet high with near vertical slope. CFPB sent an encroachment violation notice on July 27, 2011 to Kewall Singh	Cutoff Wall		struc	
229	18	1201+00			Wilbur Ranch Irrigation Water Well located within 50 feet of levee toe. Underconstruction as of March 6, 2012.	Cutoff Wall		well	
230	18	1200+69	2,194,694.58	6,669,169.33	Wilbur Ranch Irrigation Water Well located within 10 feet of levee toe. There is also a service pole and electrical panel.	Cutoff Wall	The water well does not meet Title 23 since too closure to levee. The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
~~231~~	~~18~~	~~1200+69~~	~~2,194,694.58~~	~~6,669,169.33~~	~~Abandoned 10 inch steel pipe through levee. Waterside end open. Steel Plate welded on landward end. Pump and Standpipe at the landside end.~~	~~Cutoff Wall~~	~~Not sure if the abandonment meets title 23 requirements. Pipe may need to be properly abandoned or completely removed.~~	~~IR(P)~~	~~2.8~~
232	18	1195+20			12 KV power line in overflow and levee crossing north of Rednall Road	Cutoff Wall		EL	OH
~~233~~	~~18~~	~~1182+75~~			~~20 Inch steel pipeline through levee **(not installed)**. Plans prepared by MBM Job No. 78-158.~~	~~Cutoff Wall~~	~~Pipe can never installed. No work.~~	~~IR(A)~~	~~3.0~~
234	18	1181+50			Abandoned 8 inch steel pipe through levee. Pipe plugged on the waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(A)	4.0
235	18	1180+98	2,192,727.96	6,669,163.92	3 inch steel pipe through levee crown	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	1.0
236	18	1180+50			One 12 inch steel pipe through levee. Pipe exposed on landside slope	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	1.0
237	18	1180+00			To construct a 15 inch diameter corrugated metal drain pipeline across the overflow area and through the right bank of the Feather River. The proposed pipeline will be 625 feet in length and have 15 feet of cover.	Cutoff Wall		SD(G)	
~~238~~	~~18~~	~~1182+75~~			~~To install an irrigation pump and a buried pipeline landward over the right bank levee of the Feather River, upstream Rednall Road. **Not install per Reclamation Board**~~	~~Cutoff Wall~~		~~IR(P)~~	
239	18	1174+05	2,192,054.01	6,669,096.85	Water Well and Pump 20 feet from Landside toe	Cutoff Wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
240	18	1170+04	2,191,638.99	6,669,057.61	12KV overhead power line crossing	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
241	18	1152+55	2,189,899.09	6,668,879.71	Twin 110 KV Tower line across Feather River	Cutoff Wall		EL	OH
242	18	1138+22	2,188,574.27	6,668,732.99	12 KV and 40/60 KV power pole located in landside slope	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	OH

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
243	18	1135+31	2,188,188.41	6,668,676.43	16 inch gas line through the levee. Marker post on the waterside shoulder	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.5
244	18	1133+00			To construct 1,180 feet of 12 kv line in the right bank overflow area of the Feather River	Cutoff wall		EL	OH
	18	1132+61			Levee District No. 1 Levees /Levee District No. 9 Transition				
245	18	1132+09	2,187,967.19	6,668,647.98	8-5/8" steel pipeline within railroad right-of-way parallel to tracks	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	
246	18	1131+82	2,187,840.25	6,668,647.20	Fiber optic cable	Cutoff wall	The cable does not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	
	17/18	1130+86			Reach 17/18 Transition				
247	17	1130+47	2,187,705.38	6,668,643.93	Union Pacific Railroad Crossing. There is no stop log structure.	Jet Grouting		RR	6.0
248	17	1128+00			To construct a ramp on the waterside slope of the right bank levee on the Feather River adjacent to the SPRR.	Cutoff wall		Struc	
249	17	1127+48	2,187,405.84	6,668,629.29	Village Green Trailer Park - To install a 10 inch outfall pipe through the right bank levee of the Feather River to provide storm drainage for a mobile home park.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	
250	17	1125+00			An existing irrigation well in the right bank overflow area of the Feather River.	Cutoff wall with landside toe fill		Well	
251	17	1111+46	2,185,808.02	6,668,723.59	West Onitott Frontage Road Pump Station and Clark Avenue Pump Station Drainage Area. 16 Inch welded steel 7 GA asphalt coated storm drain discharge pipe over levee connected to 24 inch pipe in overflow area, outfall ditch, and pipes in floodway (Source: City of Yuba City Pump Station No. 4 and City of Yuba City Pump Station No. 2)	Cutoff wall with landside toe fill	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	1.1
252	17	1107+82	2,185,444.63	6,668,754.75	12 KV crossing & power pole located in landside slope	Cutoff wall with landside toe fill	**Relocate outside of of the proposed right-of-way**	EL	OH
253	17				To install an intertie to an existing waste water line and abandon approximately 40 feet of 24 inch diameter pipe on the right bank of the Feather River.	Cutoff wall		RW(P)	4.0
254	17	1096+81	2,184,421.28	6,669,119.50	Yuba City Water Treatment Plant 28" (29.25/32" OD) 7 GA welded steel waterline pipe crossing of levee. New permit included installation of automatic drainage gates on pipelines. (copy of record drawings)	Jet Grouting	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	RW(P)	5.0
255	17	1096+71	2,184,412.72	6,669,124.71	Yuba City Water Treatment Plant 24" 7 GA welded steel waterline pipe crossing of levee. New permit included installation of automatic drainage gates on pipelines. (copy of record drawings)	Jet Grouting	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	RW(P)	4.7
256	17	1096+62	2,184,404.80	6,669,129.53	Yuba City Water Treatment Plant 42" cement mortar lined and coated welded steel pipe waterline crossing of levee (copy of record drawings)	Jet Grouting	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	RW(P)	2.5
257	17	1096+50	to be installed	to be installed	Yuba City Water Treatment Plant 48" cement mortar lined and coated welded steel pipe waterline crossing of levee (to be installed and requested by the City of Yuba City)	Jet Grouting	This is a new pipelines that will meet Title 23 and USACE requirements except as noted in variance column. **Replace in accordance with USACE standard**	RW(P)	2.0

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Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
258	17	1096+74	2,184,416.62	6,669,124.90	To install a 12 kv aerial pole line extension across the right bank levee of the Feather River. The pole line shall serve the Yuba City Water treatment Plant intake pump station.	Jet Grouting		EL	OH
259	17	1093+12			Telephone Call box on landside hinge point	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	TL	
260	17	1086+33			Construction of an 80 foot high Monopole for a Cell Tower. The work includes a 32' x 83' compound, PG&E 100 KVA transformer box, 600 AMP PG&E Electrical Meter Service.	Cutoff wall		Cell	
	16/17	1080+00			Reach 16/17 Transition				
261	16	1079+91	2,183,133.99	6,670,212.82	8 inch Gas Line	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.5
262	16	1073+41	2,182,671.85	6,670,670.15	16 inch Gas Line (PG&E Map shows the gas main as 12 inch)	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.5
263	16				Excavation into the levee on the waterside approximately 0.5 to 2 feet, near vertical in some places. Minor rutting, ponding, and depressions in the levee toe road. CVFPB sent a encroachment violation notice on August 16, 2011 to City of Yuba City.	No Rehabilitation Required		struc	
264	16	1054+75	2,181,074.23	6,671,588.96	Telephone Call box on landside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
265	16	1043+52	not verified		Abandon 36 inch pipe	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SS(G)	
266	16	1043+52	2,180,149.57	6,672,223.24	Abandoned 27 inch Centrifugal Spun Concrete Pipe. City of Yuba City Drawing 214-D per 1949 plans	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SS(G)	38.6
267	16	1043+45	2,180,137.11	6,672,230.51	To install a 36 Inch discharge pipe through right bank of Feather River	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	5.0
268	16	1043+27	2,180,126.23	6,672,235.13	To install a 24 inch wrapped steel pipe through the right bank levee of the Feather River	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	2.0

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Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
269	16	1043+22	2,180,121.72	6,672,237.88	To construct a 24 inch steel pipe storm drainage discharge pipe crossing the west levee of the Feather River	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	4.0
270	16	1043+03	2,180,106.36	6,672,244.70	Gilsizer Slough Storm Drain Facilities. A 16 inch welded steel discharge pipe crossing of levee. (copy of record drawings)	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	1.3
271	16	1037+50	Not Verified		Abandoned 8 inch gas line through levee. Removed per Permit 1445A	No Rehabilitation Required	Not sure if the abandonment meets title 23 requirements. Pipe may need to be properly abandoned or completely removed.	GL	
272	16				To construct approximately 4,400 lineal feet of filter trench adjacent to the right bank levee of the Feather River. The proposed trench will be located at the landward levee toe, be 3 feet wide and 4 feet deep.	No Rehabilitation Required			
273	16	1028+11	2,178,636.47	6,672,461.02	Power pole in waterside slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	
274	16	1029+10	2,179,608.80	6,672,356.03	To bury existing two submarine telephone cables into two parallel trenches 100 feet apart in the channel of the Feather River. Both cables were installed per Permit 1334 in September 15, 1948. The permit stated the cable will be buried to a depth of five feet in the levees.	No Rehabilitation Required	The conduit may not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	5.0
275	16	1028+10	2,179,506.59	6,672,370.16	To bury existing two submarine telephone cables into two parallel trenches 100 feet apart in the channel of the Feather River. Both cables were installed per Permit 1334 in September 15, 1948. The permit stated the cable will be buried to a depth of five feet in the levees.	No Rehabilitation Required	The conduit may not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	2.0
276	16	1026+71	21,784,783.54	6,672,514.29	10" overside Drain line on the water side levee slope for bridge area drainage	Seepage berm	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	TL	
277	~~16~~	~~1026+79~~			~~To place a 19 inch diameter conduit containing fiber optic cables across and under (bored) the channel and through the right bank of the Feather River. The permit was withdrawn on 9-6-00 according to the CVFPB file.~~	Seepage berm		TL	
278	16	1026+58	2,178,488.35	6,672,429.49	40 foot long retaining wall landside of levee just upstream of the Feather River Bridge	Seepage berm		Road	
279	16	1026+22	2,178,451.96	6,672,425.20	Feather River Bridge (SR 20) upstream side	Seepage berm		Bridge	
280	16	1025+32	2,178,375.92	6,672,443.76	Feather River Bridge (SR 20) downstream side	Seepage berm		Bridge	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
281	16	1025+32	2,178,375.92	6,672,443.76	Seismic Retro of Feather River Bridge and bike paths on both sides of bridge	Seepage berm		Bridge	
282	16	1024+95	2,178,319.03	6,672,456.34	12 kv power line across levee	Seepage berm	**Relocate outside of of the proposed right-of-way.**	EL	OH
283	16	1024+70			Backfill Community Swimming Pool located near the base of the Feather River Bridge (10th Street Bridge)	Seepage berm		struc	
284	16	1024+48	2,178,296.55	6,672,470.53	40 foot long retaining wall landside of levee just downstream of the Feather River Bridge	Seepage berm		Road	
285	16	1021+95	2,178,044.07	6,672,487.29	12 kv power line across levee	No Rehabilitation Required		EL	OH
286	16	1021+00			Telephone line on river slope of levee 260 feet downstream of Feather River Bridge (10th Street Bridge)	No Rehabilitation Required		TL	
287	16	1020+85			Abandon 4 inch pipe	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	1.3
288	16	1020+30	2,177,879.35	6,672,456.38	Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
289	16	1019+82	2,177,832.15	6,672,504.71	Power pole in waterside slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
290	16	1013+00			To place approximately 4,000 feet of blanket drain and filter trench on the right bank of levee of the Feather River upstream and downstream of the SR 20 Bridge	No Rehabilitation Required		Struc	
291	16	1010+75	2,176,773.87	6,672,930.97	Install Guy within in landside slope of levee, 12 kV overhead electric	No Rehabilitation Required		EL	
292	16	1008+38	2,176,779.63	6,672,929.15	12 kv power line across levee	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
293	16	1007+50			To construct approximately 1,300 feet of 12 foot wide bicycle trail on the crown of the right bank levee of the Feather River. The Project is located in Yuba City between the 5th Street Bridge and the easterly extension of Teagarden Avenue.	Jet Grouting		Struc	
294	16	1007+50			4' by 3' deep erosion pocket. 4 foot vertical bank under Twin Cities Memorial Bridge	Jet Grouting		struc	
295	16	1007+50			To construct a bicycle trail for approximately 3.5 miles on the right bank levee other the Feather River from Shanghai Bend Road to Northgate Boulevard	Jet Grouting		Road	
296	16	1007+50			Bike Path below Twin Cities Memorial Bridge	Jet Grouting		Road	
297	16	1007+51	2,176,709.34	6,672,981.09	Twin Cities Memorial Bridge upstream side	Jet Grouting		Bridge	
298	16	1007+46	2,176,706.30	6,672,984.37	Light pole in water side levee slope	Jet Grouting	**Relocate outside of of the proposed right-of-way.**	EL	OH
299	16	1007+06	2,176,671.72	6,673,005.93	Twin Cities Memorial Bridge downstream side	Jet Grouting		Bridge	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
300	16	1006+93	2,176,642.84	6,672,995.25	Power line and Anchor in Levee (actual location)	Jet Grouting		EL	
301	16	1006+60	2,176,647.27	6,673,046.63	Sacramento Northern Railroad	Jet Grouting		RR	
302	16	1006+07	2,176,610.55	6,673,084.90	Power Pole and anchor in slope of levee. 100 feet south of the SNRR bridge w/ service power overhead	Jet Grouting		EL	OH
303	16	1006+00			City of Yuba City. To replace the existing retaining wall with an 8 foot high, 76 foot long concrete retaining wall on the landside of the right (east) bank levee of Feather River.	Jet Grouting		struc	
304	16	1005+80			Concrete steps and 4 inch diameter PVC pipe on the landward slope and a pump house within 10 feet of the landward toe.	No Rehabilitation Required		struc/IR (P)	
305	16	1003+72	2,176,461.32	6,673,266.98	Power Pole and anchor in slope of levee. 300 feet south of the SNRR bridge	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
306	16	1000+50			A 3-wire barded wire fence with a gate within 5 feet of the levee toe and two mature trees at the landward toe. The project is located on Keyser Street	No Rehabilitation Required		struc	
307	16	999+90			A 120 foot long building at the landward toe	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
308	16	995+50			Authorize a 3-wire barded wire fence and two mature trees at the landward toe. The project is located at 563??? Second Street	No Rehabilitation Required		struc	
~~309~~	~~16~~	~~995+50~~			~~To excavate 25 feet into landward side of the right bank of the Feather River and construct a concrete retaining wall to provide parking lot space. The project is located at 463 2nd Street behind the Sutter County Administration Building.~~	~~No Rehabilitation Required~~		~~struc~~	
~~310~~	~~16~~	~~993+56~~			~~To install approximately 1,010 feet of 8 foot high chain link fence on the waterside side of the right bank levee of the Feather River.~~	~~No Rehabilitation Required~~		~~struc~~	
311	16	993+25			A building near the landward toe of the levee.	No Rehabilitation Required		struc	
312	16	992+00			A shed, concrete wall, and chain-link fence with gate at landward toe. The permit also covers two steel posts on the shoulder and seventeen mature trees on the landward slope	No Rehabilitation Required		struc	
313	16	991+00			A shed at the landward toe	No Rehabilitation Required		struc	
314	16	992+00			A two-story garage and shop building at the landward toe and six mature trees on the landward slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
315	16	989+75			A building at the landward toe and 21 mature trees and sprinkler system on the landward slope.	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
316	16	988+05	2,175,065.02	6,673,942.87	3 inch steel pipe, does not appear to cross levee anymore	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	
317	16	989+20			A garage and a shed at the landward toe	No Rehabilitation Required		struc	
318	16	988+50			Authorize a small building, a chain-link fence, four mature trees at the landward toe, and five clumps of oleanders on the landward slope.	No Rehabilitation Required		struc	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
319	16	987+60			Authorize a small building and a chain link fence on an existing retaining wall at the landward toe, concrete stairs, a steel pipe frame, and two large mature trees on the landward slope. A hose bib on the landward shoulder of the right bank of levee.	No Rehabilitation Required	**Recommended Relocation**	struc	
320	16	986+75			A see-through fence on a 5 foot retaining wall, steps, and nine mature trees on the landward slope.	No Rehabilitation Required		struc	
321	16	986+00			Concrete steps with railing and pomegranate bush on landward slope. The permit also covers a concrete retaining wall at the landward toe.	No Rehabilitation Required		struc	
322	16	985+30			Chain Link fence with gate, three oleander trees, and steps within the landward slope.	No Rehabilitation Required		struc	
323	16	984+50			Chain Link fence with gate, three oleander trees, and steps within the landward slope.	No Rehabilitation Required		struc	
324	16	983+20			A building, barbed wire fence, and ten trees at landward toe	No Rehabilitation Required		struc	
325	16	981+25			A 60 foot long see-through board fence and 75 foot long clothesline and landward toe. A shed 5 feet from landward toe and a mature oak tree on the landward slope.	No Rehabilitation Required		struc	
326	16	980+15			A chain-link fence with gate within 10 feet of landward toe	No Rehabilitation Required		struc	
327	16	979+90			A see-through fence and storage shed within 10 feet of the landward toe. The project is located at 265 Second Street, Yuba City, CA	No Rehabilitation Required		struc	
328	16	979+40			A see-through fence and storage shed within 5 feet of the landward toe. The project is located at 261 Second Street, Yuba City, CA	No Rehabilitation Required		struc	
329	16	978+80			A Chain Link fence with gate within 5 feet of landward toe, a cedar tree at the landward toe, and stone steps on the landward slope. This project is located at 255 Second Street.	No Rehabilitation Required		struc	
330	16	976+10			A shed and three trees at the landward toe of the right bank levee of the Feather River. The project is located at 225 Second Street, Yuba City, CA 95591	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
331	16	975+40			A 6 foot high chain link fence and gate at the right bank levee of the Feather River	No Rehabilitation Required		struc	
332	16	974+25			A residence within 5 feet of the landward toe	No Rehabilitation Required		struc	
333	16	973+30			A residence at landward toe and oak on the landward slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
334	16	973+00			To construct a restroom facility with septic tank and leach lines at the Yuba City Boat Ramp on the right bank of the Feather River.	No Rehabilitation Required		struc	
335	16	972+29			2 inch Domestic Water Line serving the Yuba City Boat Dock.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with Title 23**	W(P)	
336	16	972+00			To construct improvement for the boat launching ramp and related facilities on the right bank of the Feather River.	No Rehabilitation Required		struc	
337	16	972+00			To construct improvement for the Yuba City Boat Ramp consisting of a paved parking area, restroom facilities, floating boat dock and extension of concrete boat ramp on the right bank of the Feather River.	No Rehabilitation Required		struc	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
338	16	972+00			To reconstruct an existing access road to the Yuba-Sutter Boat Ramp on the right bank of the Feather River	No Rehabilitation Required		struc	
339	16	972+00			To maintain and operate existing boat dock for public use for boating, fishing, and a campground with related facilities including a mobile home on the right bank of the Feather River	No Rehabilitation Required		struc	
	15/16	968+50			Reach 15/16 Transition	No Rehabilitation Required			
340	15	968+00			To construct 120 lineal feet of sheet piles retaining wall, and nine 10 x 10 foot boat docks supported by seven 12 inc diameter steel piles to an existing 30 foot wide ramp (Yuba City Boat Ramp)	No Rehabilitation Required	Located within floodway. Does not affect levee project.	struc	
341	15	964+78			Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
	14/15	954+40			Reach 14/15 Transition	No Rehabilitation Required			
342	14	952+00			12 kv cable	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	UG
	13/14	927+00			Reach 13/14 Transition	No Rehabilitation Required			
343	13	925+16			Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
344	13	925+00			To construct access ramps	No Rehabilitation Required	Located within floodway. Does not affect levee project.	struc	
345	~~13~~	~~920+00~~			~~Consolidated Area Housing Authority of Sutter County - Storm Drainage Pipe Crossings. The size and location of the pipe is unknown. They have retention pond located at southwest corner of the airport. The Airport Business Park proposed crossing but application never filed.~~	~~Cutoff Wall~~	~~The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed.~~ ~~**Replace in accordance with Title 23**~~	~~SD (P)~~	
346	13	913+19	2,168,046.21	6,673,496.81	Two 16 inch gas lines. (PG&E map shows the gas lines as 2-12 inch)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.0
347	13	894+23	2,166,221.70	6,673,147.49	To install a 12kv buried power cable through the right bank levee and across the right bank overflow of the Feather River, a total distance of 896 feet. Poles will be installed near the top of the banks of the low water channel and aerial cable will be placed between the two poles which will be connected to the underground cable.	Cutoff Wall	The cable appears to meet title 23 requirements but the cutoff wall will remove improvements. **Replace in accordance with USACE standard**	EL	UG
348	13	893+84	2,166,181.41	6,673,142.43	Garden Highway Industrial Park. To install a 12 inch steel storm drain pipeline through the right bank levee of the Feather River (Source: City of Yuba City Pump Station No. 1)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	3.3
349	13	893+78	2,166,175.45	6,673,142.43	Burns Drive Storm Water Pump Station. 16 inch steel storm drain discharge pipe through levee. (Source: City of Yuba City Pump Station No. 1)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	2.7
350	13	881+40	2,164,942.19	6,673,036.13	Levee District No. 1 Relief Well Pump Station 6" pipes located just southeast of the Waste Water Treatment Plant. The waterside outlet structure has cobbles and the flap gate is damaged or plugged. CVFPB sent a notice of encroachment violation on August 16, 2011 to Sutter County.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Recommended Removal**	RW(P)	5.1

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
351	13	881+43	2,164,944.76	6,673,036.17	Levee District No. 1 Relief Well Pump Station 14" pipes located just southeast of the Waste Water Treatment Plant. The waterside outlet structure has cobbles and the flap gate is damaged or plugged. CVFPD sent a notice of encroachment violation on August 16, 2011 to Sutter County.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Recommended Removal**	RW(P)	5.1
352	13	856+23	2,162,702.52	6,674,085.34	South Yuba City Seepage Interceptor Pump Station 24 inch 7 GA Steel Pipe asphalt coated and wrapped with asphalt saturated felt discharge pipe (Source: City of Yuba City Pump Station No. 7)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Recommended Removal**	SD(P)	5.2
353	13	856+08	2,162,689.81	6,674,093.30	South Yuba City Storm Drainage Pump Station 24 inch 7 GA Steel Pipe asphalt coated and wrapped with asphalt saturated felt discharge pipe (Source: City of Yuba City Pump Station No. 3)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	5.2
354	13				Seepage Interceptor Trench and additional relief wells. The improvements were adjacent to the River Oaks subdivision between the wastewater treatment plant and Shanghai Road. All work on landside of levee.	Cutoff wall		struc	
355	13	849+85			Telephone Call box on waterside hinge point	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	
356	13				Bike Path below Twin Cities Memorial Bridge	Cutoff wall		struc	
	12/13	845+00			Reach 12/13 Transition				
~~357~~	~~12~~				~~Shanghai Bend Road Setback levee project~~	No Rehabilitation Required		~~struc~~	
358	12	832+24	to be installed	to be installed	City of Yuba City Sewer 24 inch welded steel pipe mortar lined and coated pipe discharge pipe. This pipeline shall replace the existing 24 inch located at Station 828+55. The existing pipeline will be removed and disposed.	No Rehabilitation Required	This is a new pipelines that will meet Title 23 and USACE requirements except as noted in variance column.	SS(P)	2.0
359	12	832+17	to be installed	to be installed	City of Yuba City Sewer 2-24 inch welded steel pipe mortar lined and coated pipe discharge pipe. This is a new pipeline requested by the City of Yuba City.	No Rehabilitation Required	This is a new pipelines that will meet Title 23 and USACE requirements except as noted in variance column.	SS(P)	2.0
	11/12	830+00			Reach 11/12 Transition				
360	11	828+55	2,160,267.77	6,675,134.01	City of Yuba City Sewer 24 inch welded steel pipe mortar lined and coated pipe (wall thickness 0.188" min) Discharge Pipe to river diffuser	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SS(P)	2.3
~~361~~	~~11~~				~~To place an 18 inch storm drain pipeline through the levee on the right bank of the Feather River **(project was not completed - no pipeline installed)**~~	~~Cutoff Wall~~		~~SD(P)~~	
	10/11	774+00			Reach 10/11 Transition	Cutoff Wall			
362	10	771+30			Construct a gaging station approximately 150 feet downstream form the present gaging station, known as Feather River below Shanghai Bend. It is proposed to install an 8 foot high by 5 foot 4 inch square recorder house on the right bank berm approximately 155 feet from centerline of levee.	Cutoff Wall		struc	
363	10	750+40	2,152,869.21	6,673,338.66	115 kv steel tower transmission line crossing of levee	Cutoff Wall		EL	OH
364	10	750+10	2,152,823.05	6,673,332.24	12 kv power line crossing of levee	Cutoff Wall		EL	OH
	9/10	706+50			Reach 9/10 Transition	Cutoff Wall			

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
365	9	692+00			To construct 140 lineal feet of sheet piles retaining wall, and nine 10 x 20 foot boat docks supported by seven 12 inch diameter steel piles to an existing 30 foot wide ramp (Boyd Pump Boat Ramp)	Cutoff Wall	Located within floodway. Does not affect levee project.	struc	
366	9	692+00			To improve the existing Boyd Pump Boat Launching Facility by widening the existing ramp to 30 feet with 4 foot walkways on each side, paving existing access road, and expanding parking area by 25 spaces, and placing riprap on the right bank of the Feather River.	Cutoff Wall		Struc	
367	9	692+00			To construct boat launching ramp, well, pump, pressure system, and sanitary facilities on the right bank overflow of the Feather River	Cutoff Wall		Struc	
368	9	689+09	2,146,949.33	6,672,031.04	Oswald Mutual Water Company (Boyd's Pump) 18 inch epoxy coated mortar lined steel pipe through existing 24 inch concrete pipe crossing of levee	Cutoff Wall	The pipeline does not meet title 23 requirements. The facility will need to go up and over the levee and will need a positive shut-off structure installed and anti-siphon device. **Replace in accordance with USACE standard**	IR(P)	27.6
369	9	689+00	2,146,953.52	6,672,029.11	To replace an existing pole line with a new pole line across the right bank levee of the Feather River. A new pole will be placed 10 feet landward of the landward toe of the levee and another pole will be placed 24 feet water ward of the water ward toe of the levee.	Cutoff Wall		EL	OH
370	9	689+00	2,146,953.52	6,672,029.11	To place a service line on a PG&E pole crossing the right bank levee of the Feather River	Cutoff Wall		TL	OH
371	9	688+90			Irrigation Production Well (located 25 foot west of landside levee toe)	Cutoff Wall		well	
372	9	669+20			Sierra Gold Nursery. Service Pole, Electrical Panel, Meter, and Irrigation Production Well 30 feet from landside levee toe.	Cutoff Wall		well	
373	9	664+07	2,144,450.88	6,672,127.42	Sierra Gold Nursery. An 8 inch steel pipe through levee. This pipe was pressure checked and in 1984 as part of permit 13980 to connect to existing pipe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	SD(P)	3.6
374	9	664+20			To reconstruct and pave a 12 foot wide, approximately 1370 feet long road on the landside toe of the right bank levee of the Feather River	Cutoff Wall		struc	4.9
375	9	655+30			Service Pole, Electrical Panel, Water Well, Pump, and irrigation facilities	Cutoff Wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
	8/9	654+75			Reach 8/9 Transition				
376	8	649+11	2,142,954.74	6,672,128.18	Construct #3/4 ACSR 12kv pole line across the right bank levee of the Feather River, approximately 1900 feet southerly from Messick Road extended easterly to the river. Extension to serve 50 HP agricultural pump for C.E. Sullivan	Cutoff Wall		EL	OH
377	8	647+74	2,142,830.08	6,672,119.48	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.6
378	8	647+70	2,142,826.16	6,672,118.89	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.3

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
379	8	647+66	2,142,822.01	6,672,118.27	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.4
380	8	647+61	2,142,817.52	6,672,117.60	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.3
381	8	638+20			Service Pole, Electrical Panel, Water Well, Pump, Sand Seperator, Concrete Pad, and irrigation facilities (20 feet west of levee toe)	Cutoff Wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
382	8	622+79			Stand pipe, Service Pole, Electrical Panel, and Pump House, Water Well, and Pump at landside levee toe	Cutoff Wall	The water well does not meet Title 23 since too closed to levee. The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
383	8	622+79	2,140,350.59	6,671,955.66	Installation of a 12kv power line crossing of the right bank of the Feather River	Cutoff wall		EL	OH
384	8	603+50			Service Pole, Electrical Panel, Water Well, Pump, Sand Seperator, Concrete Pad, and irrigation facilities (40 feet west of levee toe)	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	well	
	7/8	596+00			Reach 7/8 Transition	Cutoff wall			
385	7	592+67	2,137,447.24	6,671,791.94	12 kv power line across levee	Cutoff wall		EL	OH
386	7	587+00	2,136,925.70	6,671,619.94	Spur Levee upstream of Abbott Lake	Cutoff wall		struc	
387	7				WS Slope varies from 3:1 near crown to 2:1 to 1:1 at toe. Sloughing and caving toe. Along slope I is hummocky; possibly from local slumping.	Cutoff wall		struc	
388	7				caving and slumping at toe. Rip rap berm toe. Difficult to evaluate due to vegetation growth.	Cutoff wall		struc	
389	7	560+00			To fill in approximately one mile of an existing irrigation ditch at the waterside toe of the right bank of the Feather River.	Cutoff wall with existing relief wells	**Relocate outside of of the proposed right-of-way.**	Struc	
390	7				Bank caving 3 to 4 feet high, intermittent repair with rip rap berm at base of over steepened slope	Cutoff wall with existing relief wells		struc	
391	7	560+00			To construct a water well with a 14 inch casing in the right bank overflow of the Feather River at Abbott Lake	Cutoff wall with existing relief wells		well	
392	7	560+00			To extend approximately 2,500 of 12kv electric service line in the right bank overflow area of the Feather River near Abbott Lake to serve 25 HP Ag Pump for A.S. Carzolino.	Cutoff wall with existing relief wells		EL	OH
393	7	557+00			Service Pole, Electrical Panel, Water Well, Pump, Sand Seperator, Concrete Pad, and irrigation facilities (50 feet west of levee toe)	Cutoff wall with existing relief wells	**Relocate outside of of the proposed right-of-way.**	well	
394	7	545+41	2,132,940.57	6,672,317.26	Crushed CMP Riser in Land Side Slope. Possible location of 8 inch steel pipe.	Cutoff wall with existing relief wells	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(A)	3.1
395	7	536+73	2,132,153.19	6,672,681.57	Existing 10 inch steel pipe. Removed in 1964 by Levee District No. 1 as part of permit 4775	Cutoff Wall		IR(?)	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
396	7	536+64	2,132,149.73	6,672,692.81	5 inch steel drainage pipe	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(P)	2.0
397	7	532+00 to 506+00			Taylor Brothers. 15 inch Irrigation Main located within 15 feet of landside toe	Cutoff Wall	The pipeline is within twenty (20) feet of the levee toe and does not meet Title 23. **Relocate outside of of the proposed right-of-way.**	IR (G)	
398	7	529+47	2,131,549.40	6,673,081.12	Abandon 6 inch pipe	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(A)	4.0
399	7	515+00			Seepage Interceptor Trench for Star Bend Relief Well Pumps	Cutoff Wall		struc	
400	7	512+08	2,130,379.55	6,674,329.99	Corp of Engineers Star Bend Road Relief Well Pump Station north 15" Steel Discharge Pipe Crossings	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed. **Replace in accordance with USACE standard**	SD(P)	3.8
401	7	512+04	2,130,375.66	6,674,332.71	Corp of Engineers Star Bend Road Relief Well Pump Station south 15" Steel Discharge Pipe Crossings	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed. **Replace in accordance with USACE standard**	SD(P)	3.7
402	7	510+97	2,130,288.81	6,674,393.77	12 kv power line crossing of levee	Cutoff Wall		EL	OH
	6/7	510+37			Reach 6/7 Transition	Cutoff Wall			
403	6	510+50			To retain a 12 kv overhead service line and four power poles in the right bank overflow area of the Feather River	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
404	6	510+36	2,130,239.19	6,674,428.41	Volcano Vista Farms 18 inch steel irrigation discharge pipe crossing of levee	Cutoff Wall		IR(P)	4.0
405	6	510+30			To install 20 hp irrigation pump and to retain an existing walnut orchard (35 acres) all on the right bank of the Feather. Now owned by Volcano Vista Farms and located on Tudor Mutual Pump Station (relocated pipeline part of permit 18438)	Cutoff Wall		IR(P)	
406	6	510+25	2,130,230.41	6,674,434.54	Tudor Mutual Water Company North 30 inch steel irrigation discharge pipes crossing of levee	Cutoff Wall		IR(P)	4.2
407	6	510+20	2,130,222.24	6,674,437.45	Tudor Mutual Water Company South 30 inch steel irrigation discharge pipes crossing of levee	Cutoff Wall		IR(P)	4.1
408	6				12 inch steel pipe through levee	Cutoff Wall	The conduit may meet title 23 requirements but will need to be replaced during cutoff wall construction. **Replace in accordance with USACE standard**		
409	6				12 kv power line crossing of levee	Cutoff Wall			
410	6				12 kv power line crossing including 9 power poles and 3 anchors (appears to cover permit 2502 and 5072)	Cutoff Wall			
411	6				Abandon 14 inch pipe (this pipeline removed as part of 2009 setback levee project). Listed as 10" Steel in original 1955 O&M manual.	Cutoff Wall	**Recommended Removal**	IR(P)	4.1

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
412	6	509+00			To construct approximately 1,400 lineal feet of filter trench adjacent to the right bank levee of the Feather River	Cutoff Wall		Struc	
413	6	508+00			To clear, level, and plant a peach orchard on approximately 170 acres on the right bank of the Feather River.	Cutoff Wall		Trees	
414	6				Fix in-place the existing levee with 65ft deep cutoff wall between station 478+68 and station 512+00	Cutoff Wall		struc	
	5/6	478+68			Reach 5/6 Transition	Cutoff wall with seepage berm			
415	5	475+00			To plant walnut orchard in the right overflow area of the Feather River downstream from Star Bend	Cutoff wall with seepage berm		Trees	
	5	461+00			Urban (200 year) North - Nonurban (100 year) South Transition	Cutoff wall with seepage berm			
416	5	460+11	2,125,845.57	6,676,268.36	Abandon 8" steel drainpipe. The CVFPB sent an encroachment violation notice on August 16, 2011 to Dan Stephens Trust.	Cutoff wall with seepage berm	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(P)	4.1
417	5	442+80	2,124,212.69	6676803.8	Abandon 8" steel drainpipe	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(P)	4.1
418	5	433+50	2,123,304.56	6,677,004.67	Power line across levee to service pole with meter on waterside slope of levee	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
419	5	409+00 to 424+00			Taylor Brothers. 15 Inch Irrigation Main located within 15 feet of landside toe	Cutoff wall	The pipeline is within twenty (20) feet of the levee toe and does not meet Title 23. **Relocate outside of of the proposed right-of-way.**	IR (G)	
420	~~5~~	~~417+66~~	~~Not Verified~~		~~Abandon Existing 24 inch pipe through levee. The permit was revised to removal of 24 inch via 4666A so there should not be any pipe.~~	~~Cutoff wall~~		~~SD(G)~~	
	4/5	410+67			Reach 4/5 Transition	Cutoff wall			
421	4	410+53	2,121,173.09	66,776,661.21	Power line crossing to Feather Water District Pumps	Cutoff wall		EL	OH
422	4	409+84	2,121,105.29	6,677,660.77	To install a 2 inch electrical conduit through the levee. The conduit will be buried in the levee slopes and through the crown with one foot of cover. The conduit will provide electrical service to an existing pumping plant in the floodway of the Feather River.	Cutoff wall	The conduit may meet title 23 requirements but will need to be replaced during cutoff wall construction. **Replace in accordance with USACE standard**	EL	2.0
423	4	409+66	2,121,086.77	6,677,660.88	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	0.8
424	4	409+62	2,121,082.47	6,677,660.77	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	0.9
425	4	409+58	2,121,078.48	6,677,660.82	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	0.8
426	4	409+55	2,121,075.08	6,677,660.80	Taylor Brothers Farm Irrigation Pump Station. A inclined pump located on the waterside slope of levee with 14 Inch Pipeline through levee	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.4
427	4	409+50	2,121,069.88	6,677,660.77	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.7

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
428	4	407+72	2,120,892.86	6,677,656.42	Abandoned pipe and structure at landside toe, pipe is 8 inch, but the headwall appears that it is ran through a larger older pipe possibly and old drainage pipe.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	21.8
429	4	407+72	2,120,892.86	6,677,656.42	Taylor Brothers Production Water Well (facilities located at levee toe).	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	well	
430	4	396+32	2,119,752.28	6,677,651.86	8 inch pipe crossing. Headwall at land toe, art on land side of crown, and cut pipe near water side toe. CVFPB sent a notice of violation notice on October 4, 2011.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(P)	4.1
431	4	396+30 to 409+00			Taylor Brothers. 15 inch Irrigation Main located within 15 feet of landside toe.	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	IR (G)	
432	4	396+50 to 409+00			Feather Water District. 42 Inch Irrigation Main located within 10 feet of landside toe with standpipes.	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	IR (G)	
433	4	396+20			Feather Water District Irrigation Production Well (facilities located 10 foot west of toe). CVFPB sent a notice of violation notice on October 4, 2011.	Cutoff Wall		well	
434	4	386+63	2,118,786.69	6,677,704.40	Abandon 8 inch pipe crossing, stand pipe on land toe has been destroyed. CVFPB sent a notice of violation on October 4, 2011.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	4.6
435	4	365+00	2,116,703.78	6,678,265.36	Abandon 8 inch pipe crossing, stand pipe on land toe has been removed.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	4.8
436	4	342+21	2,114,521.83	6,678,856.40	Irrigation Production Well (located xx foot west of levee toe)	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	well	
437	4	320+00			Approximately 500 horizontal feet of vertical excavation in the levee toe, cut 1 to 3 feet high. CVFPB sent out a encroachment violation notice on July 27, 2011 to Monasterio Family Trust.	Cutoff Wall		struc	
438	4	313+00			Approximately 100 horizontal feet of vertical excavation in the levee toe, cut about 3 feet high. Toe excavations are eroding and caving. CVFPB sent out a encroachment violation notice on September 12, 2011 to Monasterio Family Trust.	Cutoff Wall		struc	
	3/4	300+66			Reach 3/4 Transition				
439	3	298+89	2,110,314.83	6,679,535.86	Removal of a portion and filling with concrete a portion of an abandoned 36 inch steel pipe through the right bank levee of the Feather River	Cutoff wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(G)	
440	3	298+00			Approximately 600 horizontal feet of vertical excavation in the levee toe, cut 1 to 3 feet high. Toe excavations are eroding and caving. The CVFPB sent an encroachment violation notice on July 27, 2011 to Golden Gate Hop Ranch, Inc.	Cutoff wall		struc	
441	3	298+67	2,110,292.12	6,679,458.78	Garden Highway Mutual Water - Irrigation Production Well #23 (located 30 foot west of levee toe)	Cutoff wall		IR(W)	
442	3	298+38	2,110,262.81	6,679,553.51	Garden Highway Mutual Water 54 inch Irrigation Pump Station Discharge Pipeline through Levee. The improvements include a inlet channel from the river to the 200 feet from waterside toe of levee and irrigation canal at the toe of the landside of levee.	Cutoff wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed and new pipe. **Replace in accordance with USACE standard.**	IR(G)	25.1
	3	280+90			State Maintenance Area 3 / Levee District No. 1 Levees Transition	Cutoff wall			
443	3	279+50			Garden Highway Mutual Water - Irrigation Production Well #4 (located 90 foot west of levee toe)	Cutoff wall		IR(W)	
444	3	274+50			Garden Highway Mutual Water - Irrigation Production Well #22 (located 20 foot west of levee toe)	Cutoff wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	IR(W)	

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
445	3	241+75			Garden Highway Mutual Water - Irrigation Production Well #18 (located 50 foot west of levee toe)	Cutoff wall		IR(W)	
446	3	219+00			Garden Highway Mutual Water - Irrigation Production Well #19 (located 90 foot west of levee toe)	Cutoff wall with seepage berm		IR(W)	
447	3	219+00			12 inch pipe. Appears to be removed by pipe laying on ground adjacent to location	Cutoff wall with seepage berm	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	
	2/3	218+66			Reach 2/3 Transition				
448	2	209+89	2,101,737.07	6,678,031.40	Electrical service crossing for pump	Cutoff wall with seepage berm	**Relocate outside of of the proposed right-of-way**	EL	3.0
449	2	209+23	2,101,673.35	6,678,014.21	Kuster Private Irrigation Pump Station. 14 inch welded steel pipe crossing	Cutoff wall with seepage berm	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed and new pipe. **Replace in accordance with USACE standard**	IR(P)	3.0
450	2	217+00			National Audubon Society. To plant approximately 4,000 native trees on 40 acres within the right bank overflow area of the Feather River	Cutoff wall with seepage berm		Trees	
451	2	215+00			National Audubon Society. To plant approximately 300 to 500 native trees (primarily cottonwoods) on the right bank overflow area of the Feather River	Cutoff wall with seepage berm		Trees	

Type 1A - Removal & Disposal of Abandoned Raised Pipe

Type 1B - Removal & Disposal of Abandoned Through Pipe

Type 2A - Removal & Replace of Raised Pipe

Type 2B - Removal & Replace of Through Pipe

Type 3A - Removal & Replace of Raised Pipe Adjacent to Canal

Type 3B - Removal & Replace of Through Pipe Adjacent to Canal

Type 3C - Removal & Replace of Through Pipe Under Canal

Vegetation ETL Compliance

Relocation of Utility/Structure Outside of The Proposed ROW

Additional Works

Not Applicable/No Rehabilitation Required

SD(G)	Storm Water - Gravity
SD(P)	Storm Water - Pressure
SS (G)	Waste Water - Gravity
SS (P)	Waste Water - Pressure
IR(G)	Irrigation Line - Gravity
IR(P)	Irrigation Line - Pressure
RW (P)	Raw Water - Pressure
W(P)	Water Line - Pressure
RD	
GL	Gas Line
TL	Telephone Line

TABLE 4-3 ALTERNATIVE SB7 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover

EL Electrical Line
SEEP
STRUC Structure

Table 4-4A Summary of Construction Contracts for Alternative SB7

Features	Contract A Reach 2A-North to 5 180+00 to 478+68 2020 - 2021	Contract SBFIP Reach 6 478+68 to 512+00 2019 – 2020	Contract B Reach 7 to 12 512+00 to 845+00 2019 - 2020	Contract C1 Reach 13 to 18 845+00 to 1213+85 2017 – 2018	Contract C2 Reach 19 to 21 1213+85 to 1433+83 2017 – 2018
No Rehabilitation Required	N/A	N/A	1,300LF	14,930LF	N/A
Cutoff Wall Only	22,200LF	3,340LF	26,150LF	11,490LF	21,520LF
Jet Grouting Cutoff Wall Only	N/A	N/A	N/A	560LF	N/A
Seepage Berm Only	N/A	N/A	N/A	350LF	N/A
Cutoff Wall with Full Levee Degrade	N/A	N/A	N/A	N/A	N/A
Cutoff Wall with Full Levee Degrade and Existing Relief Wells	N/A	N/A	N/A	5,300LF	N/A
Cutoff Wall with Existing Relief Wells	N/A	N/A	3,300LF	2,630LF	N/A
Cutoff Wall with New Relief Wells (22 Wells)	N/A	N/A	2,500LF	N/A	N/A
Cutoff Wall with Seepage Berm	7,670LF	N/A	N/A	N/A	N/A
Cutoff Wall with Levee Relocation	N/A	N/A	N/A	N/A	N/A
Cutoff Wall with Sutter Butte Canal Relocation	N/A	N/A	N/A	N/A	370LF
Cutoff Wall with Landside Toe Fill	N/A	N/A	N/A	1,870LF	N/A
DSM Cutoff Wall (subpart of the Cutoff Wall Only area)	2,000LF	N/A	N/A	2,630LF	2,400LF
Erosion Protection	N/A	N/A	5,760LF	N/A	N/A
Utilities & Encroachments (Total, Table 4-4B)	37	12	46	129	45
Utilities & Encroachments (To be modified, Table 4-4B)	27	4	19	53	20
Land Acquisition					
Number of Impacted Parcel					
Number of Potential Structural Demolition					
Closure Structure	N/A	N/A	N/A	1	N/A

Table 4-4B Summary of Utilities & Encroachments for Construction Contracts

Color Codes	Types of Remediation	Alt. SB7	Construction Contracts				
			A	SBFIP	B	C1	C2
		Item No. 1 - 451	Item No. 415 - 451	Item No. 403 - 414	Item No. 357 - 402	Item No. 228 - 356	Item No. 142 - 227
	Type 1A - Removal & Disposal of Abandoned Raised Pipe	**16**	6	0	3	6	1
	Type 1B - Removal & Disposal of Abandoned Through Pipe	**3**	2	0	0	1	0
	Type 2A - Removal & Replace of Raised Pipe	**47**	7	0	9	25	6
	Type 2B - Removal & Replace of Through Pipe	**1**	1	0	0	0	0
	Type 3A - Removal & Replace of Raised Pipe Adjacent to Canal	**0**	0	0	0	0	0
	Type 3B - Removal & Replace of Through Pipe Adjacent to Canal	**0**	0	0	0	0	0
	Type 3C - Removal & Replace of Through Pipe Under Canal	**0**	0	0	0	0	0
	Vegetation ETL Compliance	**10**	3	1	0	0	6
	Relocation of Utility/Structure Outside of The Proposed ROW	**40**	8	1	7	18	6
	Additional Works	**6**	0	2	0	3	1
	Not Applicable/No Rehabilitation Required	**146**	10	8	27	76	25
Total Number of Utilities & Encroachments		**269**	37	12	46	129	45
Total Number of Utilities & Encroachments To Be Modified		**123**	27	4	19	53	20

Table 4-5 Borrow Sites and Usage for SB-7	Volume of Material (Potential)		
Borrow Sites and Usage	Type 1 (cy)	Type 2 (cy)	Random (cy)
2 - CDFG (OWA - Cobble Borrow)			330,800
3 - Live Oak Detention Basin	150,000		
4 - Lanza 235 Borrow	250,000		
5 - Nevis Property	250,000		
Left over after borrow for C2 - as type 1	197,900		
Left over after borrow for C2 - as type 2	184,400		
Left over after using borrow for C1 - as type 1	66,445		
Left over after using borrow for C1 - as type 2	53,102		
7 - Lanza 620 Acres Property	119,932	359,796	
Left over after using borrow for A - as type 1	948	19,986	
Left over after using borrow for A - as type 2			
8 - Huston Property	330,000		
Left over after using borrow for B - as type 1	199,279		
Left over after using borrow for B - as type 2	33,687		
11 - Siller Live Oak Property	250,000		
12 - Siller Yuba City Property		100,000	
Left over after borrow for SBFIP - as type 2		53,200	
Total Potential	1,349,932	459,796	330,800

Table 4-6 Borrow Demand for SB-7	Volume of Material (Demand)		
Borrow Sites and Usage	Type 1 (cy)	Type 2 (cy)	Random (cy)
CONTRACT A	118,984	339,810	
7 - Lanza 620 Acres Property	118,984	339,810	
CONTRACT STAR BEND (SBFIP)		46,800	
12 - Siller Yuba City Property		46,800	
CONTRACT B	130,721	165,592	
8 - Huston Property	130,721	165,592	
CONTRACT C1	117,955	13,343	
5 - Nevis Property	117,955	13,343	
CONTRACT C2	52,100	13,500	
5 - Nevis Property	52,100	13,500	
Total Demand	419,760	579,045	0

Table 5-1A Summary of Project Features for SB8

	Feature Description	Quantity
Alternative SB8 Reach 2A-North to 41 180+00 to 2688+00 2017 - 2023	No Modification Required	28,220LF
	Cutoff Wall Only	147,570LF
	Jet Grouting Cutoff Wall Only	960LF
	Seepage Berm Only	5,350LF
	Cutoff Wall with Full Levee Degrade and Existing Relief Wells	5,300LF
	Cutoff Wall with Full Levee Degrade	600LF
	Cutoff Wall with Existing Relief Wells	5,930LF
	Cutoff Wall with New Relief Wells (22 Wells)	2,500LF
	Cutoff Wall with Seepage Berm	7,670LF
	Cutoff Wall with Levee Relocation	11,610LF
	Cutoff Wall with Sutter Butte Canal Relocation	1,540LF
	Cutoff Wall with Landside Toe Fill	1,870LF
	DSM Cutoff Wall (subpart of the Cutoff Wall Only area)	19,790LF
	Erosion Protection	7,660LF
	Utilities and Encroachments (Total)	451
	Utilities and Encroachments (To be modified)	223
	Land Acquisition	2,196AC
	Impacted Parcel	468
	Potential Structural Demolition	34
	Closure structures (stop logs)	1

Table 5-1B Summary of Project Features for Alternative SB8

Engineering Appendix Paragraph	Measure	Typical Section (Plate)	Segment	Contract	Beg. STA of Measure	End. STA of Measure	Length per Segment (LF)	Length per Contract (LF)	Length per Measure (LF)
5.2.1	No Rehabilitation Required	-	1	B	831+50	844+50	1,300	1,300	
	No Rehabilitation Required	-	2	C1	923+75	1006+24	8,249		
	No Rehabilitation Required	-	3	C1	1007+70	1024+00	1,630		
	No Rehabilitation Required	-	4	C1	1027+50	1078+00	5,050	14,930	
	No Rehabilitation Required	-	5	C2	1625+00	1673+00	4,800	4,800	
	No Rehabilitation Required	-	6	D1	1769+40	1813+30	4,390	4,390	
	No Rehabilitation Required	-	7	D2	2303+00	2331+00	2,800	2,800	28,220
5.2.2	Cutoff Wall Only	G-2A	1	A	231+00	453+00	22,200	22,200	
	Cutoff Wall Only	G-2A	2	SBFIP	478+68	512+00	3,332	3,340	
	Cutoff Wall Only	G-2A	3	B	570+00	831+50	26,150	26,150	
	Cutoff Wall Only	G-2A	4	C1	1078+00	1096+00	1,800		
	Cutoff Wall Only	G-2A	5	C1	1098+10	1107+00	890		
	Cutoff Wall Only	G-2A	6	C1	1125+70	1129+99	429		
	Cutoff Wall Only	G-2A	7	C1	1130+20	1213+85	8,365	11,490	
	Cutoff Wall Only	G-2A	7	C2	1213+85	1429+00	21,515		
	Cutoff Wall Only	G-2A	8	C2	1451+50	1455+00	350		
	Cutoff Wall Only	G-2A	9	C2	1461+00	1608+50	14,750		
	Cutoff Wall Only	G-2A	10	C2	1624+70	1625+00	30		
	Cutoff Wall Only	G-2A	11	C2	1673+00	1673+30	30	36,680	
	Cutoff Wall Only	G-2A	12	D1	1766+00	1769+40	340		
	Cutoff Wall Only	G-2A	13	D1	1813+30	1900+50	8,720		
	Cutoff Wall Only	G-2A	14	D1	1903+50	2122+00	21,850	30,910	
	Cutoff Wall Only	G-2A	14	D2	2122+00	2290+00	16,800	16,800	147,570
5.2.3	Jet Grouting Cutoff Wall Only	G-2A	1	C1	1006+04	1007+90	186		
	Jet Grouting Cutoff Wall Only	G-2A	2	C1	1095+80	1098+30	250		
	Jet Grouting Cutoff Wall Only	G-2A	3	C1	1129+50	1130+67	117	560	
	Jet Grouting Cutoff Wall Only	G-2A	4	D1	1900+00	1904+00	400	400	960
5.2.4	Seepage Berm Only	G-2B	1	C1	1024+00	1027+50	350	350	
	Seepage Berm Only	G-2B	2	D2	2290+00	2303+00	1,300		
	Seepage Berm Only	G-2B	3	D2	2331+00	2368+00	3,700	5,000	5,350
5.2.5	Cutoff Wall with Full Levee Degrade and Existing Relief Wells	G-2D	1	C1	844+50	897+50	5,300	5,300	5,300
5.2.5	Cutoff Wall with Full Levee Degrade	G-2D	2	C2	1455+00	1461+00	600	600	600
5.2.6	Cutoff Wall with Existing Relief Wells	G-2C	1	B	512+00	545+00	3,300	3,300	
	Cutoff Wall with Existing Relief Wells	G-2C	3	C1	897+50	923+75	2,625	2,630	5,930
5.2.6	Cutoff Wall with New Relief Wells	G-2C	2	B	545+00	570+00	2,500	2,500	2,500
5.2.7	Cutoff Wall with Seepage Berm	G-2C	1	A	180+00	231+00	5,100		
	Cutoff Wall with Seepage Berm	G-2C	2	A	453+00	478+68	2,568	7,670	7,670

Table 5-1B Summary of Project Features for Alternative SB8

Engineering Appendix Paragraph	Measure	Typical Section (Plate)	Segment	Contract	Beg. STA of Measure	End. STA of Measure	Length per Segment (LF)	Length per Contract (LF)	Length per Measure (LF)
5.2.8	Cutoff Wall with Levee Relocation	G-2E	1	C2	1432+70	1451+50	1,880		
	Cutoff Wall with Levee Relocation	G-2E	2	C2	1608+50	1624+70	1,620		
	Cutoff Wall with Levee Relocation	G-2E	3	C2	1673+30	1674+37	107	3,610	
	Cutoff Wall with Levee Relocation	G-2E	3	D1	1674+37	1754+30	7,993	8,000	11,610
5.2.9	Cutoff Wall with Sutter Butte Canal Relocation	G-2F	1	C2	1429+00	1432+70	370	370	
	Cutoff Wall with Sutter Butte Canal Relocation	G-2F	2	D1	1754+30	1766+00	1,170	1,170	1,540
5.2.10	Cutoff Wall with Landside Toe Fill	G-2G	1	C1	1107+00	1125+70	1,870	1,870	1,870
5.2.11	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	1	A	230+00	250+00	2,000	2,000	
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	2	C1	1125+00	1129+99	499		
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	3	C1	1130+20	1151+50	2,130	2,630	
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	4	C2	1224+00	1248+00	2,400	2,400	
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	5	D1	1987+25	2002+00	1,475		
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	6	D1	2016+75	2036+75	2,000		
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	7	D1	2067+00	2088+00	2,100	5,580	
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	8	D2	2137+00	2148+00	1,100		
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	9	D2	2182+00	2196+50	1,450		
	DSM Cutoff Wall (already included in the Cutoff Wall Only section)	G-2A	10	D2	2245+75	2292+00	4,625	7,180	19,790
5.2.12	Erosion Protection	-	1	B	547+00	604+60	5,760	5,760	
	Erosion Protection	-	2	C2	1582+00	1601+00	1,900	1,900	7,660
5.2.13	Closure Structure (Stop Log)	-	1	C1	1130+00	1130+00	-	-	-

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
2A North	180+00 to 202+50	2,250	Cutoff wall with undrained seepage berm	180+00 to 202+50: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 180+00 to 202+50: Cutoff wall extending to an elevation of 25 ft.	
2B	202+50 to 218+66	1,616	Cutoff wall with undrained seepage berm	180+00 to 218+66: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 202+50 to 218+66: Cutoff wall extending to an elevation of 25 ft.	
3	218+66 to 300+66	8,200	Cutoff wall Cutoff wall with undrained seepage berm	218+66 to 231+00: 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 218+66 to 230+00: Cutoff wall extending to an elevation of 25 ft. 230+00 to 250+00: Cutoff wall extending to an elevation of -35 ft. 250+00 to 289+00: Cutoff wall extending to an elevation of -20 ft. 289+00 to 300+66: Cutoff wall extending to an elevation of -12 ft.	
4	300+66 to 410+67	11,001	Cutoff wall	300+66 to 312+00: Cutoff wall extending to an elevation of -12 ft. 312+00 to 349+00: Cutoff wall extending to an elevation of 15 ft. 349+00 to 368+00: Cutoff wall extending to an elevation of 10 ft. 368+00 to 410+67: Cutoff wall extending to an elevation of 20 ft.	

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
5	410+67 to 478+68	6,801	Cutoff wall Cutoff wall with undrained seepage berm	453+00 to 478+00: 300 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 410+67 to 417+00: Cutoff wall extending to an elevation of 20 ft. 417+00 to 425+00: Cutoff wall extending to an elevation of 10 ft. 425+00 to 456+00: Cutoff wall extending to an elevation of 15 ft. 456+00 to 475+35: Cutoff wall extending to an elevation of 15 ft. 475+35 to 478+68: Cutoff wall extending to an elevation of 15 ft.	
6 FIP	478+68 to 512+00	3,332	Cutoff wall	478+68 to 512+00: 65ft deep (from degrade line) cutoff wall.	
7	512+00 to 596+00	8,563	Cutoff wall Cutoff wall with existing and new relief wells Erosion Protection	512+00 to 514+00: 65ft deep (from degrade line) cutoff wall. 514+00 to 526+00: Cutoff wall tip elevation +15 feet 526+00 to 570+00: Cutoff wall tip elevation -5 feet 545+00 to 570+00: 22 new relief wells at 120 feet spacing and 50 feet depth (including new concrete lined V-ditch). 570+00 to 575+00: Cutoff wall tip elevation -5 feet 575+00 to 595+00: Cutoff wall tip elevation -10 feet 595+00 to 596+00: Cutoff wall tip elevation +15 feet 547+00 to 596+00: High Performance Turf Reinforce Mat (HPTRM)	512+00 to 545+00: existing seepage interceptor system (24 relief wells, ditch and pump station) are to remain.
8	596+00 to 654+75	5,875	Cutoff wall Erosion Protection	596+00 to 654+75: Cutoff wall tip elevation +15 feet 596+00 to 604+60: High Performance Turf Reinforce Mat (HPTRM)	

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
9	654+75 to 706+50	5,175	Cutoff wall	654+75 to 670+00: Cutoff wall tip elevation +15 feet 670+00 to 697+00: Cutoff wall tip elevation +20 feet 697+00 to 706+50: Cutoff wall tip elevation -10 feet	
10	706+50 to 774+00	6750	Cutoff wall	706+50 to 726+00: Cutoff wall tip elevation -10 feet 726+00 to 746+00: Cutoff wall tip elevation -5 feet 746+00 to 754+50: Cutoff wall tip elevation +5 feet 754+50 to 774+00: Cutoff wall tip elevation +25 feet	
11	774+00 to 830+00	5,600	Cutoff wall	774+00 to 784+50: Cutoff wall tip elevation +25 feet 784+50 to 827+50: Cutoff wall tip elevation -5 feet 827+50 to 830+00: Cutoff wall tip elevation +25 feet	
12	830+00 to 845+00	1,500	No proposed rehabilitation measure with exception below Cutoff wall (transition only, at both ends of this reach)	830+00 to 831+50: Cutoff wall tip elevation +25 feet (transition only) 844+50 to 845+00: Cutoff wall tip elevation -26 feet (transition only)	829+85 to 845+25: existing cutoff wall (23.5ft deep, tip elevation 30.5)
13	845+00 to 927+00	8,200	Cutoff wall Cutoff wall with full levee degrade and existing relief wells	844+50 to 897+50: Full levee degrade and re-construction 844+50 to 849+00: Cutoff wall tip elevation -20' to -29' 848+00 to 863+00: Cutoff wall tip elevation -29' 863+00 to 877+00: Cutoff wall tip elevation -30' 877+00 to 887+00: Cutoff wall tip elevation -31' 887+00 to 893+00: Cutoff wall tip elevation -30' 893+00 to 897+50: Cutoff wall tip elevation -29' 897+50 to 923+75: Cutoff wall tip elevation +25'	844+50 to 897+50: Existing seepage interceptor system (52 relief wells, ditch and pump stations) are to remain. 897+50 to 923+75: Existing seepage interceptor system (29 relief wells, ditch and pump stations) are to remain. 923+23 to 927+00: existing cutoff wall (32.5ft deep, tip elevation 42.5)

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
14	927+00 to 954+40	2,740	No proposed rehabilitation measure	---	927+00 to 954+40: existing cutoff wall (32.5ft deep, tip elevation 42.5) No as-built drawing available for the existing cutoff wall.
15	954+40 to 968+50	1,410	No proposed rehabilitation measure	---	954+40 to 968+50: existing cutoff wall (32.5ft deep, tip elevation 42.5) No as-built drawing available for the existing cutoff wall.

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
16	968+50 to 1080+00	11,150	Jet grouting cutoff wall at 5th Street bridge crossing. Toe berm at 10th Street bridge crossing. Cutoff wall (transition only, at the end of Reach 16 to overlap existing cutoff wall).	1006+04 to 1007+90 (5th Street bridge crossing): Jet grouting cutoff wall tip elevation +40 feet 1023+90 to 1027+50 (10th Street bridge crossing): Toe berm, 23 feet wide, approximately 7 feet thick at the levee toe, 4H:1V slope at toe berm. 1077+85 to 1080+00: Cutoff wall tip elevation +30 feet and backfill landside toe depression (transition only).	968+50 to 983+23: existing cutoff wall (32.5ft deep, tip elevation 42.5) 983+23 to 996+23: existing cutoff wall (22.5ft deep, tip elevation 52.5) 996+23 to 1006+24: existing cutoff wall (32.5ft deep, tip elevation 42.5) 1007+90 to 1015+70: existing cutoff wall (32.5ft deep, tip elevation 42.5) 1015+70 to 1024+42: existing cutoff wall (43ft deep, tip elevation 35) 1026+99 to 1079+66: existing cutoff wall (39ft deep, tip elevation 38)

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Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
17	1080+00 to 1130+86	5,086	Cutoff wall Jet grouting cutoff wall at Yuba city water treatment plant Jet grouting cutoff wall at Railroad North of Yuba City Landside toe depression filled Closure Structure	1107+00 to 1125+70: Backfill landside toe depression 1080+00 to 1089+00: Cutoff wall tip elevation +30 feet 1089+00 to 1096+00: Cutoff wall tip elevation +35 feet 1095+80 to 1098+30: Jet grouting cutoff wall tip elevation +35 feet 1098+10 to 1125+00: Cutoff wall tip elevation +35 feet 1125+00 to 1129+99: Cutoff wall tip elevation +0 feet 1129+50 to 1130+67: Jet grouting cutoff wall tip elevation +0 feet 1130+20 to 1130+86: Cutoff wall tip elevation +0 feet 1130+00: Stop log closure structure or equivalence	
18	1130+86 to 1213+85	8,299	Cutoff wall	1130+86 to 1151+50: Cutoff wall tip elevation +0 feet 1151+50 to 1159+50: Cutoff wall tip elevation +30 feet 1159+50 to 1169+50: Cutoff wall tip elevation +25 feet 1169+50 to 1189+50: Cutoff wall tip elevation +30 feet 1189+50 to 1209+50: Cutoff wall tip elevation +40 feet 1209+50 to 1213+85: Cutoff wall tip elevation +35 feet	
19	1213+85 to 1297+83	8,398	Cutoff wall	1213+85 to 1219+75: Cutoff wall tip elevation +35 feet 1219+75 to 1224+00: Cutoff wall tip elevation +5 feet 1224+00 to 1238+00: Cutoff wall tip elevation -28 feet 1238+00 to 1248+00: Cutoff wall tip elevation -42 feet 1248+00 to 1268+75: Cutoff wall tip elevation +3 feet 1268+75 to 1297+83: Cutoff wall tip elevation +35 feet	
20	1297+83 to 1374+33	7,650	Cutoff wall	1297+83 to 1298+75: Cutoff wall tip elevation +35 feet 1298+75 to 1359+00: Cutoff wall tip elevation +50 feet 1359+00 to 1369+00: Cutoff wall tip elevation +40 feet 1369+00 to 1374+33: Cutoff wall tip elevation +32 feet	

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
21	1374+33 to 1433+83	5,950	Cutoff wall Levee relocation with cutoff wall (transition only) Canal relocation	1374+33 to 1386+50: Cutoff wall tip elevation +32 feet 1386+50 to 1408+50: Cutoff wall tip elevation +55 feet 1408+50 to 1433+83: Cutoff wall tip elevation +40 feet 1432+50 to 1433+83: Levee relocation (20ft riverward, transition only) 1429+00 to 1433+83 Sutter Butte Main Canal relocation.	
22	1433+83 to 1503+83	7,000	Cutoff wall Cutoff wall with full levee degrade Levee relocation with cutoff wall	1433+83 to 1450+00: Levee relocation (20ft riverward) 1451+50 to 1451+50: Levee relocation (20ft riverward, transition only) 1455+00 to 1461+00: Full levee degrade and re-construction 1433+83 to 1448+75: Cutoff wall tip elevation +40 feet 1448+75 to 1468+83: Cutoff wall tip elevation +50 feet 1468+83 to 1503+83: Cutoff wall tip elevation +55 feet	Full levee degrade and reconstruction recommended for a portion of this reach due to severe animal burrowing
23	1503+83 to 1609+37	10,554	Cutoff wall Levee relocation with cutoff wall (transition only) Erosion Protection	1503+83 to 1508+50: Cutoff wall tip elevation +55 feet 1508+50 to 1528+75: Cutoff wall tip elevation +60 feet 1528+75 to 1566+50: Cutoff wall tip elevation +55 feet 1566+50 to 1608+75: Cutoff wall tip elevation +60 feet 1608+50 to 1609+37: Levee relocation (20ft riverward, transition only) 1582+00 to 1601+00: High Performance Turf Reinforce Mat (HPTRM)	
24	1609+37 to 1623+86	1,449	Cutoff wall Levee relocation with cutoff wall	1609+37 to 1612+00: Levee relocation (20ft riverward, transition only) 1612+00 to 1623+00: Levee relocation (20ft riverward) 1623+00 to 1623+86: Levee relocation (20ft riverward, transition only) 1608+75 to 1623+86: Cutoff wall tip elevation +28 feet	

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
25	1623+86 to 1674+37	5,051	No proposed rehabilitation measure with exception below Cutoff wall (transition only, at both ends of this reach) Levee relocation with cutoff wall (transition only)	1623+86 to 1624+50: Levee relocation (20ft riverward, transition only) 1623+86 to 1625+00: Cutoff wall tip elevation +28 feet (transition only) 1673+00 to 1674+37: Cutoff wall tip elevation +65 feet (transition only) 1673+00 to 1674+37: Levee relocation (20ft riverward, transition only)	
26	1674+37 to 1707+11	3,274	Cutoff wall Levee relocation with cutoff wall	1674+37 to 1675+00: Levee relocation (20ft riverward, transition only) 1675+00 to 1707+11: Levee relocation (20ft riverward) 1674+37 to 1707+11: cutoff wall tip elevation +65 feet	Cutoff wall tip elevations to be confirmed by additional exploration (planned)
27	1707+11 to 1721+60	1,449	Cutoff wall Levee relocation with cutoff wall	1707+11 to 1721+60: Levee relocation (20ft riverward) 1707+11 to 1721+60: cutoff wall tip elevation +65 feet	Cutoff wall tip elevations to be confirmed by additional exploration (planned)
28	1721+60 to 1769+31	4,771	Cutoff wall Canal relocation Levee relocation with cutoff wall	1721+60 to 1753+00: Levee relocation (20ft riverward) 1753+00 to 1754+50: Levee relocation (20ft riverward, transition only) 1752+00 to 1766+00: Sutter Butte Main Canal Relocation 1721+60 to 1727+75: cutoff wall tip elevation +65 feet 1727+75 to 1748+50: cutoff wall tip elevation +75 feet 1748+50 to 1769+31: cutoff wall tip elevation +45 feet	Cutoff wall tip elevations to be confirmed by additional exploration (planned)
29	1769+31 to 1813+33	4,402	No proposed rehabilitation measure	---	No proposed rehabilitation measure as existing conditions meet criteria

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
30	1813+33 to 1902+00	8,867	Cutoff wall Jet grouting cutoff wall	1813+33 to 1816+50: cutoff wall tip elevation +80 feet 1816+50 to 1848+25: cutoff wall tip elevation +30 feet 1848+25 to 1866+00: cutoff wall tip elevation +70 feet 1866+00 to 1877+75: cutoff wall tip elevation +47 feet 1877+75 to 1883+00: cutoff wall tip elevation +40 feet 1883+00 to 1900+50: cutoff wall tip elevation +27 feet 1900+00 to 1902+00: jet grouting cutoff wall tip elevation +27 feet	Waterside slope maintenance to address sloughing of steep channel bank slopes may be required in the future.
31	1902+00 to 1958+00	5,600	Cutoff wall Jet grouting cutoff wall	1902+00 to 1904+00: jet grouting cutoff wall tip elevation +27 feet 1903+50 to 1907+50: cutoff wall tip elevation +27 feet 1907+50 to 1917+50: cutoff wall tip elevation +44 feet 1917+50 to 1927+50: cutoff wall tip elevation +75 feet 1927+50 to 1937+00: cutoff wall tip elevation +50 feet 1937+00 to 1958+00: cutoff wall tip elevation +40 feet	
32	1958+00 to 1989+00	3,100	Cutoff wall	1958+00 to 1971+00: cutoff wall tip elevation +40 feet 1971+00 to 1987+25: cutoff wall tip elevation +48 feet 1987+25 to 1989+00: cutoff wall tip elevation +10 feet	
33	1989+00 to 2122+00	13,300	Cutoff wall	1989+00 to 2002+00: cutoff wall tip elevation +10 feet 2002+00 to 2016+75: cutoff wall tip elevation +90 feet 2016+75 to 2036+75: cutoff wall tip elevation +20 feet 2036+75 to 2041+00: cutoff wall tip elevation +53 feet 2041+00 to 2067+00: cutoff wall tip elevation +38 feet 2067+00 to 2088+00: cutoff wall tip elevation +33 feet 2088+00 to 2122+00: cutoff wall tip elevation +90 feet	

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
34	2122+00 to 2182+00	6,000	Cutoff wall	2122+00 to 2137+00: cutoff wall tip elevation +90 feet 2137+00 to 2148+00: cutoff wall tip elevation +20 feet 2148+00 to 2164+00: cutoff wall tip elevation +90 feet 2164+00 to 2182+00: cutoff wall tip elevation +50 feet	
35	2182+00 to 2224+00	4,200	Cutoff wall	2182+00 to 2196+50: cutoff wall tip elevation +40 feet 2196+50 to 2212+00: cutoff wall tip elevation +45 feet 2212+00 to 2218+25: cutoff wall tip elevation +50 feet 2218+25 to 2224+00: cutoff wall tip elevation +55 feet	
36	2224+00 to 2259+00	3,500	Cutoff wall	2224+00 to 2233+50: cutoff wall tip elevation +55 feet 2233+50 to 2258+25: cutoff wall tip elevation +70 feet 2258+25 to 2259+00: cutoff wall tip elevation +42 feet	
37	2259+00 to 2290+00	3,100	Cutoff wall	2259+00 to 2277+00: cutoff wall tip elevation +42 feet 2277+00 to 2290+00: cutoff wall tip elevation +45 feet	
38	2290+00 to 2303+00	1,300	Seepage berm Seepage berm with cutoff wall (transition only, extend from Reach 37 into Reach 38,)	2290+00 to 2303+00: Seepage berm up to 11 foot high that extends horizontally at elevation 200 year + 4 feet for a distance of 50 feet from the landside slope of the levee before tapering to a height of 3 feet at the berm toe at a distance of 170 feet from the centerline of the existing levee. 2290+00 to 2292+00: Cutoff wall with tip elevation of +45 feet to (transition only).	Grading work to generate a level platform area will be required prior to construction of seepage berm
39	2303+00 to 2319+00	1,600	No proposed rehabilitation measure	---	No as-built drawing available for the existing cutoff wall.
40	2319+00 to 2359+00	4,000	Seepage Berm	2319+00 to 2331+00: No mitigation measure 2331+00 to 2335+00: Seepage berm 120 feet wide, 9 feet thick at the levee toe and 3 feet at the berm toe 2335+00 to 2359+00: Seepage berm 100 feet wide, 9 feet thick at the levee toe and 3 feet at the berm toe	Grading work to generate a level platform area will be required prior to construction of seepage berm

Table 5-2 Summary of Project Features for Alternative SB8

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
41	2359+00 to 2368+00	900	Seepage berm with filter drain	2359+00 to 2368+00: Seepage berm 100 feet wide, 5 feet thick at levee toe with a 1 foot thick filter layer (ASTM C33 fine aggregate) at bottom and across seepage berm. Seepage berm thickness of 5 feet includes 1 foot of filter layer and 4 feet of seepage berm material at levee toe. A geotextile separator, compatible with ASTM C33 fine aggregate, should be placed on top of the ASTM C33 fine aggregate layer.	Near Thermalito Afterbay dam and outfall facility and old Sutter Butte Canal channel

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
		2371+00			Hamilton Bend Levee Transition	Seepage berm			
	41	2368+00			End Reach 41	Seepage berm			
1	41	2365+00			To construct After bay River Outlet and dredge tailing training dike	Seepage berm		Struc	
2	41	2359+58	2,291,802.63	6,663,263.33	Old Sutter Butte Head Works Levee North	Seepage berm	The structure does not meet title 23 requirements. **Recommend Complete Removal**	IR(G)	
3	41	2359+57	2,291,800.70	6,663,265.27	Old Sutter Butte Head Works North	Seepage berm		IR(G)	
4	41	2359+07	2,291,752.42	6,663,249.77	Old Sutter Butte Head Works South	Seepage berm		IR(G)	
5	41	2359+05	2,291,752.84	6,663,244.36	Old Sutter Butte Head Works Levee South	Seepage berm		IR(G)	
	40/41	2359+00			Reach 40/41 Transition	Seepage berm			
6	40	2352+90	2,291,166.67	6,663,263.09	12 kv overhead electrical power line crossing	Seepage berm	**Relocate outside of of the proposed right-of-way.**	EL	OH
7	40	2352+80			24 Inch CM pipe through levee. Concrete saddle and apron with Calco Slide gate	Seepage berm	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	
8	40	2345+79	2,290,475.75	6,663,109.16	10 inch Iron Pipe through levee that appears to be abandoned	Seepage berm	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	12.7
	39/40	2319+00			Reach 39/40 Transition	No Rehabilitation Required			
9	39	2312+05			24 Inch CM pipe through levee. Concrete saddle and apron with Calco automatic drainage gate.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	
	38/39	2303+00			Reach 38/39 Transition	Seepage berm			
10	38	2301+00			To excavate dredger tailings from the right bank of the Feather River. The tailings are to be excavated from an area approximately 100 feet landward of the landward levee toe. **The application was deemed incomplete on 8-4-98.**	Seepage berm		Struc	
	37/38	2290+00			Reach 37/38 Transition	Cutoff wall			
	37	2285+00			Maintenance Area 07 / Hamilton Bend Levee Transition	Cutoff wall			
11	37	2283+65	2,285,659.90	6,661,586.51	24 Inch CM pipe through levee. Concrete saddle and apron with Calco automatic drainage gate.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	15.0
12	37	2283+44	2,285,640.25	6,661,593.28	24 Inch reinforced concrete encased CM irrigation pipe through levee. Slide Gate in 36 inch CM pipe riser on the waterside slope. 8 inch Irrigation pipe ran through existing pipe, pipe ends not exposed	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	17.3
13	37	2282+57	2,285,558.49	6,661,622.35	12 kv overhead electrical power line crossing	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
14	37	2281+75			Stairs and 1 Inch Domestic Water Line. Information Provided by Owner. Supplies water the Harder.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	DW (P)	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
15	37	2274+95	2,284,812.04	6,661,741.46	24 Inch CM pipe through levee. Automatic drainage gate on waterside outlet, headwall on land side inlet. Both ends of the pipe have been cleared to operate.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	17.8
16	37	2274+86	2,284,802.77	6,661,742.00	24 Inch CM reinforced concrete encased drainage pipe through levee. Slide Gate in 36 inch CM pipe riser on the waterside slope. Neither pipe end located or exposed.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	21.8
17	37	2268+27	2,284,144.45	6,661,772.03	24 Inch reinforced concrete encased CM irrigation pipe through levee. Slide Gate in 36 inch CM pipe riser on the waterside slope with waterside outlet broken off and plugged.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(G)	18.4
18	37	2265+50	2,283,868.22	6,661,784.45	12 kv overhead electrical power line crossing	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
19	37	2262+69	2,283,587.31	6,661,797.10	24 Inch CM drain pipe through levee with landside headwall. Automatic Drainage Gate on the waterside end with splash pan and saddle headwall.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	18.0
20	37	2262+14	2,283,532.17	6,661,800.26	Road Across Levee North	Cutoff Wall		Road	
21	37	2261+90	2,283,505.66	6,661,801.21	Road Across Levee South	Cutoff Wall		Road	
22	37	2261+56	2,283,474.37	6,661,801.73	Propane tank at landside toe	Cutoff Wall	**Recommended Removal**	struc	
23	37	2261+11	2,283,429.45	6,661,804.82	Propane tank at landside toe	Cutoff Wall	**Recommended Removal**	struc	
24	37	2260+55	2,283,374.22	6,661,809.27	24 Inch CM pipe through levee. Concrete saddle and apron with Calco automatic drainage gate.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	18.1
	36/37	2259+00			Reach 36/37 Transition	Cutoff wall			
25	36	2256+94	2,283,026.77	6,661,894.43	24 Inch CM pipe through levee. Concrete saddle and apron with Calco automatic drainage gate.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	17.1
26	36	2256+71	2,283,007.16	6,661,905.92	24 Inch reinforced concrete encased CM irrigation pipe through levee. Slide Gate in 36 inch CM pipe riser on the waterside slope. Neither pipe end located or exposed.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(G)	19.1
27	36	2270+00			To construct a 50 x 100 foot walnut processing building in the right overflow area of the Feather River	Cutoff Wall		Struc	
28	36	2250+76	2,282,559.01	6,662,297.09	24 Inch CM irrigation pipe through levee. Slide gate in 36 inch CM pipe riser on the waterside slope and slide gate in 48 inch RCP standpipe on landside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(G)	16.4
~~29~~	~~36~~	~~2250+10~~	~~2,282,500.09~~	~~6,662,339.63~~	~~Concrete structure in waterside slope of levee Removed~~	~~Cutoff Wall~~		~~struc~~	
30	36	2248+30	2,282,389.90	6,662,473.42	Underground telephone cable through levee at south side of paved road over levee	Cutoff Wall	Not sure if the conduit meets title 23 or 200 WSEL requirements. **Replace in accordance with USACE standard**	TL	
31	36	2245+52	2,282,232.77	6,662,762.59	24 Inch CM drain pipe through levee. Automatic Drainage Gate on the waterside end buried and not located.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	15.1

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
32	36	2239+66	2,281,676.83	6,662,766.65	24 Inch CM drain pipe through levee. Concrete headwall at both toes and automatic Drainage Gate in 36 inch concrete standpipe on berm. House near land toe, land end not located it could possibly be in house back yard.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	15.8
33	36				Excavation into toe of levee with cuts up to 4.5 feet high and near 1:1. The CVFPB sent an encroachment violation notice on August 17, 2011 to Deane and Edith Williams Trust.	Cutoff Wall		Struc	
	35/36	2224+00			Reach 35/36 Transition	Cutoff wall			
34	35	2216+71	2,280,223.64	6,663,692.84	12 Kv power line crossing of levee. One pole 215 feet water ward of levee toe with overhead clearance of 27 feet.	Cutoff Wall		EL	OH
35	35	2208+56	2,279,495.37	6,664,025.97	Irrigation well located near landside toe. Use temporary pipe to pump over levee. No standpipe and no permanent pipe over levee. Well Approx 10 feet from landside toe	Cutoff Wall	The temporary pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(G)	
36	35	2201+87	2,279,440.81	6,664,600.55	Abandoned 10 inch reinforced concrete encased steel irrigation pipe through levee. Slide gate in 24 inch concrete standpipe at the waterside toe. Pipe ends not located or exposed.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(G)	13.1
37	35	2182+45	2,277,854.11	6,665,182.53	Power pole at land side toe	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
	34/35	2182+00			Reach 34/35 Transition	Cutoff wall			
38	34	2178+48	2,277,831.66	6,665,565.26	To replace an existing buried telephone cable with aerial cable crossing of the right bank of the Feather River at the end of Cherry Road. The aerial telephone will be placed on an existing PG&E poles. Due to two right angle bends in the levee, the overhead cable will cross the levee crown at two locations within the extension	Cutoff Wall		EL	OH
39	34	2178+39	2,277,825.68	6,665,571.75	16 inch steel irrigation pipe through levee. Slide gate in 36 inch concrete standpipe at the waterside toe. Concrete distribution box at the landside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(G)	13.2
40	34				Excavation into toe of levee with cuts up to 3.5 feet high and near vertical around irrigation standpipes. The CVFPB sent an encroachment violation notice on September 12, 2011 to James Banes Ranch.	Cutoff Wall		Struc	
41	34				Excavation into toe of levee with cuts up to 3 feet high and near vertical. The CVFPB sent an encroachment violation notice on September 30, 2011 to Banes Family Trust.	Cutoff Wall		Struc	
42	34				Excavation into toe of levee with cuts up to 3 feet high. The CVFPB sent an encroachment violation notice on September 12, 2011 to James Banes Ranch.	Cutoff Wall		Struc	
43	34				Excavation into toe of levee with cuts up to 5 feet high and sloped 1:1. The CVFPB sent an encroachment violation notice on July 28, 2011 to Clinton & Gail Moffitt.	Cutoff Wall		Struc	
44	34				Excavation into toe of levee with cuts 3 to 5 feet high and sloped 1:1. The CVFPB sent an encroachment violation notice on July 28, 2011 to Clinton & Gail Moffitt.	Cutoff Wall		Struc	
45	34	2138+22	2,275,157.46	6,664,140.19	Power line crossing of levee and guy wire	Cutoff Wall		EL	OH
46	34	2127+33			To authorize an existing 2-inch irrigation pipeline through the right bank of the Feather Rivers. Removable pipe over levee found at 2120+50	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(F)	2.0
47	34				Excavation into toe of levee with near vertical cut up to 5 feet high. The CVFPB sent an encroachment violation notice on July 28, 2011 to Rodney Hodges.	Cutoff Wall		Struc	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
	33/34	2122+00			Reach 33/34 Transition	Cutoff wall			
48	33				Approximately 300 feet of excavation along the landside and waterside levee toe with cuts up to three (3) feet high. The CVFPB sent an encroachment violation notice on July 28, 2011 to Rodney Hodges.	Cutoff Wall		Struc	
49	33				Excavation into toe of levee from up to 3 feet high. The CVFPB sent an encroachment violation notice on July 28, 2011 to Rodney Hodges.	Cutoff Wall		Struc	
50	33				To plant a Kiwi vineyard parallel to the direction of river flow with a minimum row spacing of 4.9 meters and 2.4 meters spacing within each row	Cutoff Wall		Trees	
51	33	2092+90	2,272,415.47	6,665,972.41	Underground telephone cable through levee on north side of paved road over the top of the levee.	Cutoff Wall	The cable may not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	
52	34	2092+37			Power line crossing of levee on south side of road	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
53	33	2092+70			5" aluminum irrigation pipe through levee.	Cutoff Wall		IR(P)	
54	33	2084+03	2,271,531.48	6,666,011.72	5" x 0.25" wall steel irrigation line through levee	Cutoff Wall	The pipeline does meets title 23 requirements and but does not have a positive shut-off structure or anti-siphon installed. **Replace in accordance with USACE standard**	IR(P)	2.2
55	33				Excavation into toe of levee from 1 to 3 feet high. The CVFPB sent an encroachment violation notice on July 27, 2011 to Jagdeep Sandu.	Cutoff Wall		Struc	
56	33				To slope and revet 2000 feet of the right bank of Feather River and to eliminate obstructions in the channel	Cutoff Wall		struc	
57	33	2037+15	2,268,425.64	6,666,455.64	Palermo-Peachton 115kv Crossing. To construct, operate, and maintain a 115 kv transmission line crossing the Feather River. The 115 kv line replaced and existing 60 kv line. No record of the 60 kv permit.	Cutoff Wall		EL	OH
58	33	2032+90			12 inch reinforced concrete encased steel irrigation pipe through levee. Slide gate in 24 inch concrete standpipe at waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(G)	11.0
59	33	2029+00			Four (4) areas of excavation into the levee toe at tree locations. Cuts up to 3.5 feet high. The CVFPB sent an encroachment violation notice on July 28, 2011 to Betty Chambers.	Cutoff Wall		Struc	
60	33	2026+40			12 inch reinforced concrete encased steel irrigation pipe through levee. Slide gate in 24 inch concrete standpipe at waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(G)	13.5
61	33	2020+81	2,267,049.65	6,665,590.75	Large steel tank on land side at toe of levee	Cutoff Wall	**Recommended Removal**		
62	33	2018+00			To retain a spur levee between the right bank project levee and the bank of the low water channel, a distance of approximately 600 feet. The spur levee is normal to the project levee and to the direction of the overbank flow. The levee varies from 3 to 6 feet above ground surface	Cutoff Wall		Struc	
63	33	2017+78	2,266,812.83	6,665,317.53	22 inch reinforced concrete encased steel irrigation pipe through levee. Slide gate in 36 inch concrete standpipe at waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	13.9

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Location (NAD 83) Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
64	33	2013+00			Over steepended horizontal vertical levee slope 1:1 excavation at levee toe with cuts up to 5 feet high. The CVFPB sent an encroachment violation notice on July 28, 2011 to Robert Magenheimer.	Cutoff Wall		Struc	
65	33	2006+05			Irrigation well located near about 10 feet from landside toe	Cutoff wall	**Relocate outside of of the proposed right-of-way**	well	
66	33	2004+86	2,265,846.14	6,664,564.55	7 inch steel pipe sleeved through the existing 12 inch steel pipe through levee. The annular space between the two pipes is plugged with concrete on both ends. Slide gate in concrete risers on both ends.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	AG
67	33	2007+00			To construct 1255 feet of spur levee from west project levee to the Feather River west bank.	Cutoff Wall		Struc	
68	33	2001+00			Over steepended levee slope and a 4 foot high long cut excavation at the levee toe. Levee slope at toe cut is 1:1 or steeper. Tree encroachment also noted by State. The CVFPB sent an encroachment violation notice on July 27, 2011 to Jack Mariani.	Cutoff Wall		Struc	
69	33	1995+00			To authorize a pear orchard on the west bank overflow area of the Feather River	Cutoff Wall		trees	
70	33	1995+00			To authorize an existing walnut orchard on the right bank overflow area of the Feather River	Cutoff Wall		trees	
	32/33	1989+00			Reach 32/33 Transition	Cutoff wall			
71	32	1970+00			To interplant trees in an existing pear orchard on the right bank overflow area of the Feather River.	Cutoff wall		trees	
72	32	1961+03	2,264,727.12	6,660,794.20	Double 60 Inch Storm Drainage Pipes through levee. Waterside headwall with automatic drainage gates. Landside headwall within toe of levee. No positive shut-off valve.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	20.0
73	32	1959+00			Unpermitted excavation at the toe of the levee with cuts up to 5 feet high; 1:1 cut slopw at the levee toe. The CVFPB sent an encroachment violation notice on October 4, 2011 to David Henderson Trust.	Cutoff wall		struc	
	31/32	1958+00				Cutoff wall			
74	31	1957+75	2,264,471.77	6,660,429.36	To construct a earthen Berm, equipment storage shed, labor apartment and multiple-purpose building on the landward berm of the levee. The 32 foot by 34 foot building will be located adjacent to an existing shop building. The proposed building will be located on an existing earth fill located on landward slope of the levee and will be 10 feet from the toe of the levee.	Cutoff wall		Struc	
75	31	1956+20	2,264,512.56	6,660,422.66	24 inch CM irrigation pipe through levee. Slide gate in concrete riser pipe on landside berm. Pipe runs under mobile home.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(G)	11.0
76	31	1956+10			Modular Home Located on the Levee Top	Cutoff wall	**Recommended Removal**	struc	
77	31				Unpermitted excavation at the levee toe consisting of cuts up to 2 vertical feet. The CVFPB sent an encroachment violation notice on September 20, 2011 to Bassi & Dhillon, Inc.	Cutoff wall		struc	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
78	31	1947+33	2,263,626.47	6,660,477.81	Service pole 10' from water side toe with 3" steel conduit through top of levee	Cutoff wall	**Relocate pole outside of of the proposed right-of-way. Replace conduit in accordance with USACE Standard**	EL	
79	31	1934+54	2,262,349.20	6,660,821.29	24 inch steel pipe through levee. Slide gate in concrete box on the water side slope. (Corps list pipe as 36 inch CMP)	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard.**	SD(G)	17.5
80	31	1906+58			To authorize construction of stream gauging station on the right bank levee of the Feather River	Cutoff wall		Struc	
81	31	1906+58	2,259,711.16	6,661,315.13	12 kv Pole line over levee. One pole 10 foot landward and one pole on levee for DWR and service electrical to water side building	Cutoff wall		EL	OH
82	31	1903+96	2,259,482.14	6,661,442.38	To extend 3 phase No. 4 ACSR 12 kv pole line across right bank levee of the Feather River. Line to provide power to new pump for Roy Mathews	Jet Grouting		EL	OH
83	31	1902+50			For construction of a temporary fill from the left bank Feather River to a gravel bar and to excavate a channel through bar	Jet Grouting		Struc	
84	31	1902+19	2,259,338.81	6,661,543.33	Oroville-Gridley Highway Bridge Upstream	Jet Grouting		Bridge	
85	31				Open channel on landside of levee at toe	Jet Grouting	**Relocate outside of of the proposed right-of-way.**	IR(G)	
	30/31	1902+00			Reach 30/31 Transition	Jet Grouting			
86	30	1901+79	2,259,317.57	6,661,574.18	Oroville-Gridley Highway Bridge Downstream	Jet Grouting		Bridge	
87	30	1900+82	2,259,239.50	6,661,630.20	Power pole at land side toe	Jet Grouting	**Relocate outside of of the proposed right-of-way.**	EL	OH
88	30	1893+60			3/4 inch galvanized iron waterline through levee	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	WL	3.1 rd
89	30	1893+20	Not Verified		6 inch concrete encased cast iron sewer pipe through levee	Cutoff wall	**Replace in accordance with USACE standard.**	SS (G)	13.9 rd
90	30	1892+60	Not Verified		6 inch concrete encased cast iron sewer pipe through levee	Cutoff wall	**Replace in accordance with USACE standard.**	SS (G)	13.8 rd
91	30	1892+20	Not Verified		Two 4 inch concrete encased cast iron sewer lines through the levee. The Discharge end connected to the CM pump house at the landside toe of the new levee.	Cutoff wall	**Replace in accordance with USACE standard.**	SS(F)	1.5 rd
92	30	1892+89	2,258,542.19	6,662,052.68	Pole line over the levee.	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
93	30	1891+25	2,258,306.36	6,662,137.72	Pole line over the levee.	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
94	30	1888+70	2,258,285.10	6,662,367.26	To extend 3 phase No. 4 ACSR 12 kv pole line across right bank levee of the Feather River. Line to provide power to new pump for Roy Mathews	Cutoff wall		EL	OH
95	30	1888+50	2,258,298.89	6,662,410.71	To expand an existing waste water treatment facility on the left bank of the Feather River and to install a 6 inch force main along the right bank levee of the Feather River	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SS(P)	2.5 rd

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
96	30	1887+29	2,258,210.65	6,662,463.86	12 kv power line crossing of levee	Cutoff wall		EL	OH
97	30	1868+17			Butte County Drainage District No. 1. An 18-inch pipe through Levee	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	
98	30	1828+00			To plant a walnut and peach orchard on the right bank overflow area of the Feather River between LM 2.82 - 3.08 and LM 3.37 - 3.69.	Cutoff wall		Trees	
99	30	1849+80	2,255,332.08	6,664,793.22	18 inch cast iron sewer pipe through levee. Concrete thrust block for cutoff walls on both shoulders. Siphon breaker in concrete pipe riser on the waterside shoulder.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SS(P)	2.8 rd
100	30	1834+42	2,254,466.85	6,665,951.72	24 inch CM drainage pipe through levee. Automatic drainage gate on waterside toe. 12 inch pipe sleeved through 24 inch pipe.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	12.5
101	30	1828+00			To plant a walnut and peach orchard on the right bank overflow area of the Feather River between LM 2.82 - 3.08 and LM 3.37 - 3.69.	Cutoff wall		Trees	
102	30	1823+01	2,253,380.39	6,666,199.22	12 Inch cement coated and lined steel sewer pipe sleeved through the existing 24 inch CM pipe. Annular space pressure grouted.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SS (G)	21.8
103	30	1818+72	2,252,948.28	6,666,209.81	24 Inch CM pipe through levee. Slide gate in 36 inch CM riser on the waterside slope.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SS (G)	25.2
104	30				Sewer Ponds located within 30' of both toes of the levee	Cutoff wall		struc	
105	30	1816+63	2,252,738.86	6,666,205.04	City of Gridley. To install approximately 660 feet of chain link fence on the waterside toe and to authorize approximately 600 feet of 6 foot high chain link fence on the landside toe of the right bank levee of the Feather River.	Cutoff wall		struc	
106	30	1815+00			City of Gridley. To operate a sand borrow pit and gravel borrow pit within the Feather River Designated Floodway, located on the right bank overflow of the Feather River.	Cutoff wall		struc	
107	30	1814+00			To fill an eroded area along the right bank of the Feather River with concrete rubble and old tire wire. The eroded area is approximately 250 feet long and extends into the bank for a distance of 120 feet	Cutoff wall		struc	
108	30	1813+70			24 Inch CM pipe through levee. Concrete saddle and apron with Calco Slide gate.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	
	29/30	1813+33			Reach 29/30 Transition	Cutoff wall			
109	29	1809+65	2,252,095.81	6,666,415.94	24 Inch CM pipe through levee. Automatic drainage gate on waterside propped open and concrete headwall on land side. The CVFPB sent an encroachment violation notice on September 20, 2011 to Peloema Brothers.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	4.5
110	29	1809+00			Existing Prune and Walnut Orchard on right bank overflow area of the Feather River	No Rehabilitation Required		Trees	
111	29	1799+44	2,251,083.54	6,666,333.91	8"x .25" thick wall with exterior taped wrapped to a minimum thickness of 30 mil. The irrigation pipeline through levee	No Rehabilitation Required	The pipeline is meets Title 23 and is newer than 1995. No work required.	IR(P)	2.1

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
112	29	1792+96	2,250,482.00	6,666,094.79	24 inch CM drainage pipe through levee. Automatic drainage gate on waterside and concrete distribution box at waterside toe. Land side end of the pipe is not located. The CVFPB sent an encroachment violation notice on September 19, 2011 to Robert and Sandra Waller.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard.**	IR (G)	10.2
113	29	1790+00			Leveling and planting walnut and peach orchard on right overflow area of Feather River	No Rehabilitation Required		Trees	
114	29	1785+55			24 Inch CM drain pipe through levee. Concrete Headwall at land side. Automatic Drainage Gate on waterside with splash pad	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	
115	29	1785+24	2,249,771.67	6,665,793.11	24 Inch CM drain pipe through levee. Concrete Headwall at land side. Automatic Drainage Gate on waterside with splash pad.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard.**	SD(G)	5.7
116	29	1777+00	2,249,094.57	6,665,330.01	24 Inch CM drain pipe through levee. Concrete Headwall at land side. Automatic Drainage Gate on Waterside. The CVFPB sent an encroachment violation notice on September 19, 2011 to Robert and Sandra Waller.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard.**	SD(G)	4.5
117	29	1770+00			Existing walnut trees, located on the right bank of the Feather River.	No Rehabilitation Required		Trees	
	28/29	1769+31			Reach 28/29 Transition	Cutoff wall			
118	28	1767+67	2,248,176.53	6,665,251.10	Cox Spillway. North 60 Inch drain pipes through Levee. Slide Gates in 78 inch CM pipe wells on the waterside slope. Concrete bulkhead on both ends. Reinforced concrete spillway at the waterside end.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard.**	IR (G)	8.4
119	28	1767+57	2,248,167.22	6,665,252.49	Cox Spillway. South 60 Inch drain pipes through Levee. Slide Gates in 78 inch CM pipe wells on the waterside slope. Concrete bulkhead on both ends. Reinforced concrete spillway at the waterside end.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard.**	IR (G)	8.4
120	28	1767+30	2,248,140.77	6,665,254.84	To construct an 12kv aerial power line crossing of the right bank levee of the Feather River. The power line will extend from an existing pole located landward of the project levee to a new 50 foot pole located at least 20 feet water ward of the water ward toe of the levee/ The shall be 34 feet of clearance between the levee crown and the power line. The length of the span shall be 201 feet. The power line will extend from the 50 foot poles to a 30 foot pole to be located 135 downstream. This power line shall serve a pump covered by permit 11987 b Cox Brothers.	Cutoff wall		EL	OH
121	28	1766+00			To construct, operate, and maintain a 12kv aerial power line extension across the right bank levee, channel, and left bank overflow of the Feather River. A 55 foot pole will be installed 31 feet water ward of the water ward shoulder of levee. The overhead conductors will extend from an existing pole, located 138 feet landward of the landward toe of levee, the proposed 55 pole. The span between the two poles will be 212 feet. A minimum clearance of 35 feet will be provided between the overhead conductors and the top of the levee. The proposed extension will extend across the river and floodway for an additional 3,165.5 feet and will consist of an additional 10 poles.	Cutoff wall with Sutter Butte canal relocation		EL	OH
122	28	1765+33	2,247,973.94	6,665,181.76	12-inch CM pipe through the Levee. Slide Gate on the landside end and concrete distribution box on waterside.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard.**	IR(G)	4.5

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
123	28	1765+15	2,247,960.44	6,665,189.22	To install an irrigation pump on the right bank of the Feather River with a 12 inch steel pipe across the berm, levee, and the Sutter Butte Canal to existing orchards on the right bank downstream from Evans-Reimer Road. Concrete headwall at the waterside toe	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	0.7
124	28	1756+27	2,247,101.40	6,665,410.42	12-inch CM pipe through the Levee. Slide Gate on the landside end and concrete distribution box on waterside. The CVFPB sent an encroachment violation notice on August 16, 2011 to Mr. and Ms. Ratana.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR (G)	7.1
125	28	1753+50			To plant approximately 1.13 hectares of kiwi plants and install an irrigation system supplied by an existing water well.	Cutoff wall with levee relocation		Trees	
126	28	1753+50			To install an electrical pole line service extension to a new agricultural pump on the right bank overflow area of the Feather River.	Cutoff wall with levee relocation		EL	OH
127	28	1745+00			To retain a newly constructed barn on the right bank overflow area of the Feather River, approximately 150 feet water ward of the right bank levee of the Feather River	Cutoff wall with levee relocation		EL	OH
128	28	1731+32	2,248,620.98	6,665,590.38	Butte County Drainage District No. 1. A 16-inch pipe through Levee. Emergency Repair Work on Pipe 3/5/02. Pipe not physically located	Cutoff wall with levee relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	9.0
129	28	1728+33	2,244,365.98	6,665,826.21	To install a 12kv pole line westerly across the right bank levee of the Feather River and the Sutter Butte Canal, then northerly approximately 180 meters for service to well pump	Cutoff wall with levee relocation		EL	OH
130	28	1724+61	2,244,008.46	6,665,796.35	12 kv overhead electrical power line and telephone line crossing	Cutoff wall with levee relocation	**Relocate outside of of the proposed right-of-way.**	EL	OH
131	28				Over steepened, ongoing erosion and caving in the irrigation canal.	Cutoff wall with levee relocation		struc	
132	28	1700+00 to 1728+00			1800 feet of 4.5 foot tall barbed wire fence located at waterside toe of levee. The application for the fencing was denied on October 2, 2000. No indication of appeal.	Cutoff wall with levee relocation		struc	
	27/28	1721+60			Reach 27/28 Transition	Cutoff wall with levee relocation			
133	27	1721+20	2,243,713.99	6,665,636.50	End 18" wide, 12-25 feet deep cutoff wall on crown with monitoring system 2000 lineal feet.	Cutoff wall with levee relocation		struc	
134	27	1707+34	2,242,329.23	6,665,666.71	Begin 18" wide, 12-25 feet deep cutoff wall on crown with monitoring system 2000 lineal feet.			struc	
	26/27	1707+11			Reach 26/27 Transition	Cutoff wall with levee relocation			
135	26	1699+62	2,241,637.34	6,665,378.46	Propane storage tanks at waterside toe of levee	Cutoff wall with levee relocation		struc	
136	26	1697+96	2,241,498.43	6,665,289.21	To retain a telephone line aerial crossing of the right bank levee of the Feather River. The aerial telephone line extends from a pole located landward of the Sutter Butte Minor Canal to a pole located near water ward toe of the levee.	Cutoff wall with levee relocation	**Relocate outside of of the proposed right-of-way.**	TL	OH
137	26	1695+85			To construct a caretaker/ranch office and remove an existing structure on the right bank designated floodway of the Feather River.	Cutoff wall with levee relocation		Struc	
138	26	1691+00			A farm buildings (a walnut processing plant and shop) on the water ward toe of the right bank levee on the Feather River, 200 feet north of Chandon Avenue. The buildings are a 30 x 80 foot walnut dehydrator and a 40 x 40 shed.	Cutoff wall with levee relocation		Struc	
139	26	1690+00			To level and plant 160 acres of land between right bank levee and Feather River, off end of Chandon Avenue and opposite mouth of Honcut Creek	Cutoff wall with levee relocation		Trees	
140	26	1675+98	2,239,584.22	6,664,224.05	12 kv power line crossing of levee	Cutoff wall with levee relocation		EL	OH

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Location (NAD 83) Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
	26	1675+50			Maintenance Area 16/ Maintenance Area 7 Transition	Cutoff wall with levee relocation			
141	26	1675+27	2,239,518.21	6,664,204.12	Butte County Drainage District No. 1. 60" x 72" RCP culvert through levee. Slide gate in concrete well on waterside slope.	Cutoff wall with levee relocation	The pipeline appears to meet title 23 requirements but will need to be removed and replaced because of the cutoff wall. **Replace in accordance with USACE standard**	SD(G)	12.0
	25/26	1674+37			Reach 25/26 Transition	Cutoff wall with levee relocation			
142	25	1670+00			To plant kiwi plants in place of fruit and nut trees on the right bank overflow of the Feather River south of Chandon Avenue near Live Oak.	No Rehabilitation Required		Trees	
143	25	1667+00			To clear the overflow area of brush and construct a foot bridge over an old channel that meanders across the overflow area. To install a septic tank and leach lines, electric service, drill a well and park a mobile home in the overflow area.	No Rehabilitation Required		Struc	
144	25	1665+32	2,238,525.15	6,664,192.56	To construct a 12 kv aerial power line extension across the levee and into the floodway of the Feather River. An existing pole on the landside of the levee will be replaced with a new 55 foot pole to be located 13 feet from the landward toe of the levee. The overhead conductors will extend across the levee to a 55 foot pole located in the floodway 140 feet from the waterside toe of the levee. The span between the 2 poles will be 233 feet. A minimum clearance of 31 shall be provided.	No Rehabilitation Required		EL	OH
145	25	1653+15	2,237,309.20	6,664,181.79	12 Kv overhead power line crossing and along levee.	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
146	25	1650+00			To retain a walnut orchard on the right bank overflow area of the Feather River. The orchard is located a narrow strip of ground between the project levee and Drainage District No. 1's drain ditch.	No Rehabilitation Required		Trees	
147	25	1639+00	2,235,906.77	6,664,006.17	RD 777 Lateral 11. There are 2-24 inch steel pipes through levee. Automatic drainage gates on waterside end of pipe. The CFVFB sent an encroachment violation notice on September 26, 2011 to MMD Ranches	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	16.2
148	25				Construction of Waterside Approach Ramp 500 feet north of Campbell Road and Meader Road	No Rehabilitation Required		struc	
149	25	1638+72	2,235,879.28	6,664,006.22	12 Kv overhead power line crossing and along levee	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
150	25	1635+00			To plant a prune orchard on the right bank overflow area of the Feather River at the end of Riviera Road	No Rehabilitation Required		trees	
	24/25	1623+86			Reach 24/25 Transition	Cutoff wall with levee relocation			
151	24	1611+30			12 Kv overhead power line crossing and along levee	Cutoff wall with levee relocation	**Relocate outside of of the proposed right-of-way.**	EL	OH
152	24	1610+92	2,233,196.84	6,664,513.54	RD 777 Lateral 12. An 18 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe. The CVFFB sent an encroachment violation notice on July 26, 2011 to Theodore Bull. The violation was regarding the heavy vegetation on the waterside outfall pipe.	Cutoff wall with levee relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	17.3
	23/24	1609+37			Reach 23/24 Transition				
153	23	1585+05			Abandoned 12 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
154	23	1557+00			To add approximately 575 feet of 12 kv line to an existing power line on Cooley Road and within the overflow area of the Feather River	Cutoff wall		EL	OH
155	23	1556+58	2,228,785.42	6,665,751.32	To extend a 12 kv pole line from the intersection of Cooley Road and the right bank levee of the Feather across the levee and continue for 1500 feet easterly along Cooley Road. The pole line will serve a 25 HP river pump	Cutoff wall		EL	OH
156	23	1556+86			8 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe.(No gate found)	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	8.0
157	23	1555+00			To install pumping plants at two locations on the right bank of the Feather River	Cutoff wall		IR(P)	
158	23	1549+63	2,228,117.97	6,665,558.67	12 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe. Pipe partially plugged. The CVFPB sent an encroachment violation notice on August 16, 2011 to Hatamiya Trust.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	12.5
159	23	1548+00			To level and plant walnuts and either peaches or prunes on the right bank overflow area of the Feather River upstream from Live Oak Park.	Cutoff wall		Trees	
160	23	1539+00			To install 25 HP pumping plants at two locations on the right bank of the Feather River	Cutoff wall		IR(P)	
161	23	1536+12	2,226,796.76	6,665,666.06	RD 177 Lateral 7. There is a 36 inch CM pipe through levee. Automatic drainage gate on waterside end of pipe. The CVFPB sent an encroachment violation notice on August 16, 2011 to Hatamiya Trust.	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(G)	13.7
162	23	1535+95	2,226,780.47	6,665,668.20	To extend a 12 kv pole line 410 feet northerly to supply a 25 HP pump located in the river. The pump is pump referenced in permit 7380.	Cutoff wall		EL	OH
163	23				Excavation into toe of levee from up to 3 feet high on landside toe. The CVFPB sent an encroachment violation notice on August 16, 2011 to Hatamiya Trust.	Cutoff wall		Struc	
164	23	1535+64	2,226,750.14	6,665,678.35	To widen access road to Live Oak Recreation Area at the east end of Pennington Road on the right bank levee and berm of the Feather River	Cutoff wall		Struc	
165	23	1535+00			To install 2500 lf of 2 inch diameter Sch 40 PVC water pipe and 600 lf of 1 inch Sch 40 PVC pipe within the west bank overflow. (Permit number has been changed to 7440-D)	Cutoff wall		W(P)	
166	23	1534+00			To construct a water supply system, a sanitary disposal system and restrooms for the Live Oak Recreational Area	Cutoff wall		Struc	
167	23	1533+40			Potential Pipe Crossing. 6" Steel through levee	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	
168	23	1532+45	2,225,437.02	6,665,722.95	Water Well adjacent to Levee about 100 feet from toe	Cutoff wall		IR(P)	
169	23	1530+00			A trailer site, a porch, a metal storage building, fence across the waterside berm and waterside slope of the levee, on the right bank of the overflow area of the Feather River.	Cutoff wall		Struc	
170	23	1524+35			Potential Pipe Crossing. 6" Steel through levee	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	
	22/23	1503+83			Reach 22/23 Transition	Cutoff wall			
171	22	1530+00			To authorize existing pear orchard and plant 10 additional acres on the right bank overflow of the Feather River downstream of Archer Road	Cutoff wall		Trees	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Location (NAD 83) Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
172	22	1520+25			To extend approximately 1,950 feet of 12kv electric service line in the right bank overflow area of the Feather River downstream from Archer Avenue crossing	Cutoff wall		EL	OH
173	22	1493+88	2,222,717.57	6,664,731.41	Location of gate with no access	Cutoff wall		Fence	
174	22	1492+00			To construct an aerial telephone crossing of the right bank levee of the Feather River	Cutoff wall		TL	OH
175	22	1482+00			A 4 x 17 foot wooden walkway on the landside shoulder; two tool sheds, four walnut trees, a barbed wire and wooden fence within 10 feet landward of the landside toe, and an electrical gate across the crown of the right bank levee of the Feather River.	Cutoff wall		struc	
176	22	1479+98	2,221,343.18	6,664,540.45	Location of electric gate with no access	Cutoff wall		struc	
177	22	1470+15	2,220,360.26	6,664,561.50	A 4 x 17 foot wooden walkway on the landside shoulder and a 6 x 300 foot wooden lattice fence within 10 feet landward of the landside toe and parallel to the right bank of levee of Feather River.	Cutoff wall		struc	
178	22	1468+70			Four trees (oleander, pines, cherry, and birch) on the landside slope and a 5 foot high, 130 foot long wire fence within 7 feet of landward of the landside toe of the right bank levee of the Feather River.	Cutoff wall		struc	
179	22	1466+02	2,219,947.02	6,664,564.97	Transformer located 40± from land side toe	Cutoff wall		EL	
180	22	1465+50			To construct access ramp across the right bank levee of the Feather River	Cutoff wall		struc	
181	~~22~~	~~1465+50~~			~~The existing 36 inch CMP installed in 1913 failed on March 1964. The permit was for repair of levee and removal of the pipe prior to November 1964.~~	Cutoff wall		~~IR(O)~~	
182	22	1461+00			To maintain existing your walnut orchards on the right bank of the Feather River, downstream from Bishop Avenue.	Cutoff wall with full levee degrade		Trees	
	22	1460+00			Levee District No. 9 Levees /Maintenance Area 16 Transition				
	21/22	1433+83			Reach 21/22 Transition				
183	21	1430+55	2,216,425.27	6,664,383.06	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. There is a 60 Inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	15.6
184	21	1430+47	2,216,417.64	6,664,382.64	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. There is a 60 Inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	15.6
185	21	1430+40	2,216,410.86	6,664,382.27	Sunset Pump Station owned an operated by Sutter Extension Main Pump Station. There is a 36 Inch steel pipe through the levee. Pump end has gate valves on structure. Automatic drainage gates on the landside end.	Cutoff wall with Sutter Butte canal relocation	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	IR(P)	15.6

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
186	21	1430+40			To construct and operate a vertical-perforated plate fish screen with a power operated brush on the right bank of Feather River. Located at Sunset Pump Plant.	Cutoff wall with Sutter Butte canal relocation		IR	
187	21	1430+00			36" CM pipe crossing through levee. The O&M manual indicates this pipeline is located 50 feet south of Sunset Pump Station but it appears this pipeline is the same pipeline addressed in Permit 4536 and 4719 located at Station 1465+50. The pipeline at Station 1465+50 was a 36 inch CMP installed in 1913 and removed in 1964. It should have shown on the O&M manual.	Cutoff wall with Sutter Butte canal relocation	There is no documentation of proper abandonment of the pipeline. We believe this pipeline was actually located at 1465+50 and removed per permit 4719. The type and size appear to match the Reclamation Board Permit. **Replace in accordance with USACE Standard.**	IR (G)	
188	21	1429+98	2,216,368.25	6,664,376.98	12 KV OH Power	Cutoff wall with Sutter Butte canal relocation		EL	OH
189	21	1429+68	2,216,338.71	6,664,376.58	12 KV OH Power	Cutoff wall with Sutter Butte canal relocation		EL	OH
190	21	1429+50			Existing rubble coffer dam constructed with Reclamation Board Permit 3610. Repair coffer dam.	Cutoff wall with Sutter Butte canal relocation		IR	
191	21	1428+50			Sutter Butte Main Canal Begin (Station 1428+50 to 1433+83) -Main Irrigation Canal approx. 420 cfs	Cutoff Wall	**Recommended Relocation between station 1429+00 to 1433+83**	IR	
192	21				To construct a 12 KV pole line extension adjacent to the levee and across the floodway of the Feather River. The pole line will be located 30 feet from the waterside toe of the levee and will parallel the levee for a distance of 792 feet, thence across the floodway for a distance of 834 feet. The pole line extension will consists of three 264 foot spans and three 278 foot spans.	Cutoff Wall		EL	OH
193	21	1399+27	2,213,450.77	6,664,966.80	To install a 12 kv pole line across and along the right bank levee of the Feather River.	Cutoff Wall		EL	OH
194	21				To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. End Seepage Interceptor Trench	Cutoff Wall	No work proposed and the seepage drain can remain.	struc	
195	21				Plant 9 acres of Kiwi plants on waterside of levee between Bridgeford and Hermanson Avenues	Cutoff Wall		Trees	
196	21				Plant 14 acres of Kiwi plants on waterside of levee upstream of Hermanson Avenue	Cutoff Wall		Trees	
197	21				To construct a well and septic tanks for 2 mobile homes and to extend electrical service to well on right bank overflow area of Feather River	Cutoff Wall		Struc	
198	21				To plant 8 acres of kiwi plants, a submersible pump, and underground sprinkler system on the right bank overflow area of the Feather River	Cutoff Wall		Trees	
199	~~21~~				~~To pump storm water from landward drainage ditch over the right bank levee of the Feather River from one separate location for approximately size at the end of Hermanson Road.~~ **~~Pipe has been removed~~**	~~Cutoff Wall~~		~~SD(F)~~	
200	21	1391+96	2,212,767.43	6,665,226.86	To extend a 12 kv pole line out into the right bank levee and overflow area of the Feather River	Cutoff Wall		EL	OH
201	21	1375+35	2,211,296.56	6,665,998.34	Sutter Extension Sunset Lateral Begin (Station 1375+35 to 1428+50) Open irrigation ditch 15 feet from landside toe	Cutoff Wall	**Relocate outside of of the proposed right-of-way**	Struc	

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TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Location (NAD 83) Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
202	21	1374+94	2,211,260.36	6,666,016.66	To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. Begin Seepage Interceptor Trench	Cutoff Wall		Struc	
203	21	1375+00			To level and plant 13 acres Peach Orchard on the right bank overflow area of the Feather River	Cutoff Wall		Trees	
	20/21	1374+33			Reach 20/21 Transition				
204	20	1350+00			To plant peach trees and to establish two wells and install pumping plants in right bank overflow of the Feather River	Cutoff Wall		struc	
205	20	1350+00			To extend 12 kv pole line parallel to the water ward toe of levee for a distance of approximately 1,500 feet north from Koch Lane, on the right bank overflow area of the Feather River.	Cutoff Wall		EL	OH
206	20				Excavation into toe of levee from 1 to 3 feet high and ground is tilled adajcent to the landside toe. The CVFPB sent an encroachment violation notice on August 17, 2011 to Julie M. Filter-Correll.	Cutoff Wall		Struc	
207	20	1347+37	2,208,612.74	6,666,676.45	To install a 60 foot pole 86 feet from the landward toe of the levee, a 60 foot pole 10 feet from the water ward toe of the levee and 6 additional poles on the right bank overflow of the Feather River. The 12kv electrical service will be extend across the levee to serve a pump installed under Permit 6380. The span across the levee will be 234 feet. The clearance between the overhead wires and the top of the levee will be 31 feet.	Cutoff Wall		EL	OH
208	20	1347+00	2,208,582.82	6,666,680.19	Missile Communication Cable System. Installation of an underground cable at a minimum depth of 3 feet, a corrugated metal cutoff wall is located on each cable, from Beale Air Force Base to the vicinity of Chico Airport, crossing several channels in Butte, Placer, Sutter, and Yuba Counties. In 1968 the USACE requested approval to abandon the cable in-place and cut	Cutoff Wall	The cable does not meet title 23 requirements. According to email from US Government to WR, the cable is no longer in use and can be disposed. **Replace in accordance with USACE standard**	TL	4.0
209	20	1345+00			To plant prune orchard on the right bank overflow area of the Feather River, downstream from Koch Road	Cutoff Wall		Trees	
210	20	1345+00			To retain walnut orchard on the right bank overflow area of the Feather River, downstream from Koch Road	Cutoff Wall		Trees	
211	~~20~~	~~1328+10~~			~~To install 3 temporary discharge pipelines across the right bank levee of the Feather River. The proposed pipeline will be in installed in three separate locations at LM 2.53, 3.72, and 3.78. The pipelines will be exposed on the levee slopes and will have a pad constructed over them across the levee crown.~~ **~~Pipe has been removed.~~**	Cutoff Wall		~~SD(P)~~	
212	20	1328+00			To construct a 12 kv aerial power line on the right bank overflow area of the Feather River	Cutoff Wall		EL	OH
213	20	1327+00	2,206,597.56	6,666,928.33	12KV overhead power line crossing	Cutoff Wall		EL	OH
~~214~~	~~20~~	~~1317+15~~			~~To install 3 temporary discharge pipelines across the right bank levee of the Feather River. The proposed pipeline will be in installed in three separate locations at LM 2.53, 3.72, and 3.78. The pipelines will be exposed on the levee slopes and will have a pad constructed over them across the levee crown.~~ **~~Pipe has been removed.~~**	~~Cutoff Wall~~		~~SD(P)~~	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Location (NAD 83) Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
215	20	1315+03	2,205,398.45	6,666,943.63	To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. End Seepage Interceptor Trench	Cutoff Wall		Struc	
216	20	1314+80	2,205,375.80	6,666,944.25	Micheli Storm Drainage Pump Station. To install a pump with 20 Inch steel discharge pipe through the right bank of the Feather River for the removal of stormwater.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	SD(P)	2.0
217	20	1312+08			To plant an orchard and grade the land on the right bank overflow area of the Feather River. The project is located north of Yuba City approximately 5 miles.	Cutoff Wall		Trees	
~~218~~	~~20~~	~~1305+30~~			~~To pump storm water from landward drainage ditch over the right bank levee of the Feather River from one separate location for approximately size at the end of Hornmanson Road.~~ **~~Pipe has been removed~~**	~~Cutoff Wall~~		~~SD(P)~~	
	19/20	1297+83			Reach 19/20 Transition				
219	19	1295+00			To plant an orchard and grade the land on the right bank overflow area of the Feather River. The project is located north of Yuba City approximately 1.3 miles upstream (north) of the intersection of Eager Road and Live Oak Boulevard.	Cutoff Wall		Trees	
220	19	1293+66	2,203,266.22	6,666,867.99	End Concrete Lined Ditch on landside toe of levee	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	struc	
221	19	1293+66	2,203,266.22	6,666,867.99	12 KV Overhead Power line crossing of levee. One pole 6 foot from levee toe.	Cutoff Wall		EL	OH
222	19				To construct approximately 5,000 feet of lateral drain seepage relief trenches with perforated pipe and drain rock at the landward toe of the right bank levee for the Feather River. The proposed trench will be located at the landward levee toe at approximately 2 feet in width and 4 feet deep. LM 3.00 to 3.83 and LM 4.36 to 4.91. Begin Seepage Interceptor Trench	Cutoff Wall		struc	
223	19	1284+91	2,202,406.27	6,666,705.08	Begin Concrete Lined Ditch on landside toe of levee	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	struc	
224	19	1266+71	2,200,690.09	6,666,626.59	12KV overhead power line crossing.	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
225	19	1265+59	2,200,487.69	6,666,648.86	Sullivan Pump Station. 18 inch steel pipe through the levee. Pump and Gate valve in pump house on the channel bank. Concrete well on the bank. Siphon breaker in CMP riser on landside slope. (Sullivan Pump Station)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and anti-siphon device on waterside hinge of levee. The pipe line is pressurized and need to be installed above the design water surface. The current installation is at-grade. **Replace in accordance with Title 23**	IR(P)	18.3
226	19	1229+41	2,197,325.05	6,668,184.53	Kewal Singh IR PS. A 16 inch steel pipe through levee. Pump in pump house on channel bank. Gate valve on the waterside end. Concrete standpipe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and anti-siphon device on waterside hinge of levee. The pipeline is pressurized and will need to be installed about the design water surface. **Replace in accordance with USACE standard**	IR(P)	3.0 or deeper through levee?
227	19	1226+06	2,197,092.42	6,668,425.95	12 KV power pole located in landside slope	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
	18/19	1213+85			Reach 18/19 Transition				

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
228	18				Excavation into the toe of levee on waterside 0.5 to 3 feet high with near vertical slope. CFPB sent an encroachment violation notice on July 27, 2011 to Kewall Singh.	Cutoff Wall		struc	
229	18	1201+00			Wilbur Ranch Irrigation Water Well located within 50 feet of levee toe. Underconstruction as of March 6, 2012.	Cutoff Wall		well	
230	18	1200+69	2,194,694.88	6,669,169.33	Wilbur Ranch Irrigation Water Well located within 10 feet of levee toe. There is also a service pole and electrical panel.	Cutoff Wall	The water well does not meet Title 23 since too closse to levee. The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
~~231~~	~~18~~	~~1200+69~~	~~2,194,694.58~~	~~6,669,169.33~~	~~Abandoned 10 inch steel pipe through levee. Waterside end open. Steel Plate welded on landward end. Pump and Standpipe at the landside end.~~	~~Cutoff Wall~~	~~Not sure if the abandonment meets title 23 requirements. Pipe may need to be properly abandoned or completely removed.~~	~~IR(P)~~	~~2.8~~
232	18	1195+20			12 KV power line in overflow and levee crossing north of Rednall Road	Cutoff Wall		EL	OH
~~233~~	~~18~~	~~1182+75~~			~~20 inch steel pipeline through levee **(not installed)**. Plans prepared by MBM Job No. 78-158.~~	~~Cutoff Wall~~	~~Pipe was never installed. No work.~~	~~IR(A)~~	~~3.0~~
234	18	1181+50			Abandoned 8 inch steel pipe through levee. Pipe plugged on the waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(A)	4.0
235	18	1180+98	2,192,727.96	6,669,163.92	3 inch steel pipe through levee crown	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	1.0
236	18	1180+50			One 12 inch steel pipe through levee. Pipe exposed on landside slope	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	1.0
237	18	1180+00			To construct a 15 inch diameter corrugated metal drain pipeline across the overflow area and through the right bank of the Feather River. The proposed pipeline will be 625 feet in length and have 15 feet of cover.	Cutoff Wall		SD(G)	
~~238~~	~~18~~	~~1182+75~~			~~To install an irrigation pump and a buried pipeline landward over the right bank levee of the Feather River, upstream Rednall Road. **Not install per Reclamation Board**~~	~~Cutoff Wall~~		~~IR(P)~~	
239	18	1174+05	2,192,034.01	6,669,096.85	Water Well and Pump 20 feet from Landside toe	Cutoff Wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
240	18	1170+04	2,191,638.99	6,669,057.61	12KV overhead power line crossing.	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
241	18	1152+55	2,189,899.09	6,668,879.71	Twin 110 KV Tower line across Feather River	Cutoff Wall		EL	OH
242	18	1138+22	2,188,574.27	6,668,732.99	12 KV and 40/60 KV power pole located in landside slope	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
243	18	1135+31	2,188,188.41	6,668,676.43	16 inch gas line through the levee. Marker post on the waterside shoulder	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.5
244	18	1133+00			To construct 1,180 feet of 12 kv line in the right bank overflow area of the Feather River	Cutoff wall		EL	OH
	18	1132+61			Levee District No. 1 Levees /Levee District No. 9 Transition				

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
245	18	1132+09	2,187,967.19	6,668,647.98	8-5/8" steel pipeline within railroad right-of-way parallel to tracks	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	
246	18	1131+82	2,187,840.25	6,668,647.20	Fiber optic cable	Cutoff wall	The cable does not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	
	17/18	1130+86			Reach 17/18 Transition				
247	17	1130+47	2,187,705.38	6,668,643.93	Union Pacific Railroad Crossing. There is no stop leg structure.	Jet Grouting		RR	6.0
248	17	1128+00			To construct a ramp on the waterside slope of the right bank levee on the Feather River adjacent to the SPRR	Cutoff wall		Struc	
249	17	1127+48	2,187,405.84	6,668,629.29	Village Green Trailer Park - To install a 10 inch outfall pipe through the right bank levee of the Feather River to provide storm drainage for a mobile home park	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	
250	17	1125+60			An existing irrigation well in the right bank overflow area of the Feather River.	Cutoff wall with landside toe fill		Well	
251	17	1111+46	2,185,808.02	6,668,723.59	West Onstott Frontage Road Pump Station and Clark Avenue Pump Station Drainage Area: 16 inch welded steel 7 GA asphalt coated storm drain discharge pipe over levee connected to 24 inch pipe in overflow area, outfall ditch, and pipes in floodway (Source: City of Yuba City Pump Station No. 4 and City of Yuba City Pump Station No. 2)	Cutoff wall with landside toe fill	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	1.1
252	17	1107+82	2,185,444.63	6,668,754.75	12 KV crossing & power pole located in landside slope	Cutoff wall with landside toe fill	**Relocate outside of of the proposed right-of-way.**	EL	OH
253	17				To install an intertie to an existing waste water line and abandon approximately 40 feet of 24 inch diameter pipe on the right bank of the Feather River.	Cutoff wall		RW(P)	4.0
254	17	1096+81	2,184,421.28	6,669,119.50	Yuba City Water Treatment Plant 28" (29.25/32" OD) 7 GA welded steel waterline pipe crossing of levee. New permit included installation of automatic drainage gates on pipelines. (copy of record drawings)	Jet Grouting	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	RW(P)	5.0
255	17	1096+71	2,184,412.72	6,669,124.71	Yuba City Water Treatment Plant 24" 7 GA welded steel waterline pipe crossing of levee. New permit included installation of automatic drainage gates on pipelines. (copy of record drawings)	Jet Grouting	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	RW(P)	4.7
256	17	1096+62	2,184,404.80	6,669,129.53	Yuba City Water Treatment Plant 42" cement mortar lined and coated welded steel pipe waterline crossing of levee (copy of record drawings)	Jet Grouting	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	RW(P)	2.5
257	17	1096+50	to be installed	to be installed	Yuba City Water Treatment Plant 48" cement mortar lined and coated welded steel pipe waterline crossing of levee (to be installed and requested by the City of Yuba City)	Jet Grouting	This is a new pipelines that will meet Title 23 and USACE requirements except as noted in variance column. **Replace in accordance with USACE standard**	RW(P)	2.0
258	17	1096+74	2,184,416.62	6,669,124.90	To install a 12 kv aerial pole line extension across the right bank levee of the Feather River. The pole line shall serve the Yuba City Water treatment Plant intake pump station	Jet Grouting		EL	OH
259	17	1093+12			Telephone Call box on landside hinge point	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	TL	
260	17	1086+33			Construction of an 80 foot high Monopole for a Cell Tower. The work includes a 32' x 83' compound, PG&E 100 KVA transformer box, 600 AMP PG&E Electrical Meter Service.	Cutoff wall		Cell	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
	16/17	1080+00			Reach 16/17 Transition				
261	16	1079+91	2,183,133.09	6,670,212.82	8 inch Gas Line	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.5
262	16	1073+41	2,182,671.85	6,670,670.15	16 inch Gas Line (PG&E Map shows the gas main as 12 inch)	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	GL	3.5
263	16				Excavation into the levee on the waterside approximately 0.5 to 2 feet, near vertical in some places. Minor rutting, ponding, and depressions in the levee toe road. CVFPB sent a encroachment violation notice on August 16, 2011 to City of Yuba City.	No Rehabilitation Required		struc	
264	16	1054+75	2,181,074.23	6,671,588.96	Telephone Call box on landside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way**	TL	
265	16	1043+52	not verified		Abandon 36 inch pipe	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SS(G)	
266	16	1043+52	2,180,149.57	6,672,223.24	Abandoned 27 inch Centrifugal Spun Concrete Pipe. City of Yuba City Drawing 214-D per 1349 plans	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SS(G)	38.6
267	16	1043+45	2,180,137.11	6,672,230.51	To install a 36 inch discharge pipe through right bank of Feather River	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	5.0
268	16	1043+27	2,180,126.23	6,672,235.13	To install a 24 inch wrapped steel pipe through the right bank levee of the Feather River	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	2.0
269	16	1043+22	2,180,121.72	6,672,237.88	To construct a 24 inch steel pipe storm drainage discharge pipe crossing the west levee of the Feather River	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	4.0

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
270	16	1043+03	2,180,106.36	6,672,244.70	Gilsizer Slough Storm Drain Facilities. A 16 inch welded steel discharge pipe crossing of levee. (copy of record drawings)	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	1.5
271	16	1037+50	Not Verified		Abandoned 8 inch gas line through levee. Removed per Permit J445A	No Rehabilitation Required	Not sure if the abandonment meets title 23 requirements. Pipe may need to be properly abandoned or completely removed.	GL	
272	16				To construct approximately 4,400 lineal feet of filter trench adjacent to the right bank levee of the Feather River. The proposed trench will be located at the landward levee toe, be 3 feet wide and 4 feet deep	No Rehabilitation Required			
273	16	1028+11	2,178,636.47	6,672,461.02	Power pole in waterside slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	
274	16	1029+10	2,179,608.80	6,672,356.03	To bury existing two submarine telephone cables into two parallel trenches 100 feet apart in the channel of the Feather River. Both cables were installed per Permit 1334 in September 15, 1948. The permit stated the cable will be buried to a depth of five feet in the levees.	No Rehabilitation Required	The conduit may not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	5.0
275	16	1028+10	2,179,506.59	6,672,370.16	To bury existing two submarine telephone cables into two parallel trenches 100 feet apart in the channel of the Feather River. Both cables were installed per Permit 1334 in September 15, 1948. The permit stated the cable will be buried to a depth of five feet in the levees.	No Rehabilitation Required	The conduit may not meet title 23 requirements. **Replace in accordance with USACE standard**	TL	2.0
276	16	1026+71	21,784,783.54	6,672,514.29	10" overside Drain line on the water side levee slope for bridge area drainage	Seepage berm	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Replace in accordance with USACE standard**	TL	
277	~~16~~	~~1026+70~~			~~To place a 10 inch diameter conduit containing fiber optic cables across and under (bored) the channel and through the right bank of the Feather River. The permit was withdrawn on 9-6-00 according to the CVTPB file.~~	Seepage berm		TL	
278	16	1026+58	2,178,488.35	6,672,429.49	40 foot long retaining wall landside of levee just upstream of the Feather River Bridge	Seepage berm		Road	
279	16	1026+22	2,178,451.96	6,672,425.20	Feather River Bridge (SR 20) upstream side	Seepage berm		Bridge	
280	16	1025+32	2,178,375.92	6,672,443.76	Feather River Bridge (SR 20) downstream side	Seepage berm		Bridge	
281	16	1025+32	2,178,375.92	6,672,443.76	Seismic Retro of Feather River Bridge and bike paths on both sides of bridge	Seepage berm		Bridge	
282	16	1024+95	2,178,319.03	6,672,456.34	12 kv power line across levee	Seepage berm	**Relocate outside of of the proposed right-of-way.**	EL	OH
283	16	1024+70			Backfill Community Swimming Pool located near the base of the Feather River Bridge (10th Street Bridge)	Seepage berm		struc	
284	16	1024+48	2,178,296.55	6,672,470.53	40 foot long retaining wall landside of levee just downstream of the Feather River Bridge	Seepage berm		Road	

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Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
285	16	1021+95	2,178,044.07	6,672,487.29	12 kv power line across levee	No Rehabilitation Required		EL	OH
286	16	1021+00			Telephone line on river slope of levee 260 feet downstream of Feather River Bridge (10th Street Bridge)	No Rehabilitation Required		TL	
287	16	1020+85			Abandon 4 inch pipe	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(G)	1.3
288	16	1020+30	2,177,879.35	6,672,496.38	Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
289	16	1019+82	2,177,832.13	6,672,504.71	Power pole in waterside slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
290	16	1013+00			To place approximately 4,000 feet of blanket drain and filter trench on the right bank of levee of the Feather River upstream and downstream of the SR 20 Bridge	No Rehabilitation Required		Struc	
291	16	1010+75	2,176,773.87	6,672,930.97	Install Guy within in landside slope of levee, 12 kV overhead electric	No Rehabilitation Required		EL	
292	16	1008+38	2,176,779.63	6,672,929.15	12 kv power line across levee	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
293	16	1007+50			To construct approximately 1,300 feet of 12 foot wide bicycle trail on the crown of the right bank levee of the Feather River. The Project is located in Yuba City between the 5th Street Bridge and the easterly extension of Teagarden Avenue	Jet Grouting		Struc	
294	16	1007+50			4' by 3' deep erosion pocket. 4 foot vertical bank under Twin Cities Memorial Bridge	Jet Grouting		struc	
295	16	1007+50			To construct a bicycle trail for approximately 3.5 miles on the right bank levee other the Feather River from Shanghai Bend Road to Northgate Boulevard	Jet Grouting		Road	
296	16	1007+50			Bike Path below Twin Cities Memorial Bridge	Jet Grouting		Road	
297	16	1007+51	2,176,709.34	6,672,981.09	Twin Cities Memorial Bridge upstream side	Jet Grouting		Bridge	
298	16	1007+46	2,176,706.50	6,672,984.37	Light pole in water side levee slope	Jet Grouting	**Relocate outside of of the proposed right-of-way.**	EL	OH
299	16	1007+06	2,176,671.72	6,673,005.93	Twin Cities Memorial Bridge downstream side	Jet Grouting		Bridge	
300	16	1006+93	2,176,642.84	6,672,995.25	Power line and Anchor in Levee (actual location)	Jet Grouting		EL	
301	16	1006+60	2,176,647.27	6,673,046.63	Sacramento Northern Railroad	Jet Grouting		RR	
302	16	1006+07	2,176,610.55	6,673,084.90	Power Pole and anchor in slope of levee. 100 feet south of the SNRR bridge w/ service power overhead	Jet Grouting		EL	OH
303	16	1006+00			City of Yuba City. To replace the existing retaining wall with an 8 foot high, 76 foot long concrete retaining wall on the landside of the right (east) bank levee of Feather River.	Jet Grouting		struc	

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			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
304	16	1005+80			Concrete steps and 4 inch diameter PVC pipe on the landward slope and a pump house within 10 feet of the landward toe.	No Rehabilitation Required		struc/IR (P)	
305	16	1003+72	2,176,461.32	6,673,266.98	Power Pole and anchor in slope of levee. 500 feet south of the SNRR bridge	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	OH
306	16	1000+50			A 3-wire barded wire fence with a gate within 5 feet of the levee toe and two mature trees at the landward toe. The project is located on Keyser Street	No Rehabilitation Required		struc	
307	16	999+90			A 120 foot long building at the landward toe	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
308	16	995+50			Authorize a 3-wire barded wire fence and two mature trees at the landward toe. The project is located at 563??? Second Street	No Rehabilitation Required		struc	
~~309~~	~~16~~	~~995+80~~			~~To excavate 25 feet into landward side of the right bank of the Feather River and construct a concrete retaining wall to provide parking lot space. The project is located at 163 2nd Street behind the Sutter County Administration Building.~~	~~No Rehabilitation Required~~		~~struc~~	
~~310~~	~~16~~	~~993+56~~			~~To install approximately 1,010 feet of 8 foot high chain link fence on the waterside side of the right bank levee of the Feather River.~~	~~No Rehabilitation Required~~		~~struc~~	
311	16	993+25			A building near the landward toe of the levee.	No Rehabilitation Required		struc	
312	16	992+00			A shed, concrete wall, and chain-link fence with gate at landward toe. The permit also covers two steel posts on the shoulder and seventeen mature trees on the landward slope.	No Rehabilitation Required		struc	
313	16	991+00			A shed at the landward toe	No Rehabilitation Required		struc	
314	16	992+00			A two-story garage and shop building at the landward toe and six mature trees on the landward slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
315	16	989+75			A building at the landward toe and 21 mature trees and sprinkler system on the landward slope.	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
316	16	988+05	2,175,065.02	6,673,942.87	3 inch steel pipe; does not appear to cross levee anymore	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(P)	
317	16	989+20			A garage and a shed at the landward toe	No Rehabilitation Required		struc	
318	16	988+50			Authorize a small building, a chain-link fence, four mature trees at the landward toe, and five clumps of oleanders on the landward slope.	No Rehabilitation Required		struc	
319	16	987+60			Authorize a small building and a chain link fence on an existing retaining wall at the landward toe, concrete stairs, a steel pipe frame, and two large mature trees on the landward slope. A hose bib on the landward shoulder of the right bank of levee.	No Rehabilitation Required	**Recommended Relocation**	struc	
320	16	986+75			A see-through fence on a 5 foot retaining wall, steps, and nine mature trees on the landward slope.	No Rehabilitation Required		struc	
321	16	986+00			Concrete steps with railing and pomegranate bush on landward slope. The permit also covers a concrete retaining wall at the landward toe.	No Rehabilitation Required		struc	
322	16	985+30			Chain Link fence with gate, three oleander trees, and steps within the landward slope.	No Rehabilitation Required		struc	

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Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
323	16	984+50			Chain Link fence with gate, three oleander trees, and steps within the landward slope.	No Rehabilitation Required		struc	
324	16	983+20			A building, barbed wire fence, and ten trees at landward toe	No Rehabilitation Required		struc	
325	16	981+25			A 60 foot long see-through board fence and 75 foot long clothesline and landward toe. A shed 5 feet from landward toe and a mature oak tree on the landward slope	No Rehabilitation Required		struc	
326	16	980+15			A chain-link fence with gate within 10 feet of landward toe	No Rehabilitation Required		struc	
327	16	979+90			A see-through fence and storage shed within 10 feet of the landward toe. The project is located at 265 Second Street, Yuba City, CA	No Rehabilitation Required		struc	
328	16	979+40			A see-through fence and storage shed within 5 feet of the landward toe. The project is located at 261 Second Street, Yuba City, CA	No Rehabilitation Required		struc	
329	16	978+80			A Chain Link fence with gate within 5 feet of landward toe, a cedar tree at the landward toe, and stone steps on the landward slope. This project is located at 255 Second Street.	No Rehabilitation Required		struc	
330	16	976+10			A shed and three trees at the landward toe of the right bank levee of the Feather River. The project is located at 225 Second Street, Yuba City, CA 95591	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
331	16	975+40			A 6 foot high chain link fence and gate at the right bank levee of the Feather River	No Rehabilitation Required		struc	
332	16	974+25			A residence within 5 feet of the landward toe	No Rehabilitation Required		struc	
333	16	973+30			A residence at landward toe and oak on the landward slope	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	struc	
334	16	975+00			To construct a restroom facility with septic tank and leach lines at the Yuba City Boat Ramp on the right bank of the Feather River.	No Rehabilitation Required		struc	
335	16	972+29			2 Inch Domestic Water Line serving the Yuba City Boat Dock.	No Rehabilitation Required	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with Title 23**	WP	
336	16	972+00			To construct improvement for the boat launching ramp and related facilities on the right bank of the Feather River.	No Rehabilitation Required		struc	
337	16	972+00			To construct improvement for the Yuba City Boat Ramp consisting of a paved parking area, restroom facilities, floating boat dock and extension of concrete boat ramp on the right bank of the Feather River.	No Rehabilitation Required		struc	
338	16	972+00			To reconstruct an existing access road to the Yuba-Sutter Boat Ramp on the right bank of the Feather River	No Rehabilitation Required		struc	
339	16	972+00			To maintain and operate existing boat dock for public use for boating, fishing, and a campground with related facilities including a mobile home on the right bank of the Feather River.	No Rehabilitation Required		struc	
	15/16	968+50			Reach 15/16 Transition	No Rehabilitation Required			
340	15	968+00			To construct 120 lineal feet of sheet piles retaining wall, and nine 10 x 10 foot boat docks supported by seven 12 inc diameter steel piles to an existing 30 foot wide ramp (Yuba City Boat Ramp)	No Rehabilitation Required	Located within floodway. Does not affect levee project.	struc	
341	15	964+78			Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
	14/15	954+40			Reach 14/15 Transition	No Rehabilitation Required			
342	14	952+00			12 kv cable	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	EL	UG
	13/14	927+00			Reach 13/14 Transition	No Rehabilitation Required			
343	13	925+16			Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
344	13	925+00			To construct access ramps	No Rehabilitation Required	Located within floodway. Does not affect levee project.	struc	
345	~~13.~~	~~920+00~~			~~Consolidated Area Housing Authority of Sutter County. Storm Drainage Pipe Crossings. The size and location of the pipe is unknown. They have retention pond located at southwest corner of the airport. The Airport Business Park proposed crossing but application never filed.~~	~~Cutoff Wall~~	~~The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with Title 23**~~	~~SD (P)~~	
346	13	913+19	2,168,046.21	6,673,496.81	Two 16 inch gas lines. (PG&E map shows the gas lines as 2-12 inch)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	OL	3.0
347	13	894+23	2,166,221.70	6,673,147.49	To install a 12kv buried power cable through the right bank levee and across the right bank overflow of the Feather River, a total distance of 896 feet. Poles will be installed near the top of the banks of the low water channel and aerial cable will be placed between the two poles which will be connected to the underground cable.	Cutoff Wall	The cable appears to meet title 23 requirements but the cutoff wall will remove improvements. **Replace in accordance with USACE standard**	EL	UG
348	13	893+84	2,166,181.41	6,673,142.43	Garden Highway Industrial Park. To install a 12 inch steel storm drain pipeline through the right bank levee of the Feather River (Source: City of Yuba City Pump Station No. 1)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	3.3
349	13	893+78	2,166,175.45	6,673,142.43	Burns Drive Storm Water Pump Station. 16 inch steel storm drain discharge pipe through levee. (Source: City of Yuba City Pump Station No. 1)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	2.7
350	13	881+40	2,164,942.19	6,673,036.13	Levee District No. 1 Relief Well Pump Station 6" pipes located just southeast of the Waste Water Treatment Plant. The waterside outlet structure has cobbles and the flap gate is damaged or plugged. CVFPB sent a notice of encroachment violation on August 16, 2011 to Sutter County.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Recommended Removal**	RW(P)	5.1
351	13	881+43	2,164,944.76	6,673,036.17	Levee District No. 1 Relief Well Pump Station 14" pipes located just southeast of the Waste Water Treatment Plant. The waterside outlet structure has cobbles and the flap gate is damaged or plugged. CVFPB sent a notice of encroachment violation on August 16, 2011 to Sutter County.	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Recommended Removal**	RW(P)	5.1
352	13	856+23	2,162,702.52	6,674,085.34	South Yuba City Seepage Interceptor Pump Station 24 inch 7 GA Steel Pipe asphalt coated and wrapped with asphalt saturated felt discharge pipe (Source: City of Yuba City Pump Station No. 7)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Recommended Removal**	SD(P)	5.2
353	13	856+08	2,162,689.81	6,674,093.30	South Yuba City Storm Drainage Pump Station 24 inch 7 GA Steel Pipe asphalt coated and wrapped with asphalt saturated felt discharge pipe (Source: City of Yuba City Pump Station No. 3)	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SD(P)	5.2

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Location (NAD 83) Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
354	13				Seepage Interceptor Trench and additional relief wells. The improvements were adjacent to the River Oaks subdivision between the wastewater treatment plant and Shanghai Road. All work on landside of levee.	Cutoff wall		struc	
355	13	849+85			Telephone Call box on waterside hinge point	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	TL	
356	13				Bike Path below Twin Cities Memorial Bridge	Cutoff wall		struc	
	12/13	845+00			Reach 12/13 Transition				
~~357~~	~~12~~				~~Shanghai Bend Road Setback levee project~~	No Rehabilitation Required		~~struc~~	
358	12	832+24	to be installed	to be installed	City of Yuba City Sewer 24 inch welded steel pipe mortar lined and coated pipe discharge pipe. This pipeline shall replace the existing 24 inch located at Station 828+55. The existing pipeline will be removed and disposed.	No Rehabilitation Required	This is a new pipelines that will meet Title 23 and USACE requirements except as noted in variance column.	SS(P)	2.0
359	12	832+17	to be installed	to be installed	City of Yuba City Sewer 2-24 inch welded steel pipe mortar lined and coated pipe discharge pipe. This is a new pipeline requested by the City of Yuba City.	No Rehabilitation Required	This is a new pipelines that will meet Title 23 and USACE requirements except as noted in variance column.	SS(P)	2.0
	11/12	830+00			Reach 11/12 Transition				
360	11	828+55	2,160,267.77	6,675,134.01	City of Yuba City Sewer 24 inch welded steel pipe mortar lined and coated pipe (wall thickness 0.188" min) Discharge Pipe to river diffuser	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed. **Replace in accordance with USACE standard**	SS(P)	2.3
~~361~~	~~11~~				~~To place an 18 inch storm drain pipeline through the levee on the right bank of the Feather River **(project was not completed – no pipeline installed)**~~	~~Cutoff Wall~~		~~SS(P)~~	
	10/11	774+00			Reach 10/11 Transition	Cutoff Wall			
362	10	771+30			Construct a gaging station approximately 150 feet downstream form the present gaging station, known as Feather River below Shanghai Bend. It is proposed to install an 8 foot high by 5 foot 4 inch square recorder house on the right bank berm approximately 155 feet from centerline of levee.	Cutoff Wall		struc	
363	10	750+40	2,152,869.21	6,673,338.66	115 kv steel tower transmission line crossing of levee	Cutoff Wall		EL	OH
364	10	750+10	2,152,823.05	6,673,332.24	12 kv power line crossing of levee	Cutoff Wall		EL	OH
	9/10	706+50			Reach 9/10 Transition	Cutoff Wall			
365	9	692+00			To construct 140 lineal feet of sheet piles retaining wall, and nine 10 x 20 foot boat docks supported by seven 12 inch diameter steel piles to an existing 30 foot wide ramp (Boyd Pump Boat Ramp)	Cutoff Wall	Located within floodway. Does not affect levee project.	struc	
366	9	692+00			To improve the existing Boyd Pump Boat Launching Facility by widening the existing ramp to 30 feet with 4 foot walkways on each side, paving existing access road, and expanding parking area by 25 spaces, and placing riprap on the right bank of the Feather River.	Cutoff Wall		Struc	
367	9	692+00			To construct boat launching ramp, well, pump, pressure system, and sanitary facilities on the right bank overflow of the Feather River	Cutoff Wall		Struc	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
368	9	689+09	2,146,949.33	6,672,031.04	Oswald Mutual Water Company (Boyd's Pump) 18 inch epoxy coated mortar lined steel pipe through existing 24 inch concrete pipe crossing of levee	Cutoff Wall	The pipeline does not meet title 23 requirements. The facility will need to go up and over the levee and will need a positive shut-off structure installed and anti-siphon device. **Replace in accordance with USACE standard**	IR(P)	27.6
369	9	689+00	2,146,953.52	6,672,029.11	To replace an existing pole line with a new pole line across the right bank levee of the Feather River. A new pole will be placed 10 feet landward of the landward toe of the levee and another pole will be placed 24 feet water ward of the water ward toe of the levee.	Cutoff Wall		EL	OH
370	9	689+00	2,146,953.52	6,672,029.11	To place a service line on a PG&E pole crossing the right bank levee of the Feather River	Cutoff Wall		TL	OH
371	9	688+90			Irrigation Production Well (located 25 foot west of landside levee toe)	Cutoff Wall		well	
372	9	669+20			Sierra Gold Nursery. Service Pole, Electrical Panel, Meter, and Irrigation Production Well 30 feet from landside levee toe.	Cutoff Wall		well	
373	9	664+07	2,144,450.88	6,672,127.42	Sierra Gold Nursery. An 8 inch steel pipe through levee. This pipe was pressure checked and in 1984 as part of permit 13980 to connect to existing pipe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	SD(P)	3.6
374	9	664+20			To reconstruct and pave a 12 foot wide, approximately 1370 feet long road on the landside toe of the right bank levee of the Feather River	Cutoff Wall		struc	4.0
375	9	655+50			Service Pole, Electrical Panel, Water Well, Pump, and irrigation facilities	Cutoff Wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right of way.**	well	
	8/9	654+75			Reach 8/9 Transition				
376	8	649+11	2,142,954.74	6,672,128.18	Construct #3/4 ACSR 12kv pole line across the right bank levee of the Feather River, approximately 1900 feet southerly from Messick Road extended easterly to the river. Extension to serve 50 HP agricultural pump for C.E. Sullivan	Cutoff Wall		EL	OH
377	8	647+74	2,142,830.08	6,672,119.48	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.6
378	8	647+70	2,142,826.16	6,672,118.89	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.3
379	8	647+66	2,142,822.01	6,672,118.27	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.4
380	8	647+61	2,142,817.52	6,672,117.60	Feather Water District North Pump Station 1-26" irrigation discharge pipes	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off structure and anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.3
381	8	638+20			Service Pole, Electrical Panel, Water Well, Pump, Sand Seperator, Concrete Pad, and irrigation facilities (20 feet west of levee toe)	Cutoff Wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right of way.**	well	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
382	8	622+79			Stand pipe, Service Pole, Electrical Panel, and Pump House, Water Well, and Pump at landside levee toe	Cutoff Wall	The water well does not meet Title 23 since too closes to levee. The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	well	
383	8	622+79	2,140,350.59	6,671,955.66	Installation of a 12kv power line crossing of the right bank of the Feather River.	Cutoff wall		EL	OH
384	8	609+50			Service Pole, Electrical Panel, Water Well, Pump, Sand Separator, Concrete Pad, and irrigation facilities (40 feet west of levee toe)	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	well	
	7/8	596+00			Reach 7/8 Transition	Cutoff wall			
385	7	592+67	2,137,447.24	6,671,791.94	12 kv power line across levee	Cutoff wall		EL	OH
386	7	587+00	2,136,925.70	6,671,619.94	Spur Levee upstream of Abbott Lake	Cutoff wall		struc	
387	7				WS Slope varies from 3:1 near crown to 2:1 to 1:1 at toe. Sloughing and caving toe. Along slope I is hummocky; possibly from local slumping.	Cutoff wall		struc	
388	7				caving and slumping at toe. Rip rap berm toe. Difficult to evaluate due to vegetation growth.	Cutoff wall		struc	
389	7	569+00			To fill in approximately one mile of an existing irrigation ditch at the waterside toe of the right bank of the Feather River.	Cutoff wall with existing relief wells	**Relocate outside of of the proposed right-of-way.**	Struc	
390	7				Bank caving 3 to 4 feet high, intermittent repair with rip rap berm at base of over steepened slope	Cutoff wall with existing relief wells		struc	
391	7	560+00			To construct a water well with a 14 inch casing in the right bank overflow of the Feather River at Abbott Lake.	Cutoff wall with existing relief wells		well	
392	7	560+00			To extend approximately 2,500 of 12kv electric service line in the right bank overflow area of the Feather River near Abbott Lake to serve 25 HP Ag Pump for A.S. Cozzalino.	Cutoff wall with existing relief wells		EL	OH
393	7	557+00			Service Pole, Electrical Panel, Water Well, Pump, Sand Seperator, Concrete Pad, and irrigation facilities (50 feet west of levee toe)	Cutoff wall with existing relief wells	**Relocate outside of of the proposed right-of-way.**	well	
394	7	545+41	2,132,940.57	6,672,317.26	Crushed CMP Riser in Land Side Slope. Possible location of 8 inch steel pipe.	Cutoff wall with existing relief wells	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(A)	3.1
395	7	536+73	2,132,153.19	6,672,681.57	Existing 10 inch steel pipe. Removed in 1964 by Levee District No. 1 as part of permit 4775	Cutoff Wall		IR(?)	
396	7	536+64	2,132,149.73	6,672,692.81	5 inch steel drainage pipe	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(P)	2.0
397	7	532+00 to 596+00			Taylor Brothers. 15 inch Irrigation Main located within 15 feet of landside toe	Cutoff Wall	The pipeline is within twenty (20) feet of the levee toe and does not meet Title 23. **Relocate outside of of the proposed right-of-way.**	IR (G)	
398	7	529+47	2,131,549.40	6,673,081.12	Abandon 6 inch pipe	Cutoff Wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	IR(A)	4.0
399	7	515+00			Seepage Interceptor Trench for Star Bend Relief Well Pumps	Cutoff Wall		struc	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
400	7	512+08	2,130,379.55	6,674,329.99	Corp of Engineers Star Bend Road Relief Well Pump Station north 15" Steel Discharge Pipe Crossings	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed. **Replace in accordance with USACE standard**	SD(P)	3.8
401	7	512+04	2,130,375.66	6,674,332.71	Corp of Engineers Star Bend Road Relief Well Pump Station south 15" Steel Discharge Pipe Crossings	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed. **Replace in accordance with USACE standard**	SD(P)	3.7
402	7	510+97	2,130,288.81	6,674,393.77	12 kv power line crossing of levee	Cutoff Wall		EL	OH
	6/7	510+37			Reach 6/7 Transition	Cutoff Wall			
403	6	510+30			To retain a 12 kv overhead service line and four power poles in the right bank overflow area of the Feather River	Cutoff Wall	**Relocate outside of of the proposed right-of-way**	EL	OH
404	6	510+36	2,130,239.19	6,674,428.41	Volcano Vista Farms 18 inch steel irrigation discharge pipe crossing of levee	Cutoff Wall		IR(P)	4.0
405	6	510+30			To install 20 hp irrigation pump and to retain an existing walnut orchard (35 acres) all on the right bank of the Feather. Now owned by Volcano Vista Farms and located on Tudor Mutual Pump Station (relocated pipeline part of permit 18438)	Cutoff Wall		IR(P)	
406	6	510+25	2,130,230.41	6,674,434.54	Tudor Mutual Water Company North 30 inch steel irrigation discharge pipes crossing of levee	Cutoff Wall		IR(P)	4.2
407	6	510+20	2,130,222.24	6,674,437.45	Tudor Mutual Water Company South 30 inch steel irrigation discharge pipes crossing of levee	Cutoff Wall		IR(P)	4.1
408	6				12 inch steel pipe through levee	Cutoff Wall	The conduit may meet title 23 requirements but will need to be replaced during cutoff wall construction. **Replace in accordance with USACE standard**		
409	6				12 kv power line crossing of levee	Cutoff Wall			
410	6				12 kv power line crossing including 9 power poles and 3 anchors (appears to cover permit 2502 and 5072)	Cutoff Wall			
411	6				Abandon 14 inch pipe (this pipeline removed as part of 2009 setback levee project). Listed as 10" Steel in original 1955 O&M manual	Cutoff Wall	**Recommended Removal**	IR(P)	4.1
412	6	509+00			To construct approximately 1,400 lineal feet of filter trench adjacent to the right bank levee of the Feather River	Cutoff Wall		Struc	
413	6	508+00			To clear, level, and plant a peach orchard on approximately 170 acres on the right bank of the Feather River.	Cutoff Wall		Trees	
414	6				Fix in-place the existing levee with 65ft deep cutoff wall between station 478+68 and station 512+00	Cutoff Wall		struc	
	5/6	478+68			Reach 5/6 Transition	Cutoff wall with seepage berm			
415	5	475+00			To plant walnut orchard in the right overflow area of the Feather River downstream from Star Bend	Cutoff wall with seepage berm		Trees	
	5	461+00			Urban (200 year) North - Nonurban (100 year) South Transition	Cutoff wall with seepage berm			

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
416	5	460+11	2,125,845.57	6,676,268.36	Abandon 8" steel drainpipe. The CVFPB sent an encroachment violation notice on August 16, 2011 to Dan Stephens Trust.	Cutoff wall with seepage berm	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(P)	4.1
417	5	442+80	2,124,212.69	6676803.8	Abandon 8" steel drainpipe	Cutoff wall	The pipeline does not meet title 23 requirements and will need a positive shut-off structure installed and automatic drainage gate on waterside of levee. **Recommend Removal**	SD(P)	4.1
418	5	433+50	2,123,304.56	6,677,004.67	Power line across levee to service pole with meter on waterside slope of levee	Cutoff wall	**Relocate outside of of the proposed right-of-way.**	EL	OH
419	5	405+90 to 424+00			Taylor Brothers. 15 Inch Irrigation Main located within 15 feet of landside toe	Cutoff wall	The pipeline is within twenty (20) feet of the levee toe and does not meet Title 23. **Relocate outside of of the proposed right-of-way.**	IR (G)	
420	~~5~~	~~417+66~~	~~Not Verified~~		~~Abandon floating 24 inch pipe through levee. The permit was revoked to removal of 24 inch via 1666A so there should not be any pipe.~~	~~Cutoff wall~~		~~SD(G)~~	
	4/5	410+67			Reach 4/5 Transition	Cutoff wall			
421	4	410+53	2,121,173.09	66,776,661.21	Power line crossing to Feather Water District Pumps	Cutoff wall		EL	OH
422	4	409+84	2,121,105.29	6,677,660.77	To install a 2 inch electrical conduit through the levee. The conduit will be buried in the levee slopes and through the crown with one foot of cover. The conduit will provide electrical service to an existing pumping plant in the floodway of the Feather River.	Cutoff wall	The conduit may meet title 23 requirements but will need to be replaced during cutoff wall construction. **Replace in accordance with USACE standard**	EL	2.0
423	4	409+66	2,121,086.77	6,677,660.88	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	0.8
424	4	409+62	2,121,082.47	6,677,660.77	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	0.9
425	4	409+58	2,121,078.48	6,677,660.82	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	0.8
426	4	409+55	2,121,075.08	6,677,660.80	Taylor Brothers Farm Irrigation Pump Station. A inclined pump located on the waterside slope of levee with 14 inch Pipeline through levee	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.4
427	4	409+50	2,121,069.88	6,677,660.77	Feather Water District South Pump Station 1-18" irrigation discharge pipes. The improvements include a reservoir at the landside toe of levee and a inlet channel from river to waterside toe.	Cutoff Wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure and new anti-siphon device installed. **Replace in accordance with USACE standard**	IR(P)	1.7
428	4	407+72	2,120,892.86	6,677,656.42	Abandoned pipe and structure at landside toe, pipe is 8 inch, but the headwall appears that it is run through a larger older pipe possibly and old drainage pipe	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	21.8
429	4	407+72	2,120,892.86	6,677,656.42	Taylor Brothers Production Water Well (facilities located at levee toe).	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	well	
430	4	396+32	2,119,752.28	6,677,651.86	8 inch pipe crossing. Headwall at land toe, art on land side of crown, and cut pipe near water side toe. CVFPB sent a notice of violation notice on October 4, 2011	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(P)	4.1
431	4	396+50 to 409+00			Taylor Brothers. 15 Inch Irrigation Main located within 15 feet of landside toe	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	IR (G)	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
432	4	396+50 to 409+00			Feather Water Distrpct. 42 inch Irrigation Main located within 10 feet of landside toe with standpipes	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	IR (G)	
433	4	396+20			Feather Water District Irrigation Production Well (facilities located 10 foot west of toe). CVFPB sent a notice of violation notice on October 4, 2011.	Cutoff Wall		well	
434	4	386+63	2,118,786.69	6,677,704.40	Abandon 8 inch pipe crossing, stand pipe on land toe has been destroyed. CVFPB sent a notice of violation on October 4, 2011.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	4.6
435	4	365+00	2,116,703.78	6,678,265.36	Abandon 8 inch pipe crossing, stand pipe on land toe has been removed.	Cutoff Wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	4.8
436	4	342+27	2,114,521.84	6,678,856.40	Irrigation Production Well (located on foot west of levee toe).	Cutoff Wall	**Relocate outside of of the proposed right-of-way.**	well	
437	4	320+00			Approximately 500 horizontal feet of vertical excavation in the levee toe, cut 1 to 3 feet high. CVFPB sent out a encroachment violation notice on July 27, 2011 to Monasterio Family Trust.	Cutoff Wall		struc	
438	4	313+00			Approximately 100 horizontal feet of vertical excavation in the levee toe, cut about 3 feet high. Toe excavations are eroding and caving. CVFPB sent out a encroachment violation notice on September 12, 2011 to Monasterio Family Trust.	Cutoff Wall		struc	
	3/4	300+66			Reach 3/4 Transition				
439	3	298+89	2,110,314.83	6,679,535.86	Removal of a portion and filling with concrete a portion of an abandoned 36 inch steel pipe through the right bank levee of the Feather River	Cutoff wall	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(G)	
440	3	298+00			Approximately 600 horizontal feet of vertical excavation in the levee toe, cut 1 to 3 feet high. Toe excavations are eroding and caving. The CVFPB sent an encroachment violation notice on July 27, 2011 to Golden Gate Hop Ranch, Inc.	Cutoff wall		struc	
441	3	298+67	2,110,292.12	6,679,458.78	Garden Highway Mutual Water - Irrigation Production Well #23 (located 30 foot west of levee toe)	Cutoff wall		IR(W)	
442	3	298+38	2,110,262.81	6,679,553.31	Garden Highway Mutual Water 54 inch Irrigation Pump Station Discharge Pipeline through Levee. The improvements include a inlet channel from the river to the 200 feet from waterside toe of levee and irrigation canal at the toe of the landside of levee.	Cutoff wall	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed and new pipe. **Replace in accordance with USACE standard**	IR(G)	25.1
	3	280+90			State Maintenance Area 3 / Levee District No. 1 Levees Transition	Cutoff wall			
443	3	279+50			Garden Highway Mutual Water - Irrigation Production Well #4 (located 90 foot west of levee toe)	Cutoff wall		IR(W)	
444	3	274+50			Garden Highway Mutual Water - Irrigation Production Well #22 (located 20 foot west of levee toe)	Cutoff wall	The water well is located within the proposed right-of-way for levee project. **Relocate outside of of the proposed right-of-way.**	IR(W)	
445	3	241+75			Garden Highway Mutual Water - Irrigation Production Well #18 (located 50 foot west of levee toe)	Cutoff wall		IR(W)	
446	3	219+00			Garden Highway Mutual Water - Irrigation Production Well #19 (located 90 foot west of levee toe)	Cutoff wall with seepage berm		IR(W)	
447	3	219+00			12 inch pipe. Appears to be removed by pipe laying on ground adjacent to location	Cutoff wall with seepage berm	The pipeline does not meet title 23 requirements and no longer in use. **Recommend Removal**	IR(A)	
	2/3	218+66			Reach 2/3 Transition				
448	2	209+89	2,101,737.07	6,678,931.40	Electrical service crossing for pump	Cutoff wall with seepage berm	**Relocate outside of of the proposed right-of-way.**	EL	OH

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

Item No.	Reach	STA	Location (NAD 83) Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
449	2	209+23	2,101,673.35	6,678,014.21	Kuster Private Irrigation Pump Station; 14 inch welded steel pipe crossing	Cutoff wall with seepage berm	The pipeline does not meet title 23 requirements. The crossing will need a positive shut-off device and structure installed and new pipe. **Replace in accordance with USACE standard**	IR(P)	3.0
450	2	217+00			National Audubon Society. To plant approximately 4,000 native trees on 40 acres within the right bank overflow area of the Feather River.	Cutoff wall with seepage berm		Trees	
451	2	217+00			National Audubon Society. To plant approximately 300 to 500 native trees (primarily cottonwoods) on the right bank overflow area of the Feather River.	Cutoff wall with seepage berm		Trees	

Type 1A - Removal & Disposal of Abandoned Raised Pipe

Type 1B - Removal & Disposal of Abandoned Through Pipe

Type 2A - Removal & Replace of Raised Pipe

Type 2B - Removal & Replace of Through Pipe

Type 3A - Removal & Replace of Raised Pipe Adjacent to Canal

Type 3B - Removal & Replace of Through Pipe Adjacent to Canal

Type 3C - Removal & Replace of Through Pipe Under Canal

Vegetation ETL Compliance

Relocation of Utility/Structure Outside of The Proposed ROW

Additional Works

Not Applicable/No Rehabilitation Required

SD(G)	Storm Water - Gravity
SD(P)	Storm Water - Pressure
SS (G)	Waste Water - Gravity
SS (P)	Waste Water - Pressure
IR(G)	Irrigation Line - Gravity
IR(P)	Irrigation Line - Pressure
RW (P)	Raw Water - Pressure
W(P)	Water Line - Pressure
RD	
GL	Gas Line
TL	Telephone Line
EL	Electrical Line
SIEEP	
STRUC	Structure

Table 5-4A Summary of Construction Contracts for Alternative SB8

Features	Contract A Reach 2A-North to 5 180+00 to 478+68 2022 - 2023	Contract SBFIP Reach 6 478+68 to 512+00 2021 – 2022	Contract B Reach 7 to 12 512+00 to 845+00 2021 - 2022	Contract C1 Reach 13 to 18 845+00 to 1213+85 2017 – 2018	Contract C2 Reach 19 to 25 1213+85 to 1674+37 2018 – 2019	Contract D1 Reach 26 to 33 1674+37 to 2122+00 2019 – 2020	Contract D2 Reach 34 to 41 2122+00 to 2638+00 2020 - 2021
No Rehabilitation Required	N/A	N/A	1,300LF	14,930LF	4,800LF	4,390LF	2,800LF
Cutoff Wall Only	22,200LF	3,340LF	26,150LF	11,490LF	36,680LF	30,910LF	16,800LF
Jet Grouting Cutoff Wall Only	N/A	N/A	N/A	560LF	N/A	400LF	N/A
Seepage Berm Only	N/A	N/A	N/A	350LF	N/A	NA	5,000LF
Cutoff Wall with Full Levee Degrade	N/A	N/A	N/A	N/A	600LF	NA	N/A
Cutoff Wall with Full Levee Degrade and Existing Relief Wells	N/A	N/A	N/A	5,300LF			
Cutoff Wall with Existing Relief Wells	N/A	N/A	3,300LF	2,630LF	N/A	NA	N/A
Cutoff Wall with New Relief Wells (22 Wells)	N/A	N/A	2,500LF	N/A	N/A	NA	N/A
Cutoff Wall with Seepage Berm	7,670LF	N/A	N/A	N/A	N/A	NA	N/A
Cutoff Wall with Levee Relocation	N/A	N/A	N/A	N/A	3,610LF	8,000LF	N/A
Cutoff Wall with Sutter Butte Canal Relocation	N/A	N/A	N/A	N/A	370LF	1,170LF	N/A
Cutoff Wall with Landside Toe Fill	N/A	N/A	N/A	1,870LF	N/A	NA	N/A
DSM Cutoff Wall (subpart of the Cutoff Wall Only area)	2,000LF	N/A	N/A	2,630LF	2,400LF	5,580LF	7,180LF
Erosion Protection	N/A	N/A	5,760LF	N/A	1,900LF	NA	N/A
Utilities & Encroachments (Total, Table 5-4B)	37	12	46	129	86	94	47
Utilities & Encroachments (To be modified, Table 5-4B)	27	4	19	53	37	52	31
Land Acquisition							
Number of Impacted Parcel							
Number of Potential Structural Demolition							
Closure Structure	N/A	N/A	N/A	1	N/A	N/A	N/A

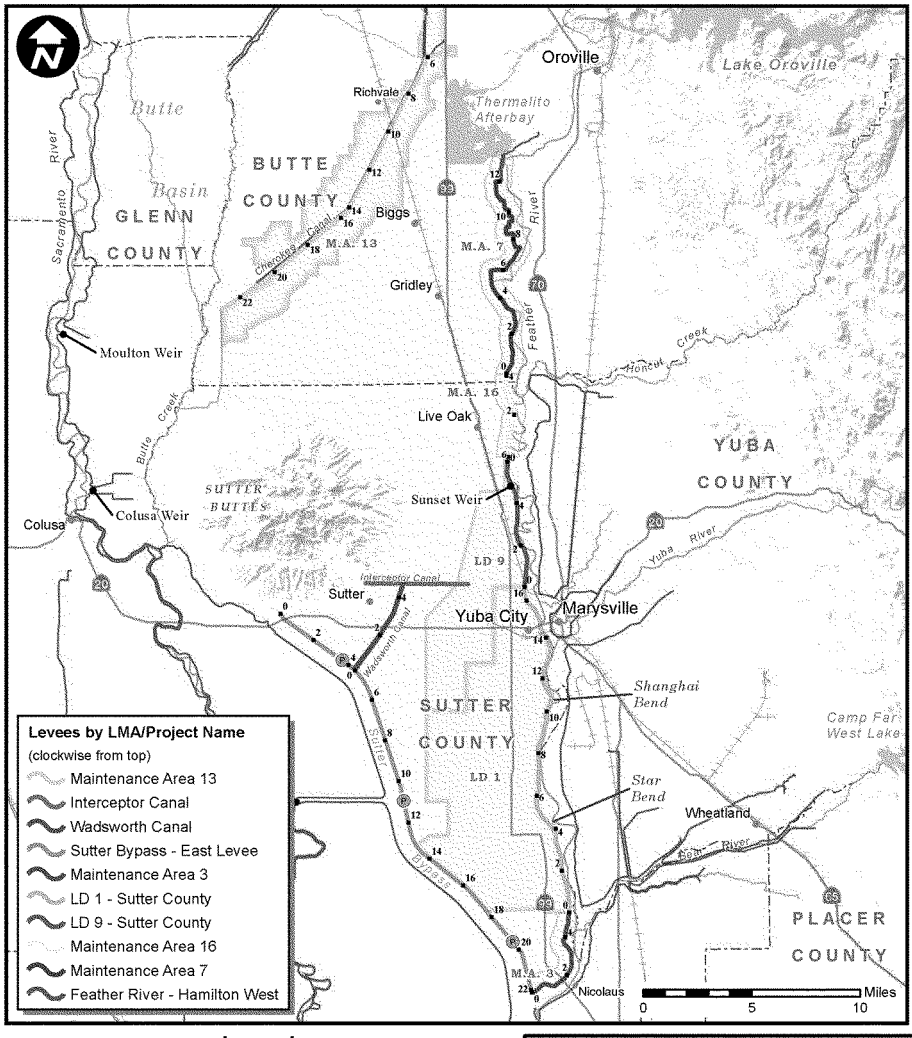
Table 5-4B Summary of Utilities & Encroachments for Construction Contracts

Color Codes	Types of Remediation	Alt. SB8	Construction Contracts: A	SBFIP	B	C1	C2	D1	D2
		Item No. 1 - 451	Item No. 415 - 451	Item No. 403 - 414	Item No. 357 - 402	Item No. 228 - 356	Item No. 142 - 227	Item No. 48 - 141	Item No. 1 - 47
	Type 1A - Removal & Disposal of Abandoned Raised Pipe	**21**	6	0	3	6	4	2	0
	Type 1B - Removal & Disposal of Abandoned Through Pipe	**12**	2	0	0	1	1	5	3
	Type 2A - Removal & Replace of Raised Pipe	**57**	7	0	9	25	6	6	4
	Type 2B - Removal & Replace of Through Pipe	**24**	1	0	0	0	3	9	11
	Type 3A - Removal & Replace of Raised Pipe Adjacent to Canal	**1**	0	0	0	0	0	1	0
	Type 3B - Removal & Replace of Through Pipe Adjacent to Canal	**3**	0	0	0	0	0	3	0
	Type 3C - Removal & Replace of Through Pipe Under Canal	**4**	0	0	0	0	1	3	0
	Vegetation ETL Compliance	**26**	3	1	0	0	12	10	0
	Relocation of Utility/Structure Outside of The Proposed ROW	**57**	8	1	7	18	9	9	5
	Additional Works	**18**	0	2	0	3	1	4	8
	Not Applicable/No Rehabilitation Required	**228**	10	8	27	76	49	42	16
Total Number of Utilities & Encroachments		**451**	37	12	46	129	86	94	47
Total Number of Utilities & Encroachments To Be Modified		**223**	27	4	19	53	37	52	31

Table 5-5 Borrow Sites and Usage for SB-8	Volume of Material (Potential)		
Borrow Sites and Usage	Type 1 (cy)	Type 2 (cy)	Random (cy)
2 - CDFG (OWA - Cobble Borrow)			330,800
Leftover after using borrow for D2			151,280
3 - Live Oak Detention Basin	150,000		
Leftover after using borrow for D2 - as Type 1	92,150		
Leftover after using borrow for D1 - as Type 1	0		
4 - Lanza 235 Borrow	250,000		
Leftover after using borrow for D1 - as Type 1	233,250		
Leftover after using borrow for D1 - as Type 2	62,850		
Leftover after using borrow for C2 - as Type 1	0		
5 - Nevis Property	250,000		
Leftover after using borrow for C2 - as Type 1	217,450		
Leftover after using borrow for C2 - as Type 2	143,550		
Leftover after using borrow for C1 - as Type 1	25,595		
Leftover after using borrow for C1 - as Type 2	12,252		
7 - Lanza 620 Acres Property	119,932	359,796	
Leftover after using borrow for A - as Type 1	948		
Leftover after using borrow for A - as Type 2		19,986	
8 - Huston Property	330,000		
Leftover after using borrow for B - as Type 1	199,279		
Leftover after using borrow for B - as Type 2	33,687		
11 - Siller Live Oak Property	250,000		
12 - Siller Yuba City Property		100,000	
Leftover after using borrow for SBFIP - as Type 2		53,200	
Total Potential	1,349,932	459,796	330,800

Table 5-6 Borrow Demand for SB-8	**Volume of Material (Demand)**		
Construction Contracts and Usage	Type 1 (cy)	Type 2 (cy)	Random (cy)
CONTRACT A	118,984	339,810	
Unknown (7 or within vicinity R of the contract)	118,984	339,810	
CONTRACT STAR BEND (SBFIP)		46,800	
12 - Siller Yuba City Property		46,800	
CONTRACT B	130,721	165,592	
8 - Huston Property	130,721	165,592	
CONTRACT C1	117,955	13,343	
5 - Nevis Property	117,955	13,343	
CONTRACT C2	95,400	73,900	
4 - Lanza 235 Borrow	62,850		
5 - Nevis Property	32,550	73,900	
CONTRACT D1	108,900	170,400	
3 - Live Oak Detention Basin	92,150		
4 - Lanza 235 Borrow	16,750	170,400	
CONTRACT D2	57,850		179,520
2 - CDFG (OWA - Cobble Borrow)			179,520
3 - Live Oak Detention Basin	57,850		
Total Demand	629,810	809,845	179,520

PLATES



Legend

- Study Area Extent
- Levee Maintenance Agency
- Federal Levee
- Levee Mile
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

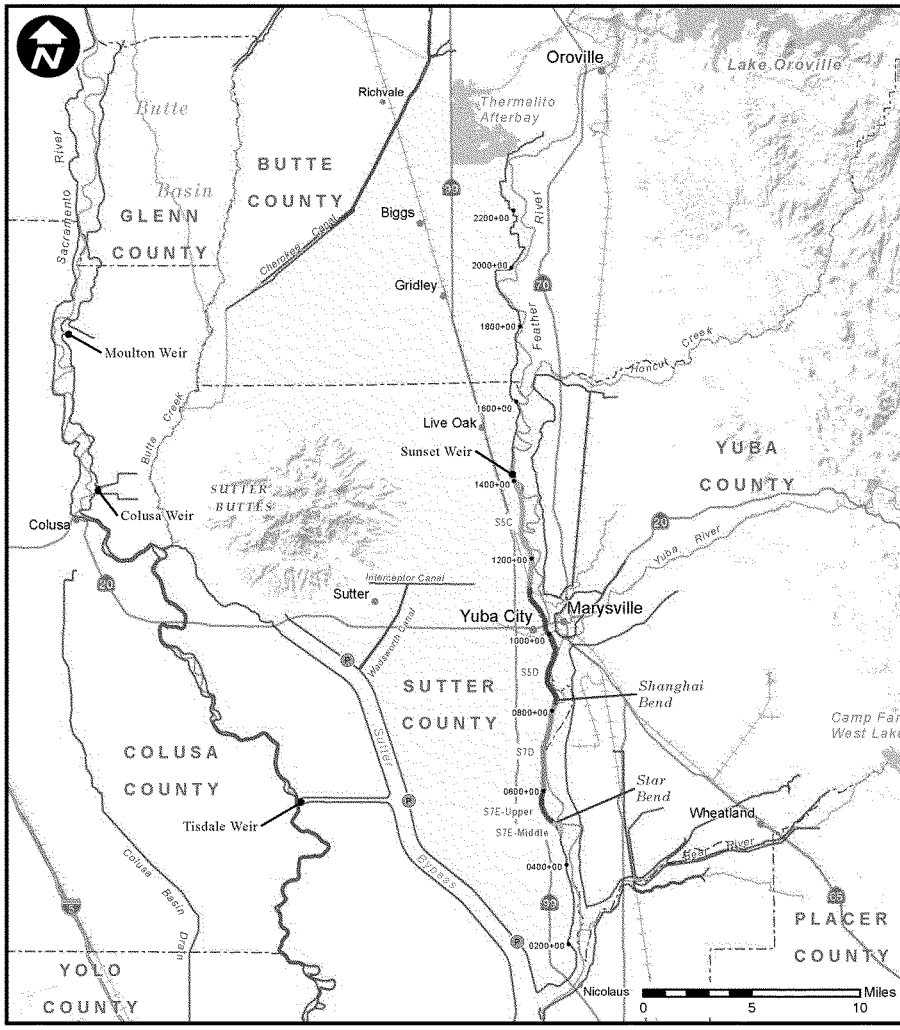
SUTTER BASIN PROJECT AREA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-1



Legend

Study Area Extent	Lake or Reservoir
S5B Project Reach	River or Stream
Federal Levee	Highway
Stationing Point	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

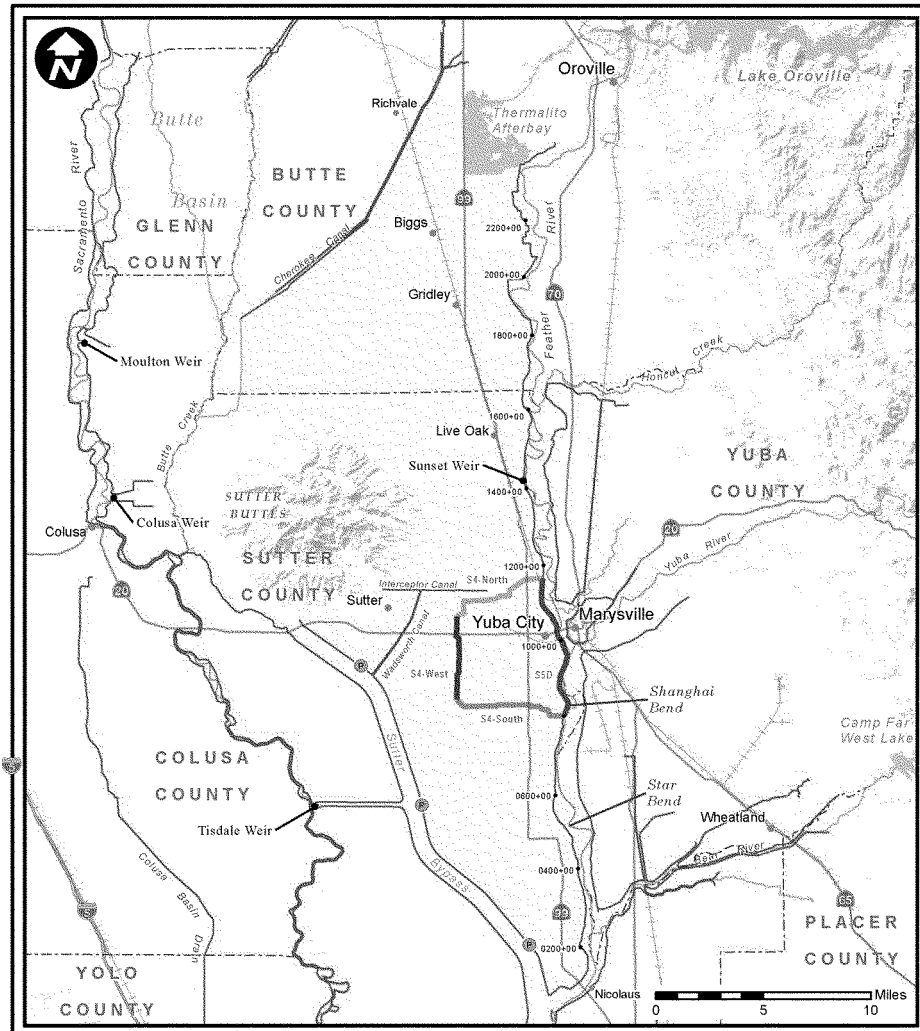
ALTERNATIVE SB-2:
MINMAL FIX-IN-PLACE
FEATHER RIVER LEVEES:
SUNSET WEIR TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-2



Legend

Study Area Extent	Lake or Reservoir
Project Reach	River or Stream
Federal Levee	Highway
Stationing Point	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

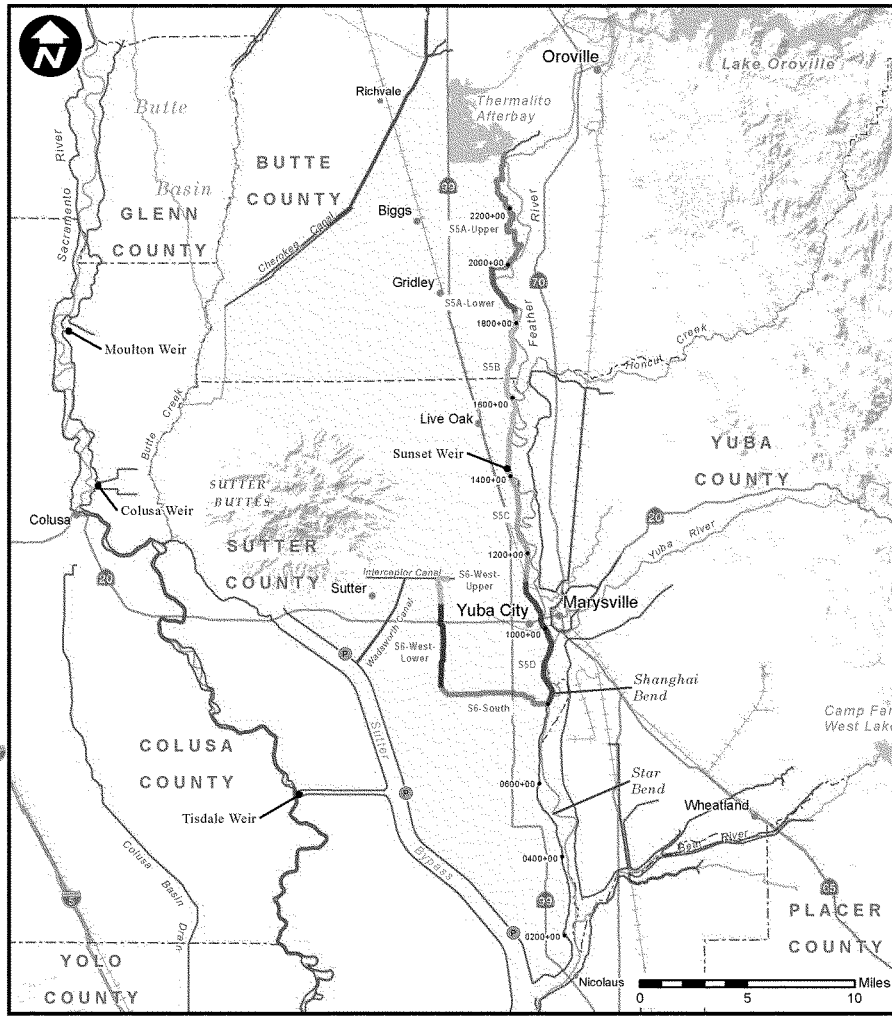
ALTERNATIVE SB-3:
YUBA CITY RING LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-3



Legend

Study Area Extent	Lake or Reservoir
S5B Project Reach	River or Stream
Federal Levee	Highway
Stationing Point	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

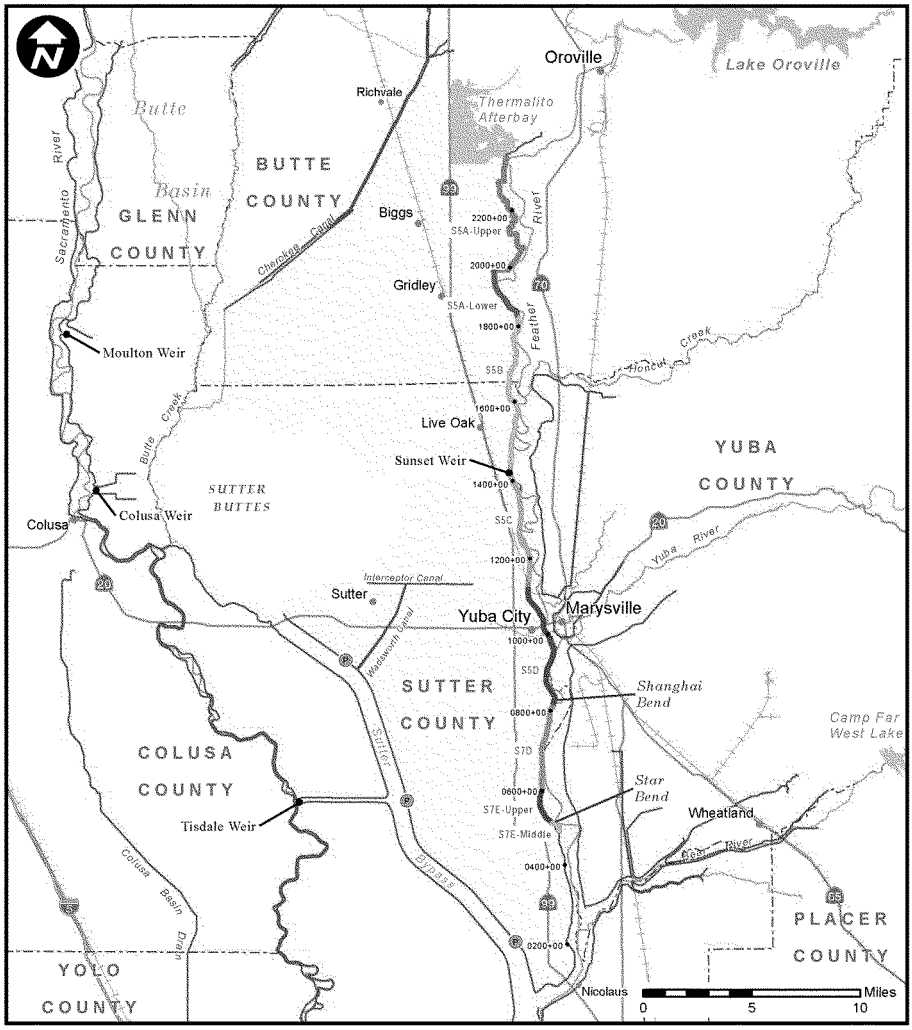
ALTERNATIVE SB-4:
LITTLE J LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-4



Legend

- Study Area Extent
- S5B Project Reach
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-5:
FIX-IN-PLACE
FEATHER RIVER LEVEES:
THERMAILTO TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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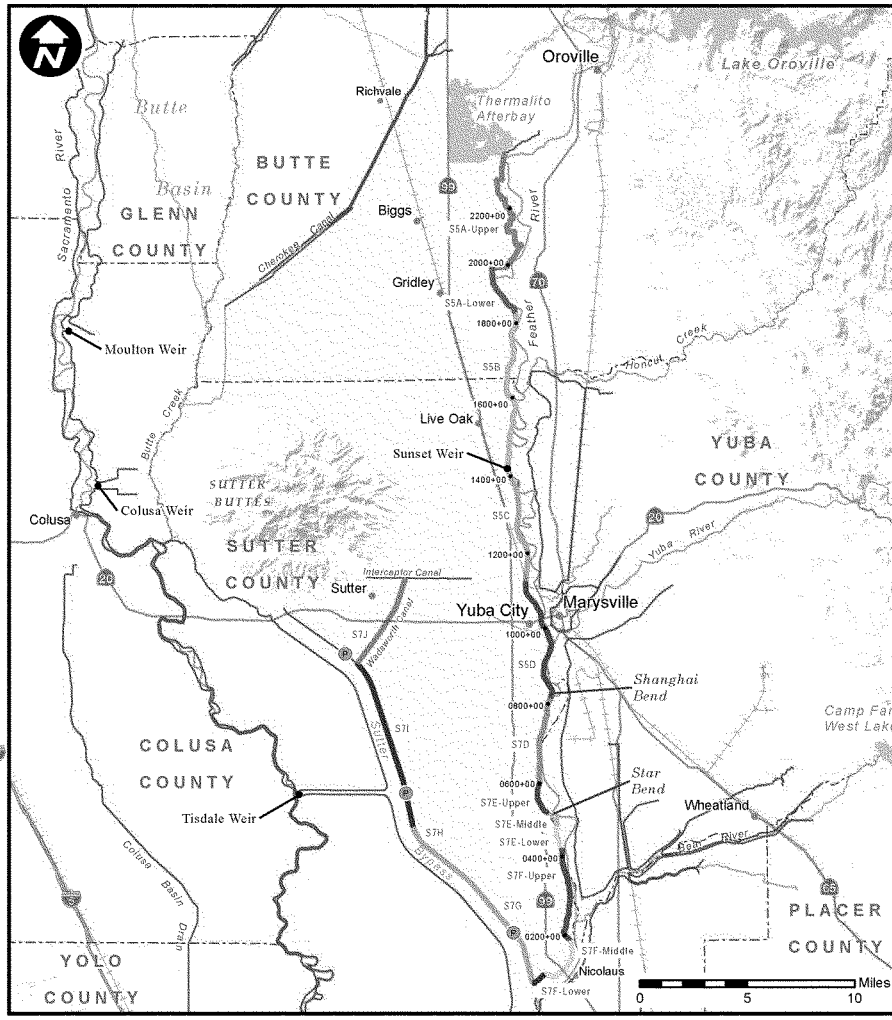
APR 2013

PLATE 1-5



Legend

Study Area Extent	Lake or Reservoir
Project Reach	River or Stream
Federal Levee	Highway
Stationing Point	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

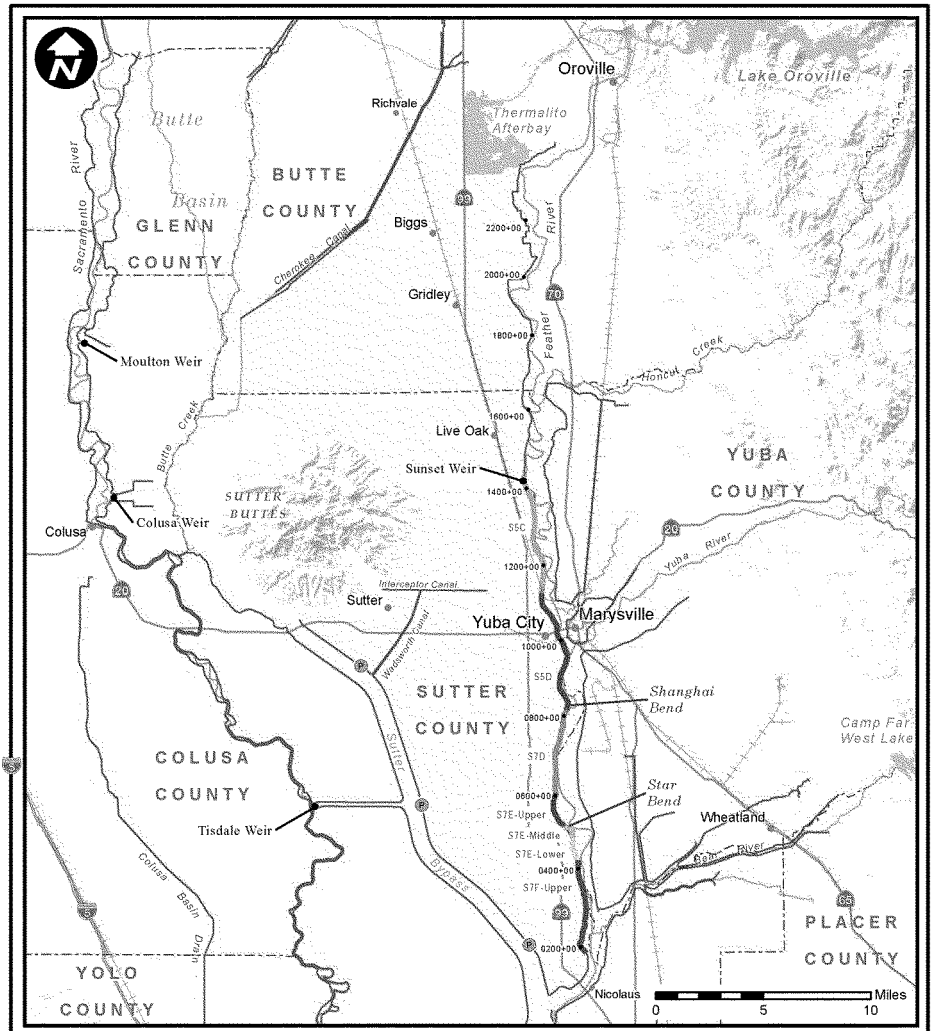
ALTERNATIVE SB-6:
FIX-IN-PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH CANAL LEVEES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-6



Legend

Study Area Extent	Lake or Reservoir
Project Reach	River or Stream
Federal Levee	Highway
Stationing Point	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-7:
FIX-IN-PLACE
FEATHER RIVER LEVEES:
SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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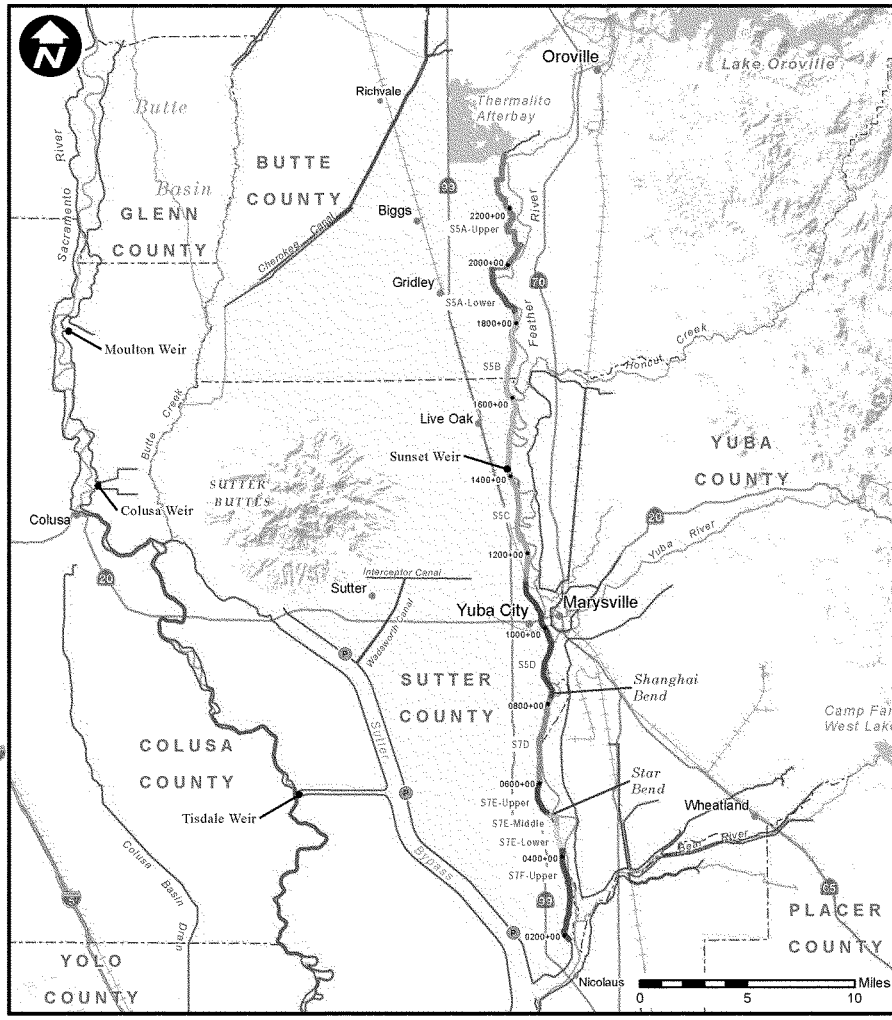
PLATE 1-7



Legend

Study Area Extent	Lake or Reservoir
S5B Project Reach	River or Stream
Federal Levee	Highway
Stationing Point	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-8:
FIX-IN-PLACE
FEATHER RIVER LEVEES:
THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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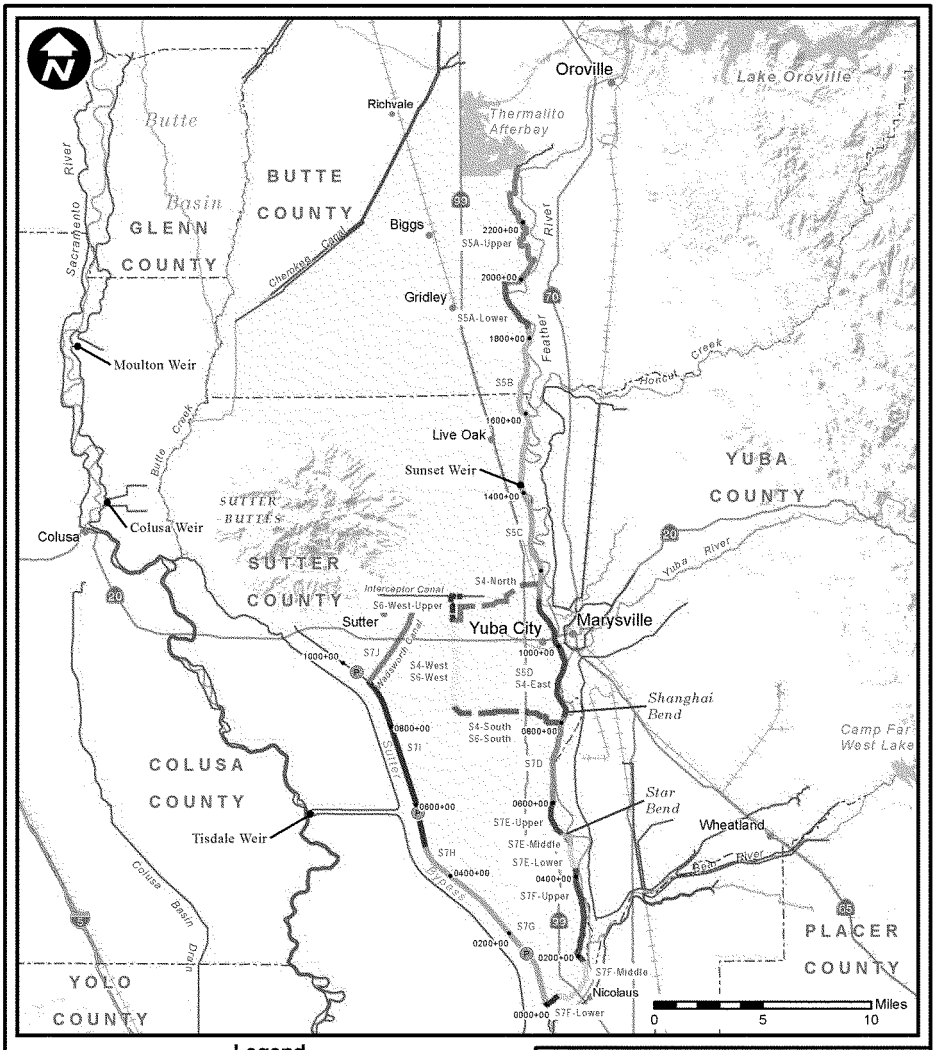
PLATE 1-8



Legend

- Study Area Extent
- S5B Project Reach
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

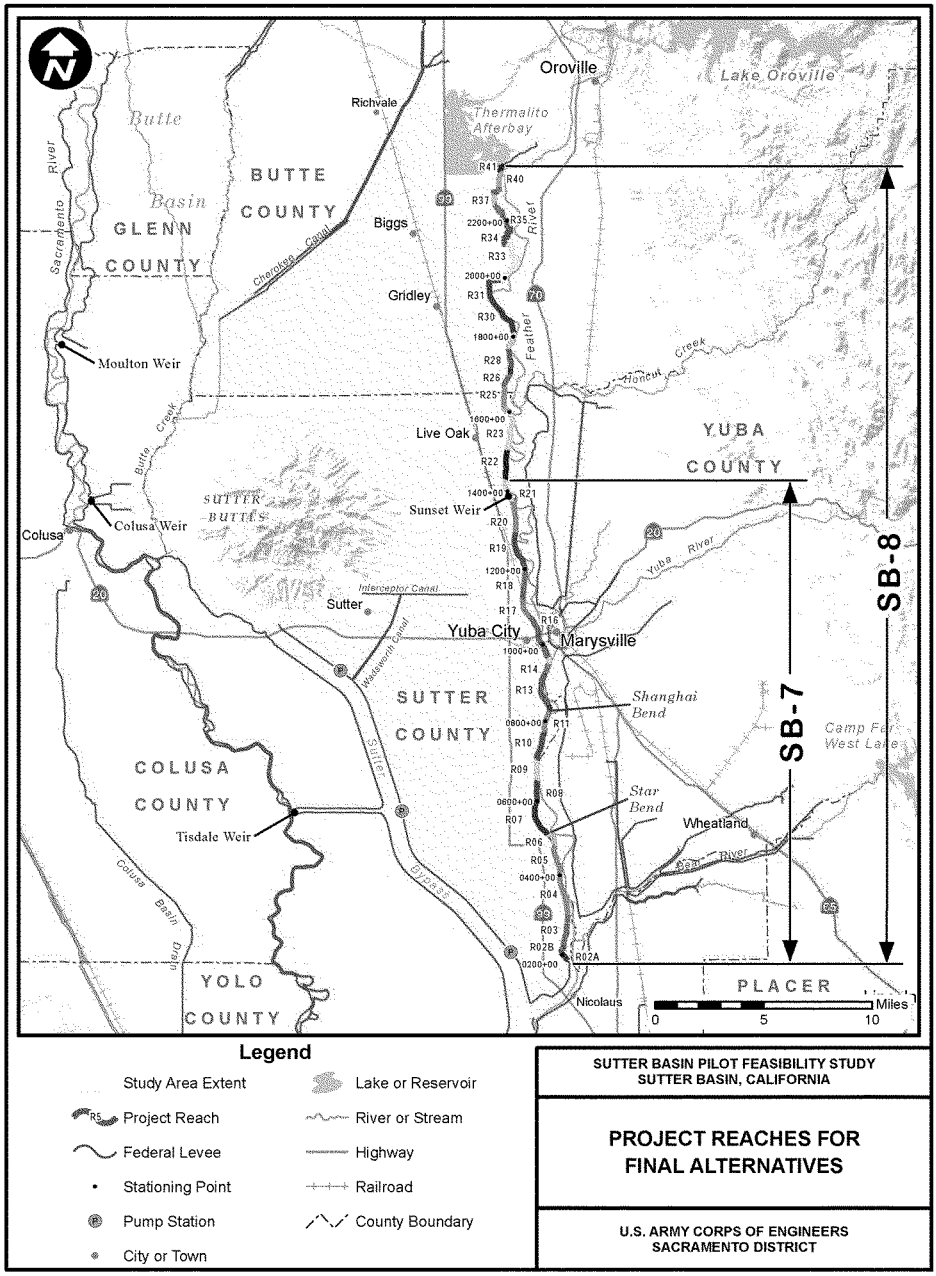
PROJECT REACHES FOR CONCEPTUAL ALTERNATIVES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 2-1



Legend

Study Area Extent	Lake or Reservoir
Project Reach	River or Stream
Federal Levee	Highway
Stationing Point	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

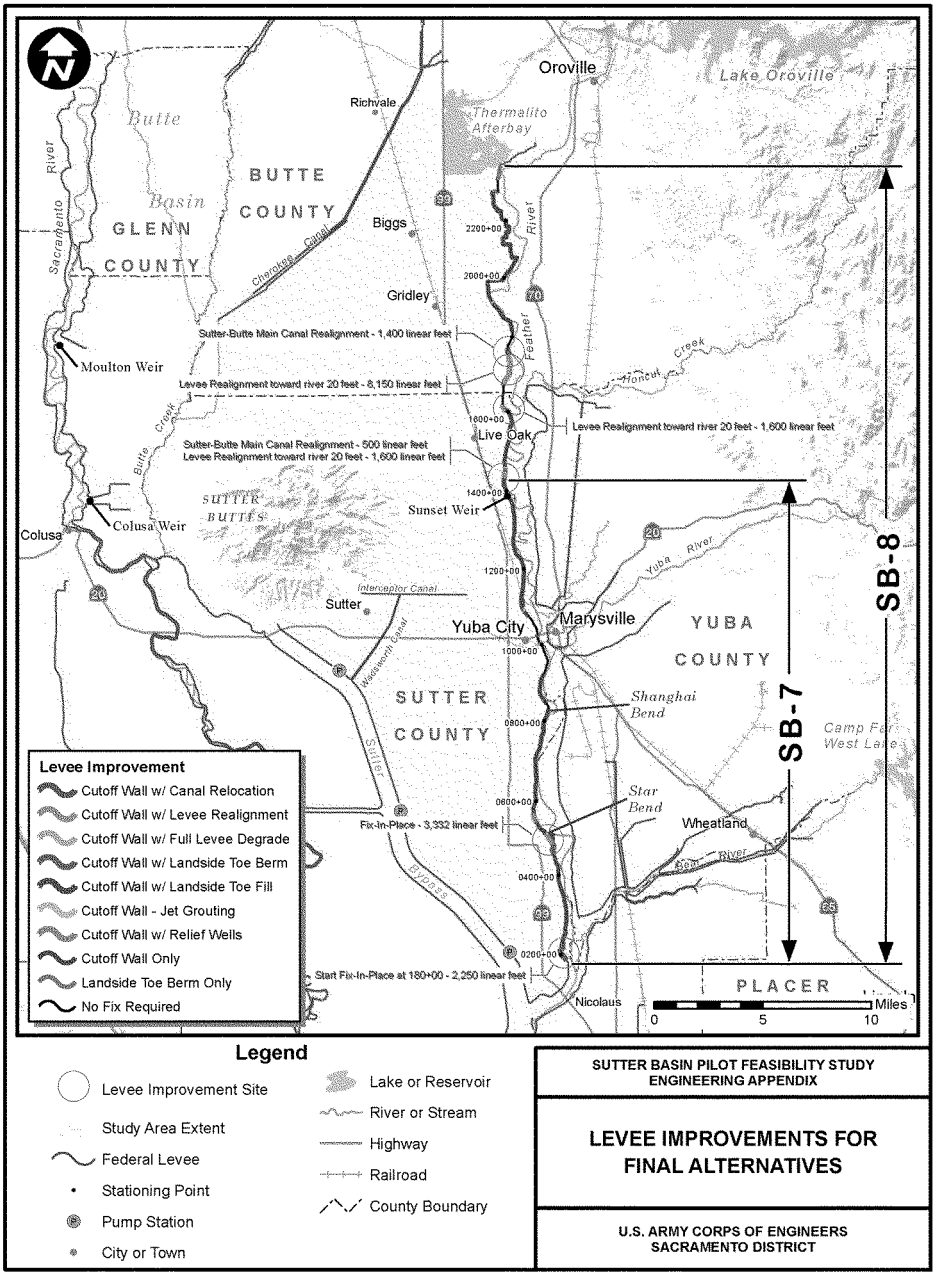
PROJECT REACHES FOR FINAL ALTERNATIVES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 2-2



Legend

- Levee Improvement Site
- Study Area Extent
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

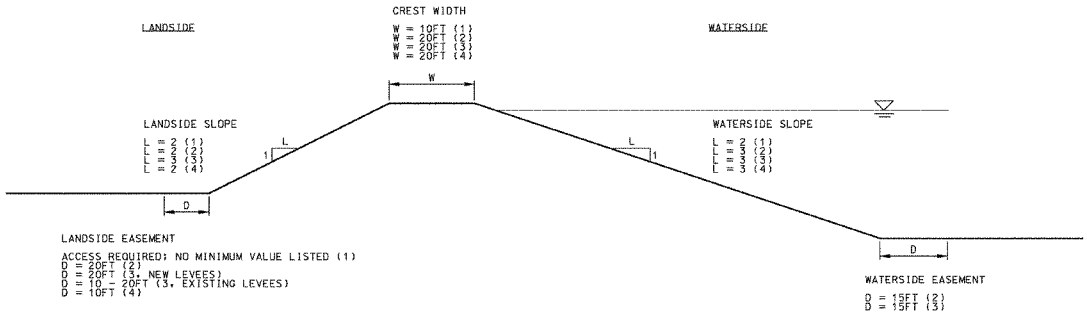
LEVEE IMPROVEMENTS FOR FINAL ALTERNATIVES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 2-3



REFERENCES

(1) EM 1110-2-1913, DESIGN & CONSTRUCTION OF LEVEES, APRIL 2000
(2) SPK, GEOTECHNICAL LEVEE PRACTICE (REFP1OLO OR SOP3), 11 APRIL 2008
(3) DWR, URBAN LEVEE DESIGN CRITERIA, MAY 2012 (NEW LEVEES, EXCEPTIONS MAY BE ALLOWED FOR RECONSTRUCTION OF EXISTING LEVEES
(4) CCR TITLE 23, WATERS DIVISION 1, CVFPB REGULATIONS, 22 JAN 2010

US Army Corps of Engineers®
Sacramento District

Designed by: TBM SE
Date:
Rev.
Drawn by: TBM SE
Design Sys: —
Scale: —
Checked by: —
Submitted by: —
Sys version: 5/1
Drawing Code: —
File name: —
File path: —
CADD: 20-206-05 SCI

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

SUTTER BUTTE COUNTY
SUTTER BASIN FEASIBILITY STUDY
ENGINEERING APPENDIX

CALIFORNIA

PLATE 2-4
TYPICAL LEVEE GEOMETRIES
MINIMUM REQUIREMENTS

Sheet reference number:
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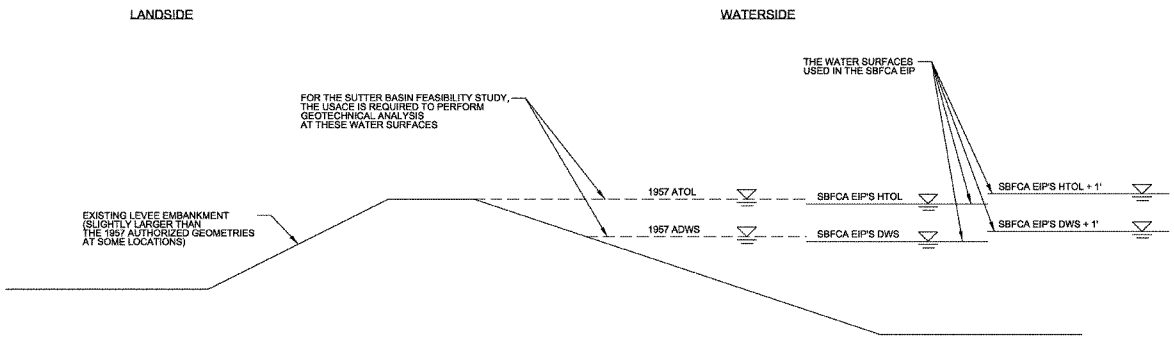
Sheet — of —
AM-XX



1957 ADWS: THE 1957 AUTHORIZED DESIGN WATER SURFACE
1957 ATOL: THE 1957 AUTHORIZED TOP OF LEVEE

SBFCA: SUTTER BUTTE FLOOD CONTROL AGENCY
EIP: EARLY IMPLEMENTATION PROJECT
SBFCA EIP'S DWS: THE "DESIGN" WATER SURFACE USED IN THE SBFCA EIP
SBFCA EIP'S HTOL: THE "HYDRAULIC TOP OF LEVEE" WATER SURFACE USED IN THE SBFCA EIP

US Army Corps of Engineers® Sacramento District

SUTTER BUTTE COUNTY CALIFORNIA
SUTTER BASIN FEASIBILITY STUDY
ENGINEERING APPENDIX

PLATE 2-5
CURRENT AUTHORIZATION & GEOTECHNICAL ANALYSIS

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

Sheet reference number:
—
Sheet – of –
AM-XX

SUTTER BUTTE FLOOD CONTROL AGENCY FEATHER RIVER
WEST LEVEE PROJECT
PROPOSED NOMENCLATURE AND PROJECT APPROACH TO LEVEE ENCROACHMENTS

Levee Encroachment
All Utilities and Structures Within the Levee Footprint or Project Right-of-Way (ROW) Limits

Levee Prism Encroachment[1]
Encroachment Located Within the Levee Prism

Levee Prism Structure Encroachment[3]
- Retaining Wall
- Railroad Tracks
- Home
- Shed
- Roadway/Bridge

Levee Prism Wet Utility Encroachment[3]
- Pump Discharge Line
- Gravity Drainage Pipeline
- Sewer Outfall
- Natural Gas Pipeline
- Ag Turnout

Levee Prism Dry Utility Encroachment[3]
- Telephone Cable
- Overhead Power
- Fiber Optic Cable

ROW Encroachment[1]
Encroachment Located Within Project ROW Limits[2] Only

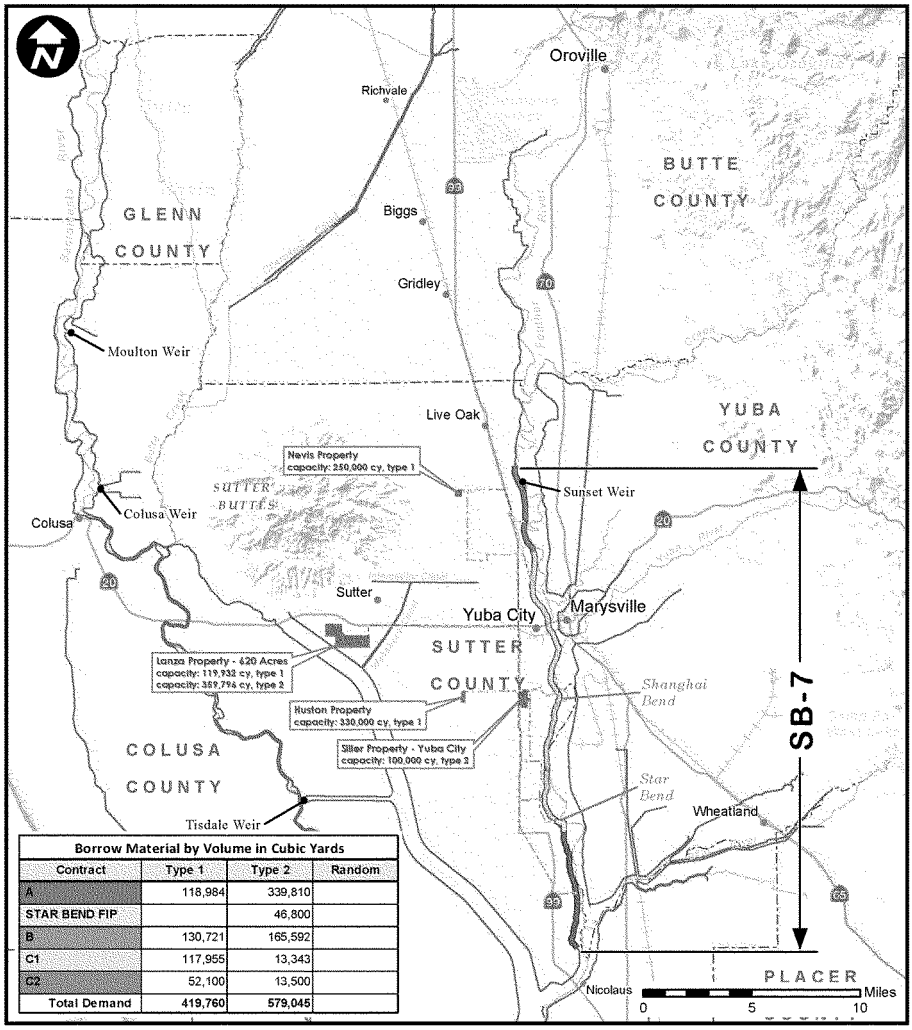
ROW Structure Encroachment
- Home
- Shed
- Roadway
- Railroad Tracks

ROW Wet Utility Encroachment
- Ag or Drainage Canal[4]
- Water Supply Pipeline
- Sewer Pipeline
- Natural Gas Pipeline
- Ag well
- Ag Turnout

ROW Dry Utility Encroachment
- Telephone Cable
- Overhead Utility[4]
- Fiber Optic Cable

Notes:
1. All utilities running parallel to the levee, unless located within the levee prism, are considered ROW Encroachments. All utilities running perpendicular to the levee are considered Levee Prism Encroachments, with the exception of overhead utilities, which are ONLY a levee prism encroachment if a supporting pole is located within the levee prism.
2. ROW Encroachments are those encroachments that fall within the limits of the Project ROW, 20 feet from landside levee toe, and 15 feet from waterside levee toe.
3. In general, levee prism structure and wet utility encroachments will be relocated or otherwise modified as part of the levee improvement contract. Levee prism dry utility encroachments will be addressed where expeditious or necessary to do so in advance of the levee improvement contract.
4. ROW wet or dry utility encroachments will be relocated prior to the levee improvement contract if they are deemed an impediment to construction access.

PLATE 2-6 UTILITY HANDLE CHART



Borrow Material by Volume in Cubic Yards			
Contract	Type 1	Type 2	Random
A	118,984	339,810	
STAR BEND FIP		46,800	
B	130,721	165,592	
C1	117,955	13,343	
C2	52,100	13,500	
Total Demand	419,760	579,045	

Legend

- Borrow Site
- Haul Route
- Contract Extent
- Federal Levee
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

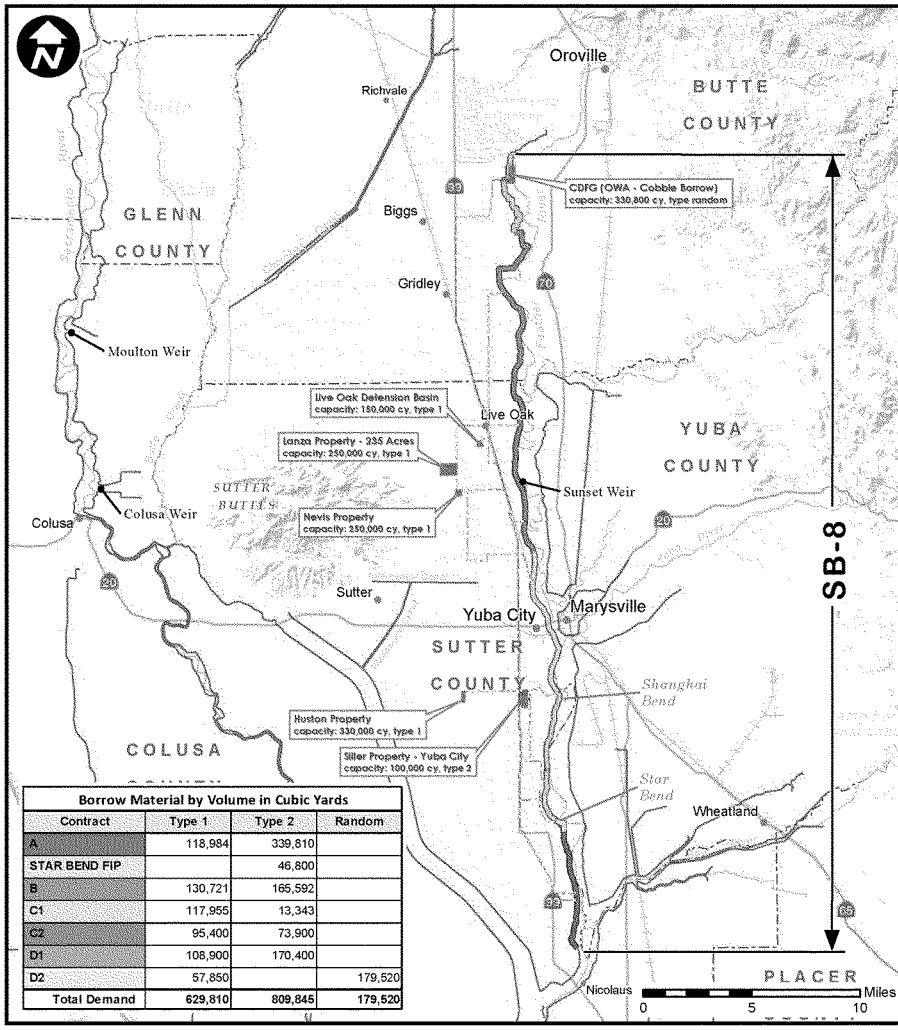
ALTERNATIVE SB-7: CONSTRUCTION CONTRACT BORROW SITES AND HAUL ROUTES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 4-3



Borrow Material by Volume in Cubic Yards			
Contract	Type 1	Type 2	Random
A	118,984	339,810	
STAR BEND FIP		46,800	
B	130,721	165,592	
C1	117,955	13,343	
C2	95,400	73,900	
D1	108,900	170,400	
D2	57,850		179,520
Total Demand	629,810	809,845	179,520

Legend

- Borrow Site
- Haul Route
- Contract Extent
- Federal Levee
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

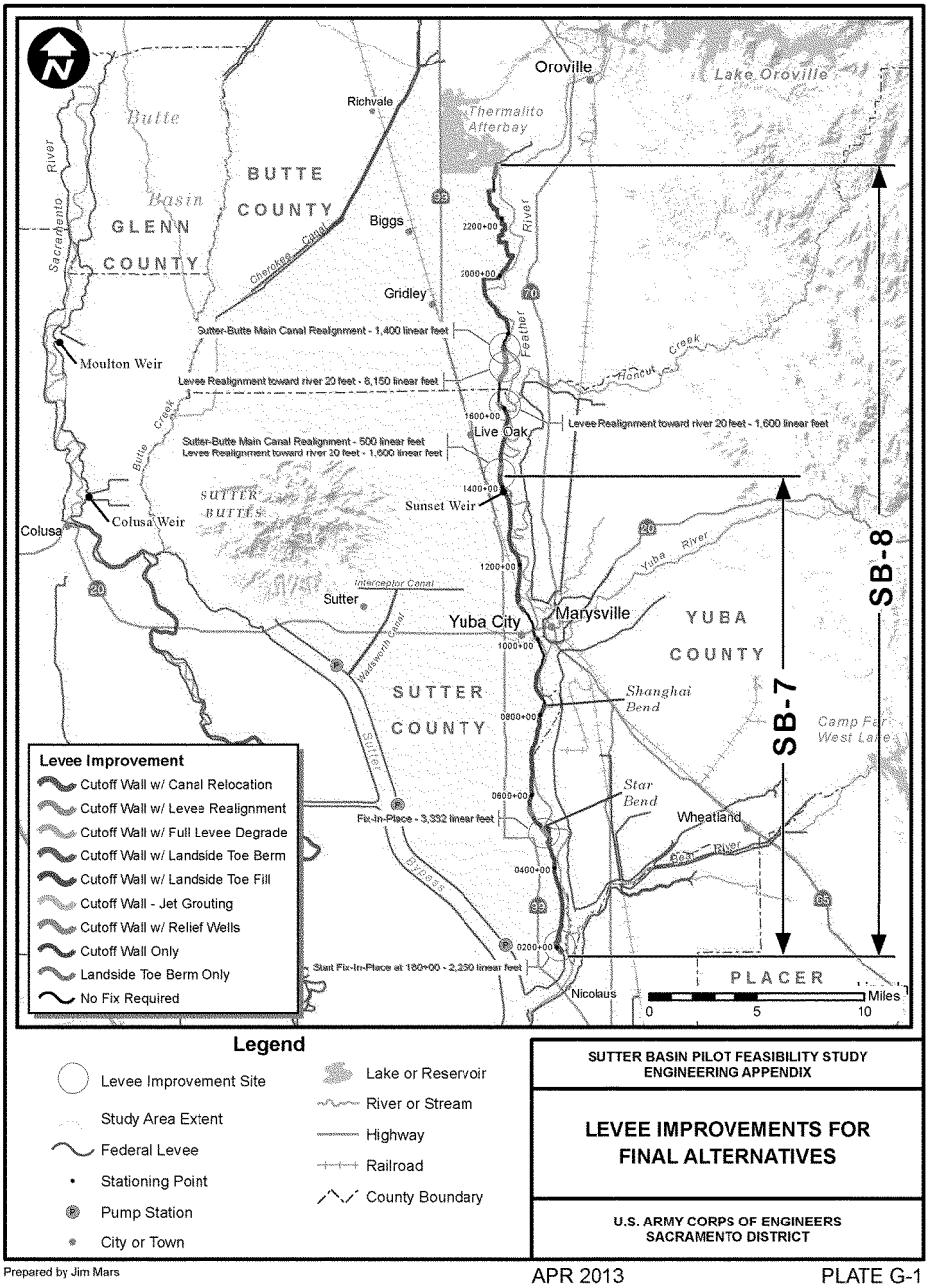
ALTERNATIVE SB-8: CONSTRUCTION CONTRACT BORROW SITES AND HAUL ROUTES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 5-3



Legend

- Levee Improvement Site
- Study Area Extent
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

LEVEE IMPROVEMENTS FOR FINAL ALTERNATIVES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE G-1

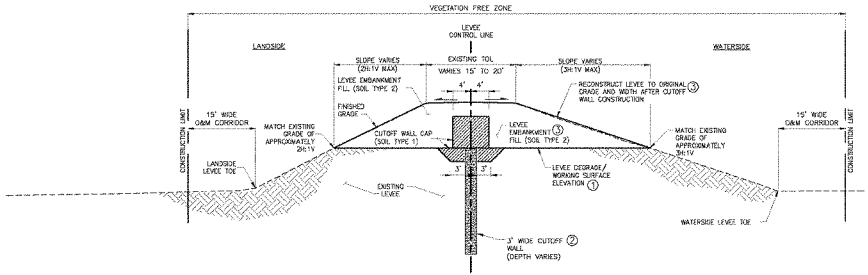


PLATE G-2A: TYPICAL CUTOFF WALL

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.

US Army Corps of Engineers
Sacramento District

26	DESCRIPTION	DATE	APPROVED
25	DESCRIPTION	DATE	APPROVED
24	DESCRIPTION	DATE	APPROVED
23	DESCRIPTION	DATE	APPROVED
22	DESCRIPTION	DATE	APPROVED
21	DESCRIPTION	DATE	APPROVED
20	DESCRIPTION	DATE	APPROVED
19	DESCRIPTION	DATE	APPROVED
18	DESCRIPTION	DATE	APPROVED

DEPARTMENT OF THE ARMY
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SACRAMENTO DISTRICT
SACRAMENTO, CA 95814-2922

Designed by: Scale: Rev.
Dwn by: Date: Depth: 15 to 1
Checked by: Drawing Code: 3
Submitted by: Plot date:
Date: Plot scale: 1:1
FILE: G-2A.DWG

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-2A
TYPICAL LEVEE IMPROVEMENT-CUTOFF WALL

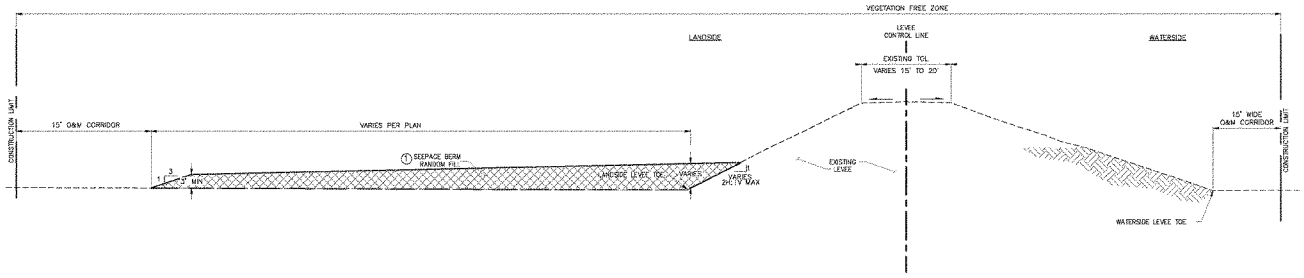

PLATE G2-B: TYPICAL SEEPAGE BERM

SCALE: NONE

CONSTRUCTION SEQUENCE:

1 INSTALL RANDOM FILL FOR SEEPAGE BERM

US Army Corps of Engineers
Sacramento District

NO.	DESCRIPTION	DATE	APPROVED
01	DESCRIPTION	DATE	APPROVED
02	DESCRIPTION	DATE	APPROVED
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08	DESCRIPTION	DATE	APPROVED
09	DESCRIPTION	DATE	APPROVED
10	DESCRIPTION	DATE	APPROVED

REVISIONS

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
H-H-LEVEE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

Designed by: | Date: | Rev.
Drawn by: | Scale: NO | Design file no.
Reviewed by: | 1 Drawing Code
Approved by: | 2 Drawing Number
Date approved: | 3 File name
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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DAMAGING APPENDIX
PLATE G-2B
TYPICAL LEVEE IMPROVEMENT - SEEPAGE BERM

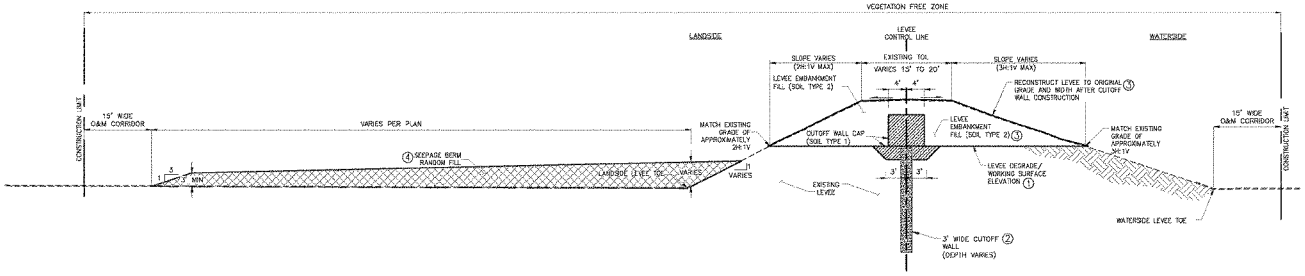

PLATE G-2C1: TYPICAL CUTOFF WALL WITH SEEPAGE BERM

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.
4. INSTALL RANDOM FILL FOR SEEPAGE BERM

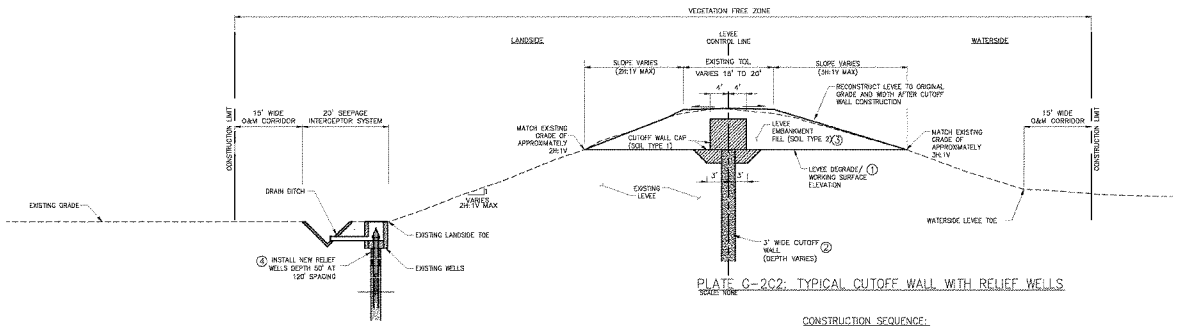

PLATE G-2C2: TYPICAL CUTOFF WALL WITH RELIEF WELLS

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.
4. INSTALL ADDITIONAL RELIEF WELLS (WHERE APPLICABLE)

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28	DESCRIPTION	DATE	APPROVED
27	DESCRIPTION	DATE	APPROVED
26	DESCRIPTION	DATE	APPROVED
25	DESCRIPTION	DATE	APPROVED
24	DESCRIPTION	DATE	APPROVED
23	DESCRIPTION	DATE	APPROVED
22	DESCRIPTION	DATE	APPROVED
21	DESCRIPTION	DATE	APPROVED
20	DESCRIPTION	DATE	APPROVED

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA. 95814-2922

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Date by: Spec No.
Drawing Code:
Submitted by:
Drawing No.
Plot date:
Plot scale: 1" = 1'

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-2C
TYPICAL LEVEE IMPROVEMENTS - CUTOFF WALL
WITH SEEPAGE BERM OR RELIEF WELLS

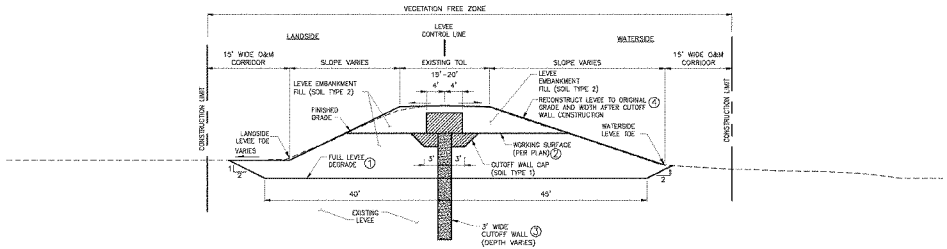

PLATE G-2D1: TYPICAL CUTOFF WALL WITH FULL LEVEE DEGRADE

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. FILL UP TO WORKING SURFACE ELEVATION
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.

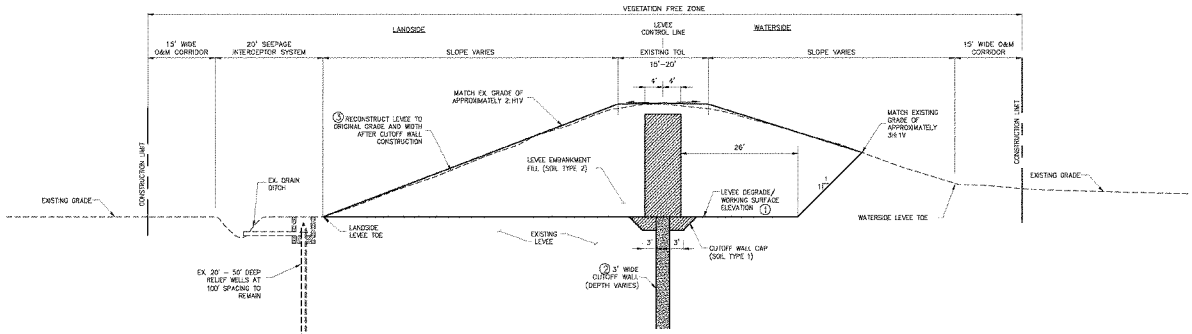

PLATE G-2D1: TYPICAL CUTOFF WALL WITH FULL LEVEE DEGRADE AND RELIEF WELLS

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.

US Army Corps of Engineers
Sacramento District

No.	Date	Description	Approved
01		DESCRIPTION	MATE APPROVED
02		DESCRIPTION	MATE APPROVED
03		DESCRIPTION	MATE APPROVED
04		DESCRIPTION	MATE APPROVED
05		DESCRIPTION	MATE APPROVED
06		DESCRIPTION	MATE APPROVED
07		DESCRIPTION	MATE APPROVED
08		DESCRIPTION	MATE APPROVED
09		DESCRIPTION	MATE APPROVED
10		DESCRIPTION	MATE APPROVED

Revisions

Designed by: Date: Rev.
Drawn by: Spec. No.: Design Rev. no.
Checked by: Drawing No.: Dwg. Code
Approved by: Dwg. Type: Sheet size: A
Date Created: 8/1/2011 Rev. Date: 8/1/2011

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
H-HIGHWAY DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOot FEASIBILITY STUDY
EMBANKING APPENDIX
PLATE G-2D
TYPICAL LEVEE IMPROVEMENT - CUTOFF WALL
WITH LEVEE DEGRADE AND RELIEF WELLS

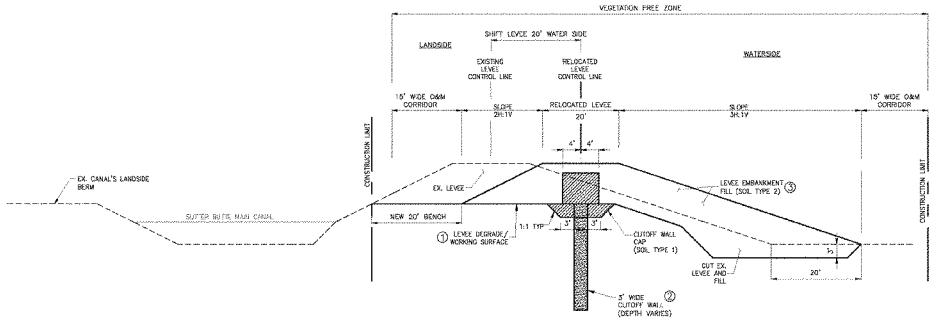

PLATE G-2E: TYPICAL CUTOFF WALL WITH LEVEE RELOCATION

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. CONSTRUCT RELOCATED LEVEE EMBANKMENT.

US Army Corps of Engineers
Sacramento District

08	DESCRIPTION	DATE/APPROVAL
07	DESCRIPTION	DATE/APPROVAL
06	DESCRIPTION	DATE/APPROVAL
05	DESCRIPTION	DATE/APPROVAL
04	DESCRIPTION	DATE/APPROVAL
03	DESCRIPTION	DATE/APPROVAL
02	DESCRIPTION	DATE/APPROVAL
01	DESCRIPTION	DATE/APPROVAL
00	DESCRIPTION	DATE/APPROVAL

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
PROJECT DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-2E

- LOCAL LEVEE IMPROVEMENT - CUTOFF WALL
- TYPICAL CUTOFF WALL WITH LEVEE RELOCATION

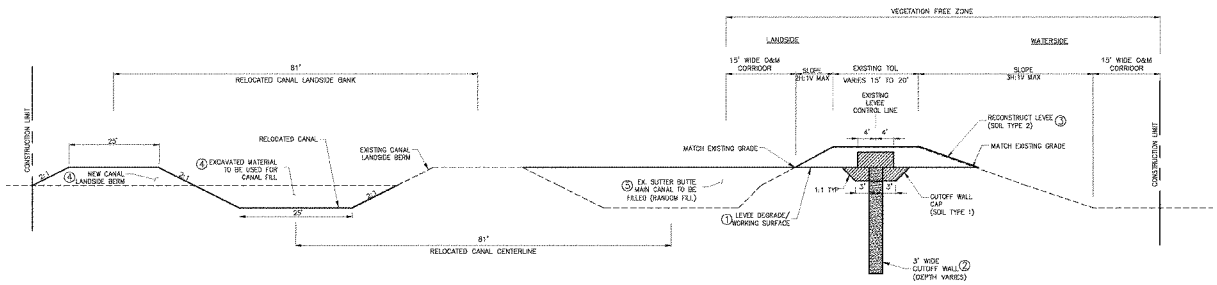

PLATE G-2F: TYPICAL CUTOFF WALL WITH CANAL RELOCATION

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.
4. EXCAVATE NEW SUTTER BUTTE CANAL AND CONSTRUCT NEW CANAL LANDSIDE BERM.
5. FILL SUTTER BUTTE CANAL WITH EXCAVATED MATERIAL

US Army Corps of Engineers
Sacramento District

DESCRIPTION:	DATE:	APPROVED:
DESCRIPTION:	DATE:	APPROVED:
DESCRIPTION:	DATE:	APPROVED:
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DESIGNED:	DRAWN:	CHECKED:

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
P-MCACE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

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Drawn by: | Check Rev.: | Design Date:
Sec. by: | Sec. Rev.: | 1
Drawing Date: | 1 | Drawing Scale:
Approved By: | Plot Date: | Plot Scale: 1:1

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
EMBANKING APPENDIX
PLATE G-2F
TYPICAL LEVEE IMPROVEMENT - CUTOFF WALL
WITH CANAL RELOCATION

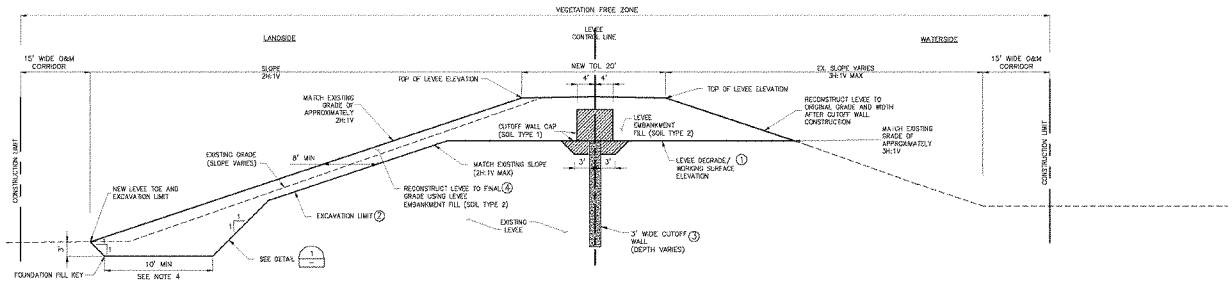
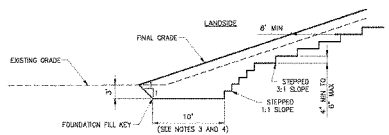


PLATE G--2G: TYPICAL CUTOFF WALL WITH LANDSIDE TOE FILL

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE LANDSIDE OF EXISTING LEVEE.
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.



1 FILL KEY AND BENCHING DETAIL

NTS

TYPICAL KEY & BENCHING NOTES:

1. PLACE FILL IN HORIZONTAL LIFTS AGAINST VERTICAL FACES CUT INTO EXISTING LEVEE MATERIAL.
2. THE BOTTOM OF THE KEY TRENCH SHALL BE SCARIFIED TO A DEPTH OF 8 INCHES AND RECOMPACTED TO 95% MAXIMUM DENSITY PER ASTM D698.
3. THE LEVEE KEY TRENCH SHALL BE INSPECTED BY THE AGENCY'S GEOTECHNICAL ENGINEER BEFORE PLACEMENT OF FILL.
4. WHERE EMBANKMENT FILL IS GREATER THAN 10' IN WIDTH, FOUNDATION KEY SHALL EXTEND FROM THE TOE OF THE NEW LEVEE TO THE TOE OF THE EXISTING LEVEE. IN NO CASE SHALL THE FOUNDATION KEY WIDTH BE LESS THAN 10'.

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03	DESCRIPTION	DATE	APPROVED
02	DESCRIPTION	DATE	APPROVED
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REVISIONS

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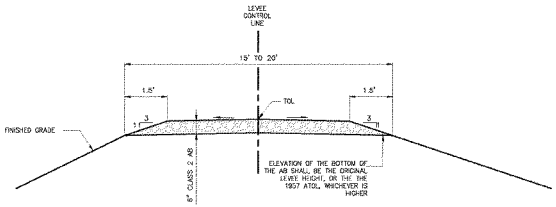
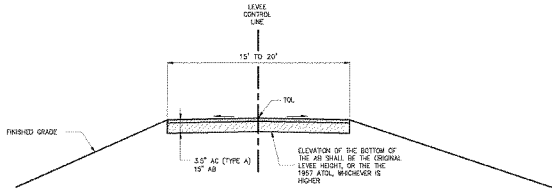
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-2G
TYPICAL CUTOFF WALL WITH LANDSIDE TOE FILL



CROWN SURFACING DETAIL (TYP)

NTS



PAVED LEVEE ROAD SECTION

NTS

PLATE G-2H: TYPICAL LEVEE ROAD DETAIL

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AG	DESCRIPTION	DATE	APPROVED
AH	DESCRIPTION	DATE	APPROVED
AJ	DESCRIPTION	DATE	APPROVED
AK	DESCRIPTION	DATE	APPROVED
AL	DESCRIPTION	DATE	APPROVED

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Checked By: | Drawing Code
Approved By: | Drawing No.
Pay Item:
Pay Item:
Pay Item:

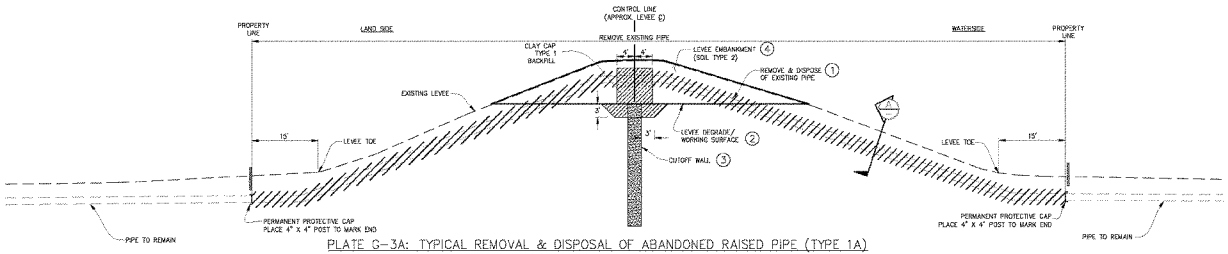
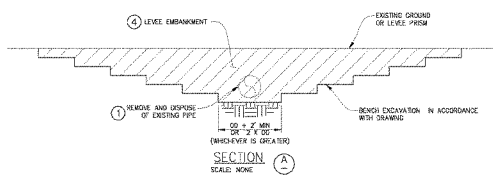


PLATE G-3A: TYPICAL REMOVAL & DISPOSAL OF ABANDONED RAISED PIPE (TYPE 1A)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE.
2. DEGRADE EXISTING LEVEE.
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.



SECTION A

SCALE: NONE

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21	DESCRIPTION	DATE/APPROVAL
20	DESCRIPTION	DATE/APPROVAL
19	DESCRIPTION	DATE/APPROVAL

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Submitted by: Approved by: Pgm Mgr:
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ENGINEERING APPENDIX
PLATE G-3A
TYPICAL UTILITY, IMPROVEMENT - REMOVAL AND DISPOSAL OF ABANDONED RAISED PIPE

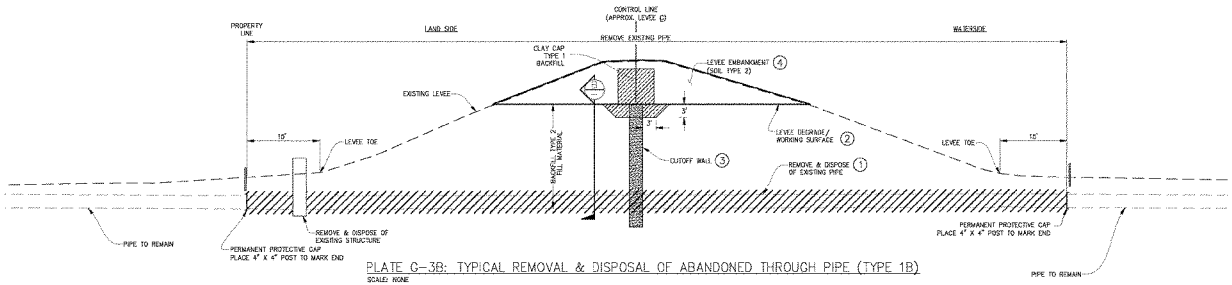
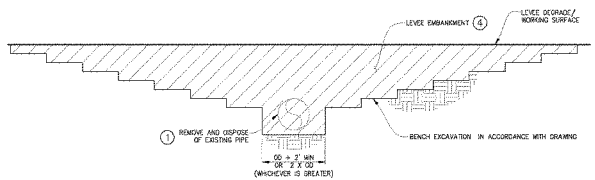


PLATE G-3B: TYPICAL REMOVAL & DISPOSAL OF ABANDONED THROUGH PIPE (TYPE 1B)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE.
2. DEGRADE EXISTING LEVEE.
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.



SECTION B

SCALE: NONE

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AG	DESCRIPTION	DATE/APPROVAL
AH	DESCRIPTION	DATE/APPROVAL

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Drawing No. 2 | Drawing Scale
Drawing No. 3 | Plot Date
Plot Scale: 1" = 1'

SUTTER & BUTTE COUNTY CALIFORNIA
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DAMNECKING APPENDIX
PLATE G-3B
TYPICAL UTILITY IMPROVEMENT - REMOVAL AND DISPOSAL OF ABANDONED THROUGH PIPE

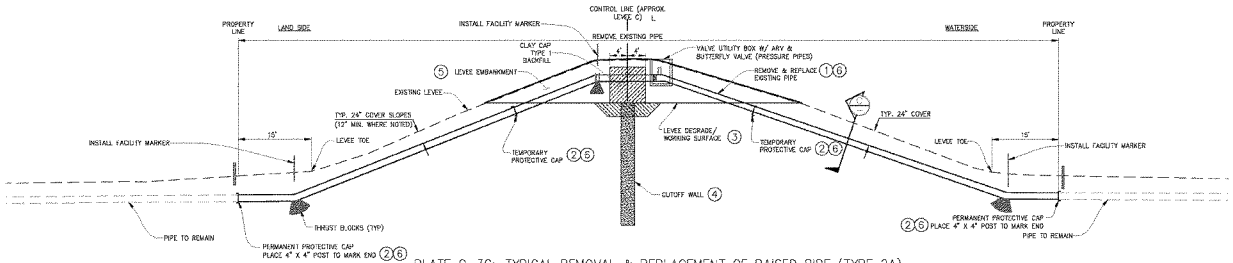


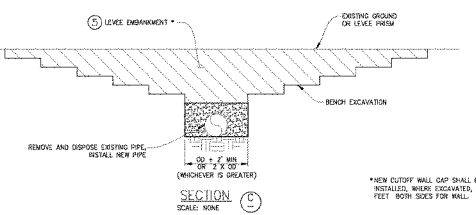
PLATE G-3C: TYPICAL REMOVAL & REPLACEMENT OF RAISED PIPE (TYPE 2A)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO DEGRADE / WORKING SURFACE.
2. PROVIDE CAP AND MARKER AT THE END OF THE EXISTING PIPE WITH PROPER THRUST BLOCK OR RESTRAINED JOINT FOR PRESSURIZED PIPES.
3. DEGRADE EXISTING LEVEE.
4. CONSTRUCT CUTOFF WALL.
5. RECONSTRUCT LEVEE EMBANKMENT.
6. EXCAVATE, INSTALL NEW PIPE, CONNECT TO EXISTING PIPE, INSTALL MARKER AND BACKFILL

NOTE: THE BOTTOM OF THE NEW PIPE SHALL BE ABOVE THE FREEBOARD ELEVATION AT THE LEVEE CROWN



SECTION C

SCALE: NONE

*NEW CUTOFF WALL CAP SHALL BE INSTALLED, WHERE EXCAVATED, FOUR (4) FEET BOTH SIDES FOR WALL.

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SUTTER & BUTTE COUNTY CALIFORNIA
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ENGINEERING APPENDIX
PLATE G-3C
TYPICAL LEVEE MAINTENANCE - REMOVAL AND REPLACEMENT OF RAISED PIPE

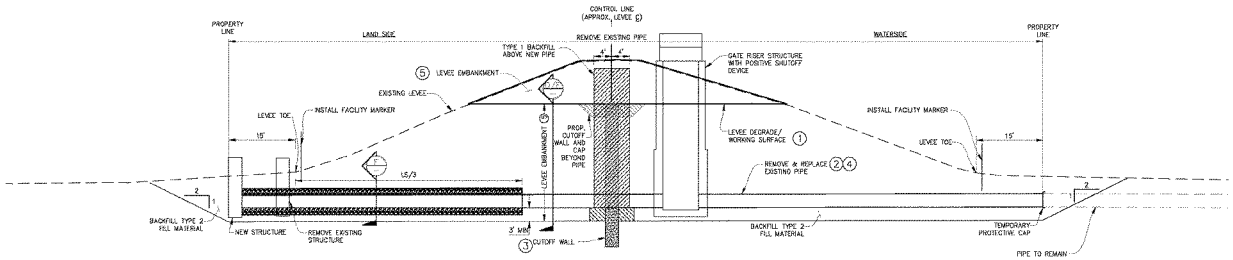
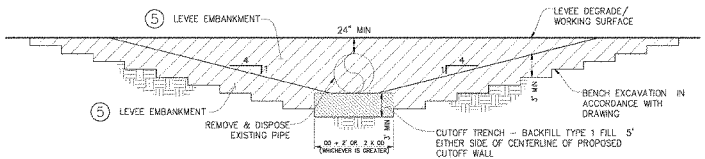


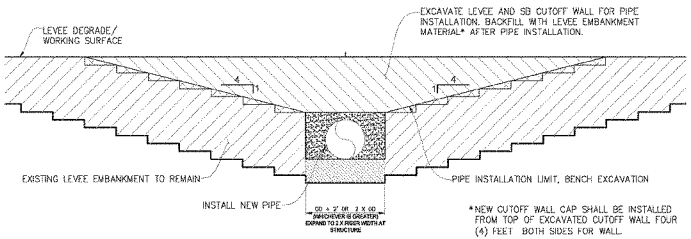
PLATE G-30: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE (TYPE 2B)

SCALE: NONE



SECTION D

SCALE: NONE



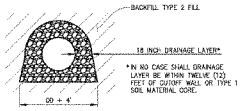
*NEW CUTOFF WALL CAP SHALL BE INSTALLED FROM TOP OF EXCAVATED CUTOFF WALL FOUR (4) FEET BOTH SIDES FOR WALL.

SECTION E

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE (SEE SECTION D).
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE (SEE SECTION E).
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AN RISER INSTALLATION.



*IN NO CASE SHALL DRAINAGE LAYER BE WITHIN TWELVE (12) FEET OF CUTOFF WALL OR TYPE 1 SOIL MATERIAL CORE.

SECTION F

SCALE: NONE

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SUTTER & BUTTE COUNTY CALIFORNIA
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ENGINEERING APPENDIX
PLATE G-30
TYPICAL UTILITY (BRIDGE/ROAD) - REMOVAL AND REPLACEMENT OF THROUGH PIPE

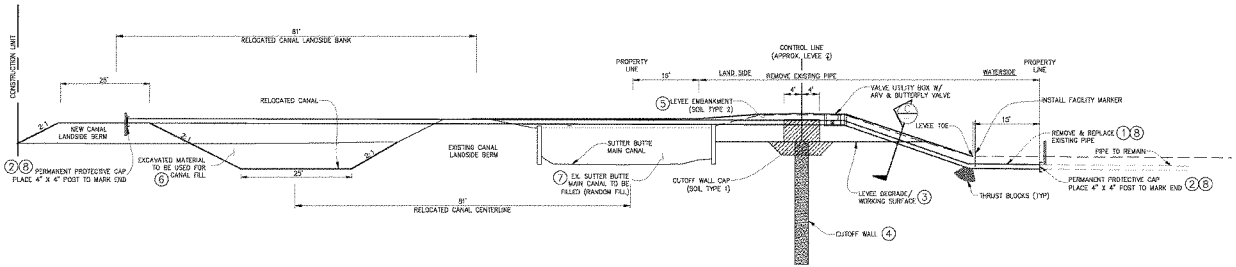
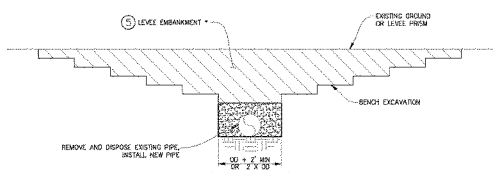


PLATE G-3E1: TYPICAL REMOVAL & REPLACEMENT OF RAISED PIPE WITH CANAL RELOCATION (TYPE 3A1)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO DEGRADE / WORKING SURFACE.
2. PROVIDE CAP AND MARKER AT THE END OF THE EXISTING PIPE WITH PROPER THRUST BLOCK OR RESTRAINED JOINT FOR PRESSURIZED PIPES.
3. DEGRADE EXISTING LEVEE.
4. CONSTRUCT CUTOFF WALL.
5. RECONSTRUCT LEVEE EMBANKMENT.
6. EXCAVATE NEW SUTTER BUTTE CANAL AND CONSTRUCT NEW LANDSIDE BERM
7. FILL SUTTER BUTTE CANAL WITH EXCAVATED MATERIAL
8. EXCAVATE, INSTALL NEW PIPE, CONNECT TO EXISTING PIPE, INSTALL MARKER AND BACKFILL



SECTION C

SCALE: NONE

*NEW CUTOFF WALL CAP SHALL BE INSTALLED, WHERE EXCAVATED, FOUR (4) FEET BOTH SIDES FOR WALL.

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ENGINEERING APPENDIX
PLATE G-3E1
TYPICAL LATERAL REMOVAL AND REPLACEMENT OF RAISED PIPE W/ CANAL RELOCATION

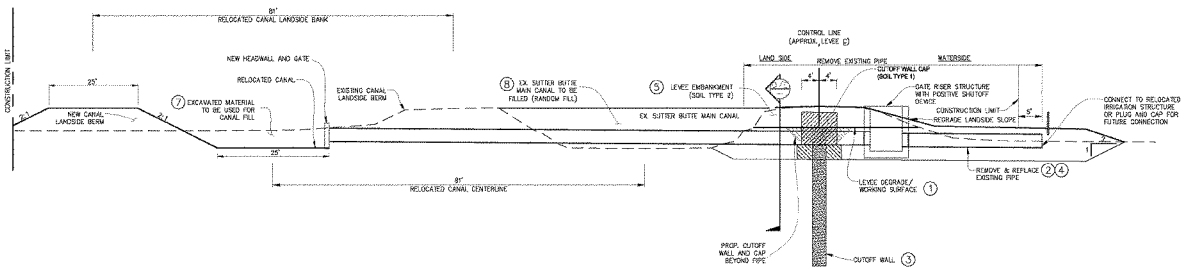
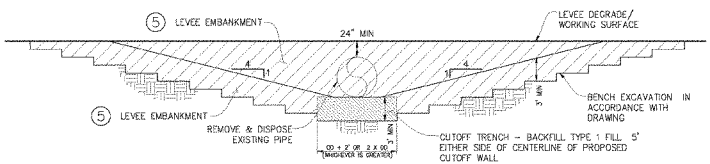


PLATE G-3E2: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE WITH CANAL RELOCATION (TYPE 3A2)

SCALE: NONE

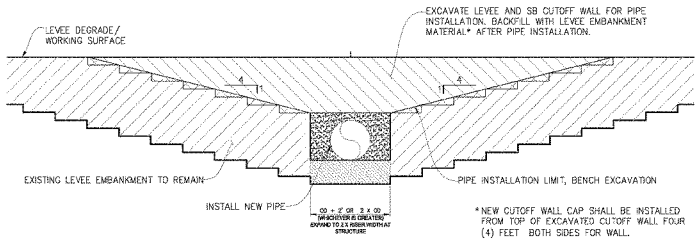
CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE.
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE.
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AND RISER INSTALLATION.
6. EXCAVATE NEW SUTTER BUTTE CANAL AND CONSTRUCT LANDSIDE BERM
7. BACKFILL OLD SUTTER BUTTE CANAL.



SECTION D

SCALE: NONE



SECTION E

SCALE: NONE

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01	DESCRIPTION	DATE	INITIAL APPROVAL

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DACW51-00-C-0014 | Plot scale:

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DRAINAGE APPENDIX
PLATE G-3E2
TYPICAL SECTIONS - REMOVAL AND REPLACEMENT OF THROUGH PIPE W/ CANAL RELOCATION

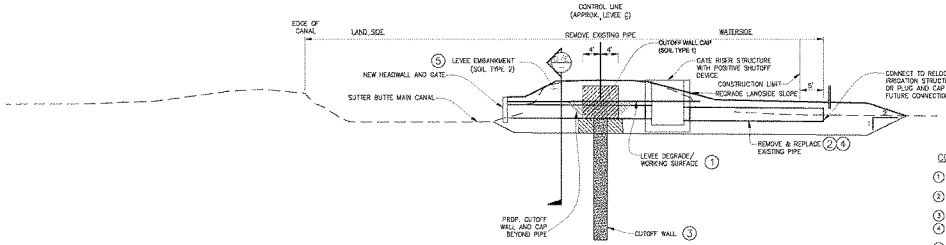
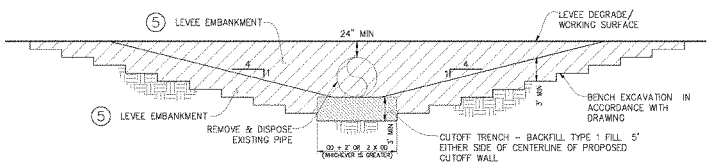


PLATE G-3F: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE ADJACENT TO CANAL (TYPE 3B)

SCALE: NONE

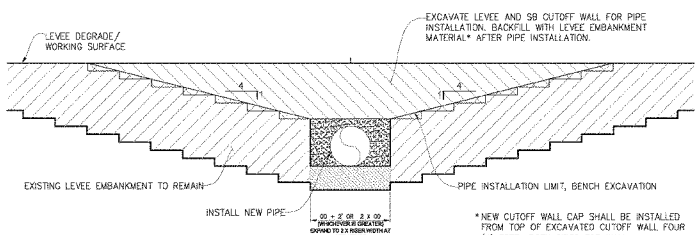
CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE.
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE.
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AND RISER INSTALLATION.



SECTION D

SCALE: NONE



SECTION E

SCALE: NONE

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01	DESCRIPTION	DATE	APPROVED

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ENGINEERING APPENDIX
PLATE G-3F
TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE ADJACENT TO CANAL

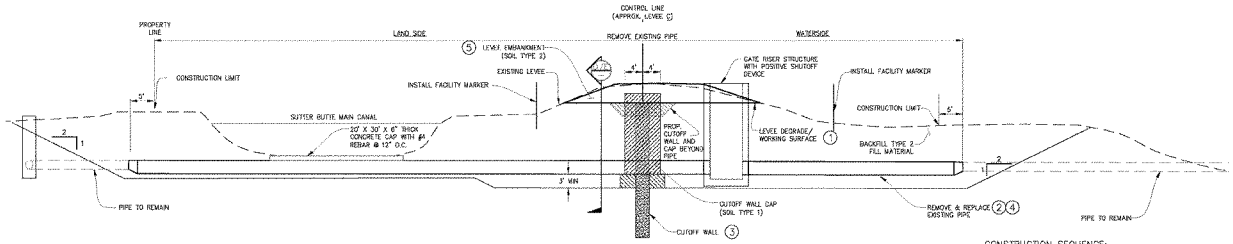
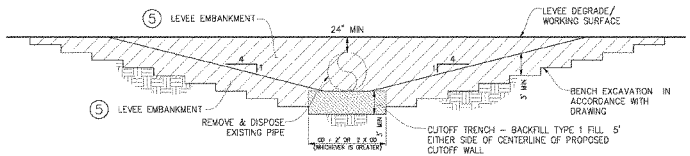


PLATE G-3C1: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL (TYPE 3C1)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE (SEE SECTION D).
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE (SEE SECTION E).
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AND RISER INSTALLATION.



SECTION D

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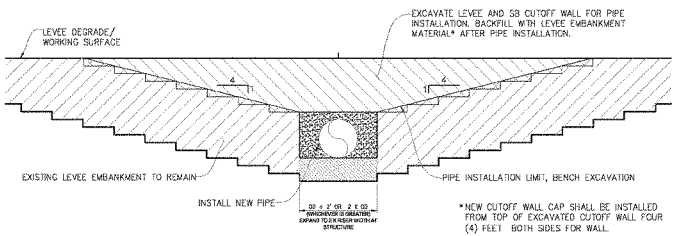


*NEW CUTOFF WALL CAP SHALL BE INSTALLED FROM TOP OF EXCAVATED CUTOFF WALL FOUR (4) FEET BOTH SIDES FOR WALL.

SECTION E

SCALE: NONE

US Army Corps of Engineers
Sacramento District

SYM	DESCRIPTION	DATE	APPROVED
3A	DESCRIPTION		INITIAL APPROVAL
3B	DESCRIPTION		INITIAL APPROVAL
3C	DESCRIPTION		INITIAL APPROVAL
3D	DESCRIPTION		INITIAL APPROVAL
3E	DESCRIPTION		INITIAL APPROVAL
3F	DESCRIPTION		INITIAL APPROVAL
3G	DESCRIPTION		INITIAL APPROVAL
3H	DESCRIPTION		INITIAL APPROVAL
3I	DESCRIPTION		INITIAL APPROVAL
3J	DESCRIPTION		INITIAL APPROVAL

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

Designed by: | Date: | Title:
Dwn by: | Spec No.: | Design File No.:
Checked by: | Contract No.:
Approved by: | Plot date:
Plot scale:

CALIFORNIA
SUTTER & BUTTE COUNTY
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-3C1

TYPICAL UTILITY DEMOLISHED - REMOVAL AND REPLACEMENT OF THROUGH PIPE UNDER CANAL

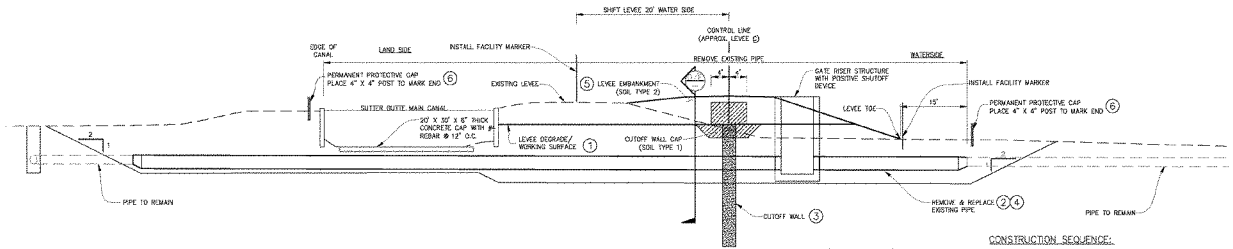
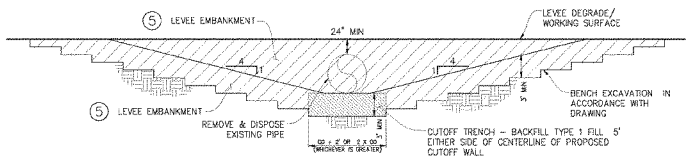


PLATE G-3C2: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL WITH LEVEE RELOCATION (TYPE 3C2)
SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE (SEE SECTION D).
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE (SEE SECTION E).
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AN RISER INSTALLATION.
6. EXCAVATE, INSTALL NEW PIPE, CONNECT TO EXISTING PIPE, INSTALL MARKER AND BACKFILL



SECTION (D)
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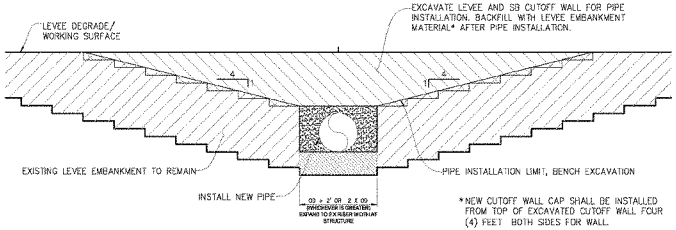

SECTION (E)
SCALE: NONE

US Army Corps of Engineers
Sacramento District

08	DESCRIPTION	DATE/APPROVAL
07	DESCRIPTION	DATE/APPROVAL
06	DESCRIPTION	DATE/APPROVAL
05	DESCRIPTION	DATE/APPROVAL
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01	DESCRIPTION	DATE/APPROVAL
00	DESCRIPTION	DATE/APPROVAL

DEPARTMENT OF THE ARMY
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SACRAMENTO DISTRICT
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SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-3C2
TYPICAL UNDERGROUND PIPE REMOVAL AND REPLACEMENT OF THROUGH PIPE UNDER CANAL BETWEEN STATIONS

US Army Corps
of Engineers®

Sacramento District

Engineering Division

Sutter Basin Pilot Feasibility Report - Environmental Impact Report / Supplemental Environmental Impacts Statement

Butte and Sutter Counties, California

Civil Design Appendix

October 2013

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ENCLOSURES

- Enclosure 1, Evaluation of Preliminary Array of Conceptual Alternatives
- Enclosure 2, Review & Incorporation of the Data from the EIP
- Enclosure 3, Design of New Levee Segments
- Enclosure 4, Encroachment Improvements & Estimates

REFERENCES

- USACE EM 1110-2-1913, "Design and Construction of Levees", 30 April 2000
- CESPK-ED-G, SOP-EDG-03 "Geotechnical Levee Practice", 11 April 2008

ACRONYMS

CCEL Cherokee Canal East Levee (Left Levee)
EIP Early Implementation Project (local sponsor's Plan)
FRWL Feather River West Levee (Right Levee)
MEIP Modified EIP (COE's modifications to the EIP)
O&M Operation and Maintenance
ROW Right of Way
SBEL Sutter Bypass East Levee (Left Levee)
SBLS Sutter Basin Levee System
WCEL Wadsworth Canal East Levee (Left Levee)
WCWL Wadsworth Canal West Levee (Right Levee)

CHAPTER 1 – INTRODUCTION

1.1 Project Description

The existing Sutter Basin Levee System (SBLS) consists of four mainline levees which are Feather River West Levee (FRWL or right levee), Sutter Bypass East Levee (SBEL or left levee), Wadsworth Canal East Levee (WCEL or left levee) and Wadsworth Canal West Levee (WCWL or right levee), and Cherokee Canal East Levee (CCEL or left levee) surrounding the communities of Yuba City, Live Oak, Gridley, Biggs and other smaller towns in Sutter and Butte Counties, California.

During the preliminary phase of this Feasibility Study, many potential remediation measures were considered and combined to form a preliminary array of conceptual alternatives. Through plan formulation process, the preliminary array was refined to a draft array that includes 8 potential alternatives:

- SB-1: No Action.
- SB-2: Minimal Fix-in-place the FRWL from Star Bend to Sunset Weir
- SB-3: Yuba City Ring Levee
- SB-4: Little "J" Levee
- SB-5: Fix-in-place the FRWL from Star Bend to Thermalito Afterbay
- SB-6: Fix-in-Place the FRWL, SBEL and WCEL
- SB-7: Fix-in-Place the FRWL from Laurel Avenue to Sunset Weir
- SB-8: Fix-in-Place the FRWL from Laurel Avenue to Thermalito Afterbay.

The draft array was analyzed and refined to a final array that includes 3 alternatives, SB-1, SB-7 and SB-8. During the final phase of this Feasibility Study, alternatives SB-7 and SB-8 were further evaluated to determine the Recommended Plan for final recommendation. (Plates 1-1 to 1-8 depict the extent of the potential alternatives included in the draft array).

1.2 Purpose and Scope

The purpose of this report is to provide a summary of the civil design evaluation of and consideration for the draft array. The evaluation is a refinement of the preliminary analysis completed for the conceptual alternatives and conforms to the minimum requirements for the development of Class 4 estimate for reconnaissance level analysis. (The preliminary analysis of the conceptual alternatives is documented in enclosure 1, Evaluation of Preliminary Array of Conceptual Alternatives. Classification of the estimate was in accordance with EM 1110-2-1302, Civil Works Cost Engineering, which was based on ASTM E 2516-06, Standard Classification for Cost Estimate Classification System.)

The civil design evaluation of and consideration for alternatives SB-7 and SB-8 of the final array are discussed in paragraph 2.9 of the Engineering Appendix and conform to the minimum requirements for the development of Class 3 estimate for feasibility level analysis. (Enclosure 2, Review & Incorporation of the EIP, of this report is an extension of paragraph 2.9 of the Engineering Appendix.)

(Enclosure 2, Review & Incorporation of the EIP, of this report is an extension of paragraph 2.9 of the Engineering Appendix.)

1.3 Coordination

Existing information and information from the local sponsor's Early Implementation Plan (EIP) were utilized for civil design considerations and evaluations. Close coordination with the local sponsor's design teams took place throughout the study.

CHAPTER 2 – DESIGN CONSIDERATIONS

2.1 General

This chapter provides a summary of the civil design evaluation of and consideration for the draft array of 8 potential alternatives, SB1 to SB8. Design considerations include engineering guidance or methodology used and assumptions.

2.2 Alignment and Stationing

Three levees considered were the FRWL (right levee), SBEL (left levee) and WCEL (left levee).

The project levee alignments and stationing for the SBEL and the WCEL were developed based on the surveyed data from the National Levee Data Base. The stationing for the SBEL begins with station 0+00 at the confluence of the SBEL at the FRWL and increases in an upstream (North) direction. The stationing for the WCEL begins with station 0+00 at the confluence of the WCEL at the SBEL and increases in an upstream (North) direction.

The project levee alignment and stationing for the FRWL, adopted from the 65% EIP, follows the existing levee centerline of the FRWL except at Star Bend where the levee alignment follows the centerline of the setback levee. The stationing begins with station 10+00 at the confluence of the FRWL at the SBEL and increases in an upstream (North) direction. This levee stationing conforms to the existing levee centerline and accounts for recent changes in the alignment, such as the Star Bend Setback Levee (between station 478+68 and station 512+00). At locations where levee relocations (e.g. roughly between station 1432+70 and station 1754+30 etc.) are proposed, supplementary levee alignments stationing necessary for designs and analyses were established.

2.3 Reaches and Alternatives

2.3.1 Reaches

A total of 28 reaches were considered. 16 of these reaches are the existing levee segments (see table 2-1). The other 12 reaches are either proposed setback or new levee segments (see table 2-2). The reaches are shown in figure 1-1.

Table 2-1 – Existing Levee Segments

Reach	Alignment	Type	STA. (Beg.)	STA. (End.)
S5-A-Upper	FRWL	Existing Levee	1958+00	2372+17
S5-A-Lower	FRWL	Existing Levee	1825+00	1958+00
S5-B	FRWL	Existing Levee	1432+00	1825+00
S5-C	FRWL	Existing Levee	1129+00	1432+00
S5-D	FRWL	Existing Levee	816+00	1129+00
S7-D	FRWL	Existing Levee	603+00	816+00
S7-E-Upper	FRWL	Existing Levee	512+00	603+00
S7-E-Middle	FRWL	Existing Levee	479+00	512+00
S7-E-Lower	FRWL	Existing Levee	420+00	479+00
S7-F-Upper	FRWL	Existing Levee	200+00	420+00
S7-F-Middle	FRWL	Existing Levee	47+00	200+00
S7-F-Lower	FRWL	Existing Levee	10+00	47+00
S7-G	SBEL	Existing Levee	0+00	400+00
S7-H	SBEL	Existing Levee	400+00	493+00
S7-I	SBEL	Existing Levee	493+00	922+16
S7-J	WCEL	Existing Levee	0+00	244+00

Table 2-2 – New Levee Segments

Reach	Alignment	Type	STA. (Beg.)	STA. (End.)
S4-South	YCRL	New Ring Levee	0+00	280+00
S4-West	YCRL	New Ring Levee	280+00	490+00
S4-North	YCRL	New Ring Levee	490+00	750+00
S6-South	YCJL	New "J" Levee	0+00	280+00
S6-West-lower	YCJL	New "J" Levee	280+00	490+00
S6-West-upper	YCJL	New "J" Levee	490+00	550+00
S9-G	SBEL	Setback Levee	0+00	400+00
S9-H	SBEL	Setback Levee	400+00	493+00
S9-I	SBEL	Setback Levee	493+00	922+16
S10	FRWL	Setback Levee	1958+00	2372+17
S11	FRWL	Setback Levee	47+00	200+00
S12	FRWL	Setback Levee	479+00	512+00

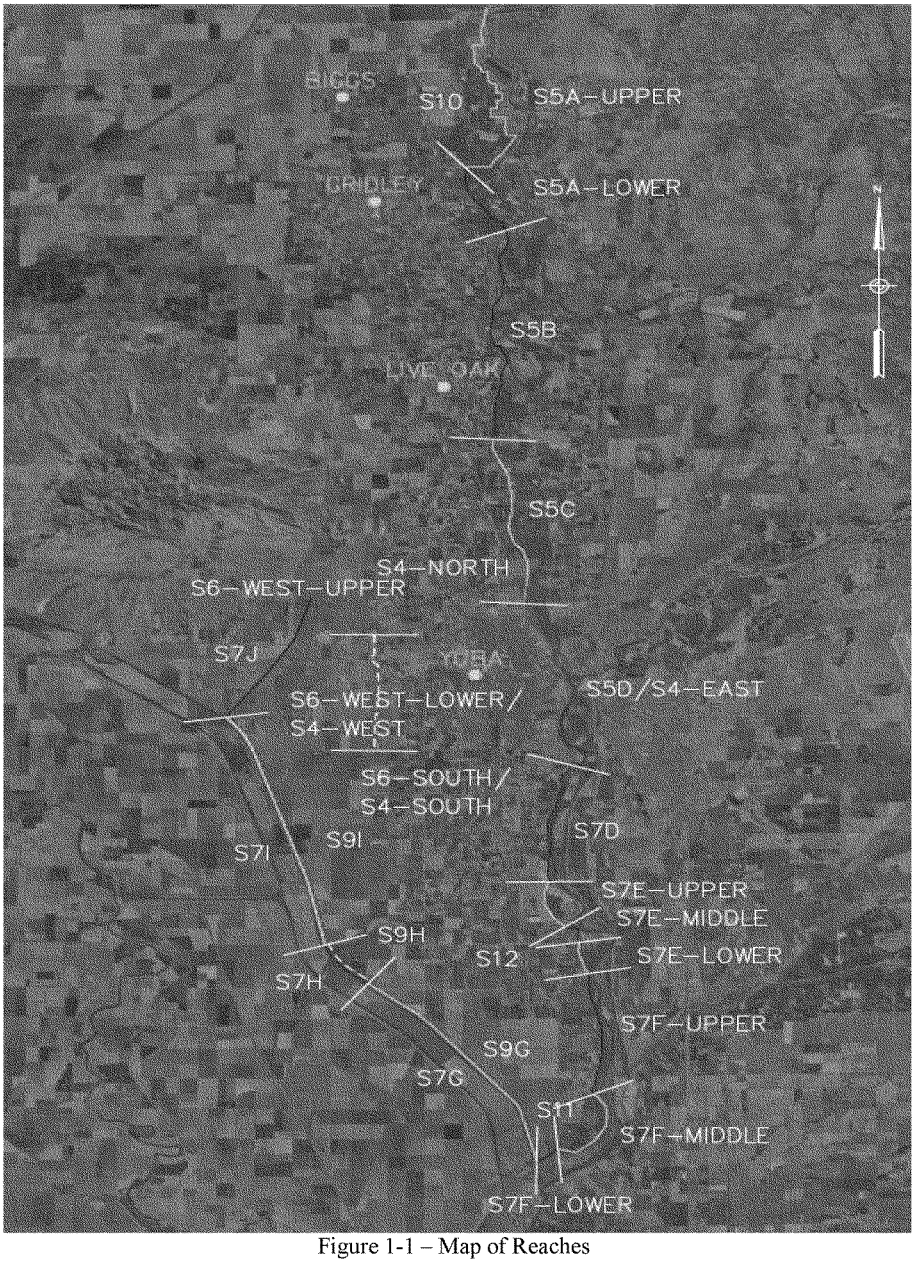


Figure 1-1 – Map of Reaches

2.3.2 Alternatives

Through plan formulation eight potential alternatives were retained from the preliminary array for further evaluation, these include:

- SB-1: No Action.
- SB-2: Minimal Fix-in-place the FRWL from Star Bend to Sunset Weir
- SB-3: Yuba City Ring Levee
- SB-4: Little "J" Levee
- SB-5: Fix-in-place the FRWL from Star Bend to Thermalito Afterbay
- SB-6: Fix-in-Place the FRWL, SBEL and WCEL
- SB-7: Fix-in-Place the FRWL from Laurel Avenue to Sunset Weir
- SB-8: Fix-in-Place the FRWL from Laurel Avenue to Thermalito Afterbay.

Table 2-3 summarizes the reaches included in each of the 8 potential alternatives.

Table 2-3 – Draft Array of Potential Alternatives

Reach	SB-1	SB-2	SB-3	SB-4	SB-5	SB-6	SB-7	SB-8
S5-A-Upper				X	X	X		X
S5-A-Lower				X	X	X		X
S5-B				X	X	X		X
S5-C		X		X	X	X	X	X
S5-D		X	X	X	X	X	X	X
S7-D		X			X	X	X	X
S7-E-Upper		X			X	X	X	X
S7-E-Middle		X			X	X	X	X
S7-E-Lower						X	X	X
S7-F-Upper						X	X	X
S7-F-Middle						X		
S7-F-Lower						X		
S7-G						X		
S7-H						X		
S7-I						X		
S7-J						X		
S4-South			X					
S4-West			X					
S4-North			X					
S6-South				X				
S6-West-lower				X				
S6-West-upper				X				
S9-G								
S9-H								
S9-I								
S10								
S11								
S12								

2.4 Existing Condition and Remediation Measures

2.4.1 Existing Condition

Based on the result of preliminary geotechnical investigations, the average geometry of the existing levees were defined and shown in table 2-4.

Table 2-4 – Average Geometry of Existing Levee Segments

Reach	Length (LF)	Height (LF)	Crest Width (LF)	LS Slope (H:V)	WS Slope (H:V)	Base Width (LF)
S5-A-Upper	41,417	17.5	20	2:1	3:1	107.5
S5-A-Lower	13,300	17.5	20	2:1	3:1	107.5
S5-B	39,300	12.5	20	2:1	3:1	82.5
S5-C	30,300	17.5	16	2:1	3:1	103.5
S5-D	31,300	25	15	2:1	3:1	140
S7-D	21,300	25	15	2:1	3:1	140
S7-E-Upper	9,100	22.5	17	2:1	3:1	127.5
S7-E-Middle	3,300	22.5	17	2:1	3:1	127.5
S7-E-Lower	5,900	22.5	17	2:1	3:1	127.5
S7-F-Upper	22,000	22.5	13	2:1	3:1	125.5
S7-F-Middle	15,300	22.5	13	2:1	3:1	125.5
S7-F-Lower	3,700	22.5	13	2:1	3:1	125.5
S7-G	40,000	22.5	22	2:1	3:1	134.5
S7-H	9,300	20	22	2:1	3:1	122
S7-I	42,916	20	22	2:1	3:1	122
S7-J	24,400	15	24	2:1	3:1	99

2.4.2 Proposed Levee Remediation Measures

Based on preliminary geotechnical design recommendations, 9 conceptual typical levee remediation measures were developed and shown in figure 2-1 through 2-9.

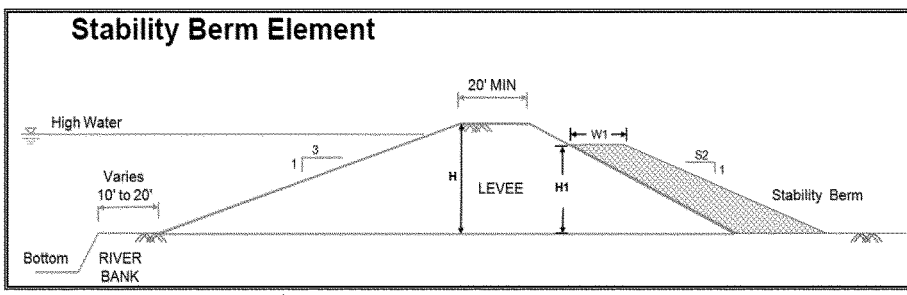


Figure 2-1 – Levee Improvement Type 1

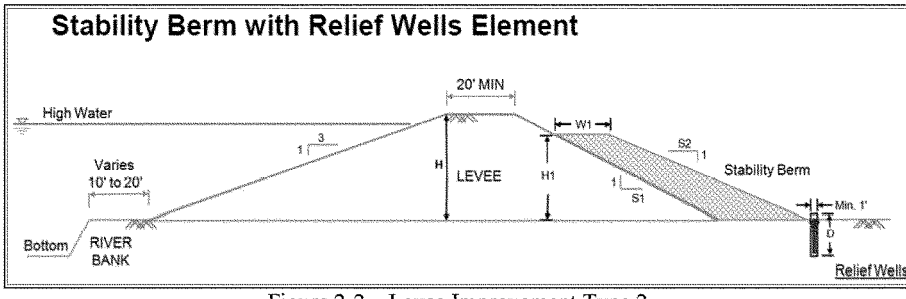


Figure 2-2 – Levee Improvement Type 2

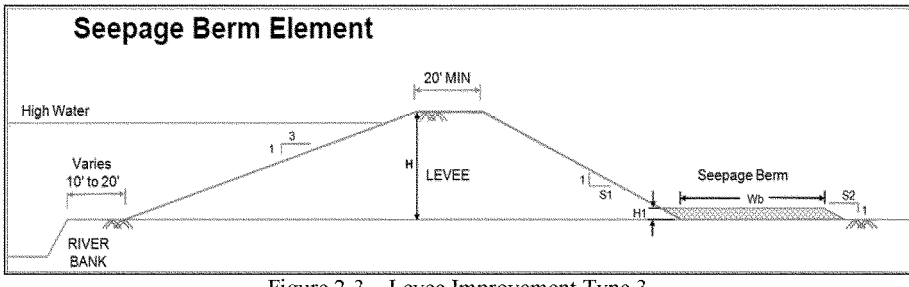


Figure 2-3 – Levee Improvement Type 3

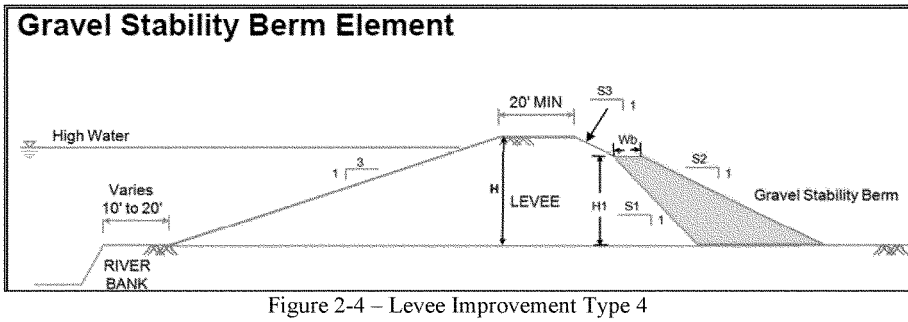


Figure 2-4 – Levee Improvement Type 4

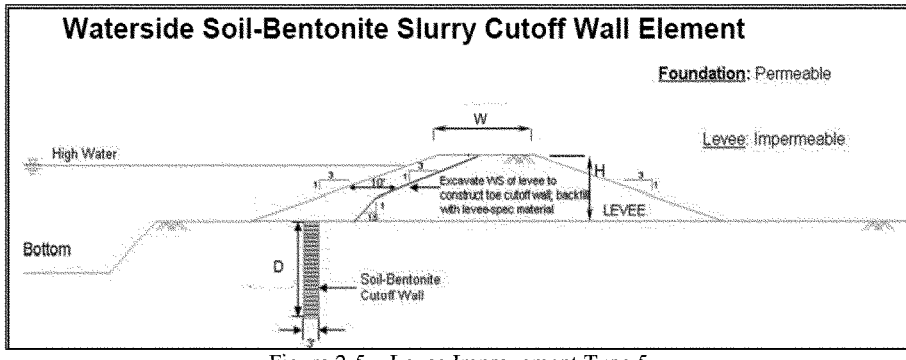


Figure 2-5 – Levee Improvement Type 5

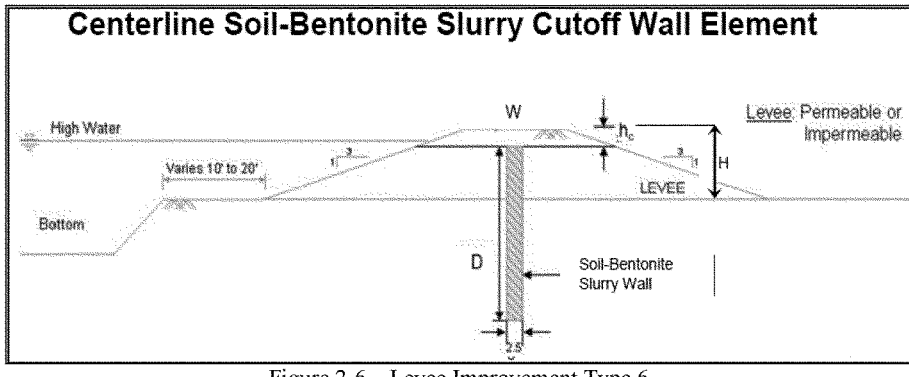


Figure 2-6 – Levee Improvement Type 6

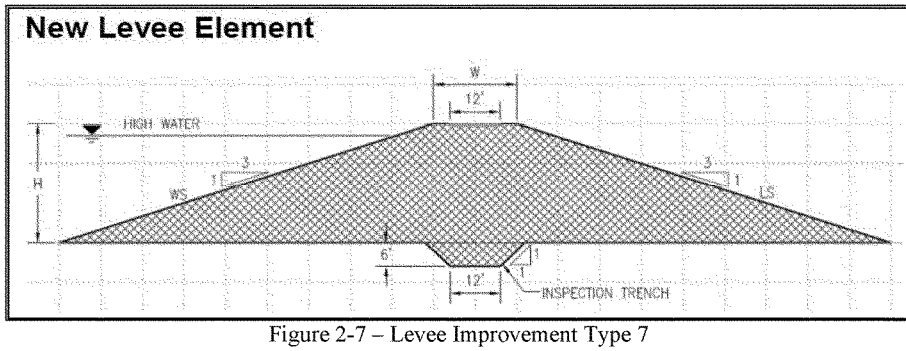


Figure 2-7 – Levee Improvement Type 7

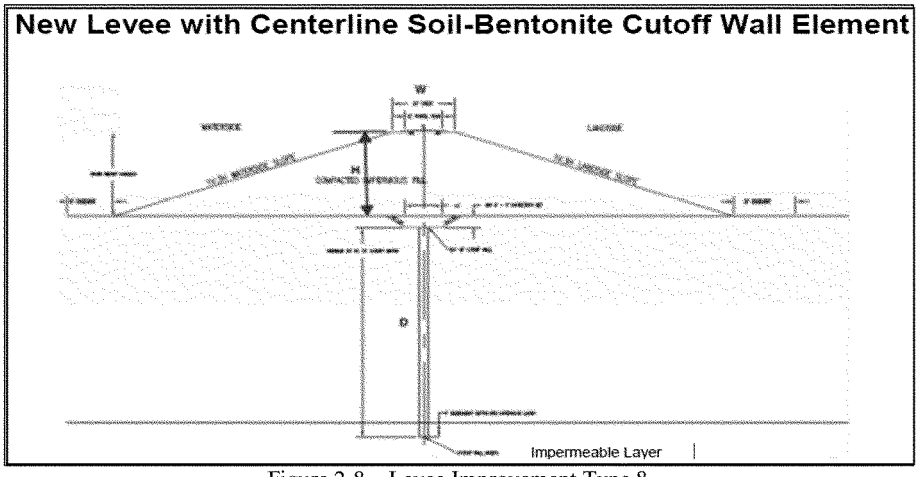


Figure 2-8 – Levee Improvement Type 8

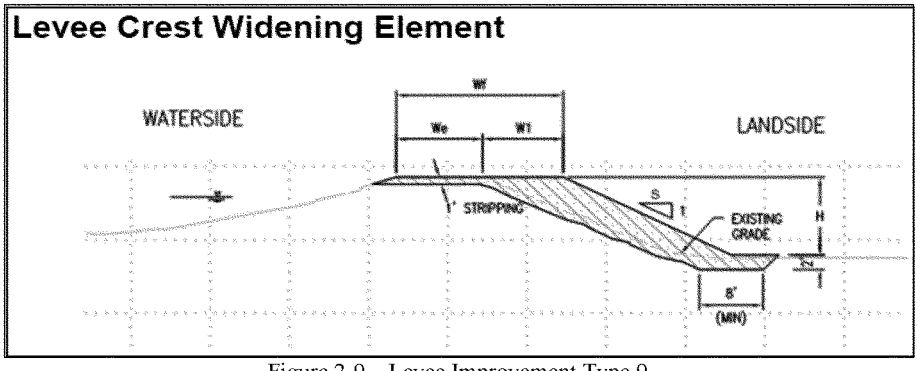


Figure 2-9 – Levee Improvement Type 9

The typical levee remediation measures (shown in figure 2-1 through 2-9) were assigned to each of the 28 reaches as shown in table 2-5A and 2-5B:

Table 2-5A – Levee Remediation Measures (by Percentage of Reach Length)

Reach	Length (LF)	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9
S5-A-Upper	41,417				25%		100%			
S5-A-Lower	13,300				25%		100%			
S5-B	39,300				75%		75%			
S5-C	30,300				25%		75%			100%
S5-D	31,300				10%		50%			100%
S7-D	21,300				10%		50%			100%
S7-E-Upper	9,100				10%		75%			100%

S7-E-Middle	3,300				10%		75%			100%
S7-E-Lower	5,900				10%		75%			100%
S7-F-Upper	22,000				10%		75%			100%
S7-F-Middle	15,300				10%		75%			100%
S7-F-Lower	3,700				10%		75%			100%
S7-G	40,000				10%		100%			
S7-H	9,300				10%		100%			
S7-I	42,916				10%		100%			
S7-J	24,400				10%		50%			
S4-South	28,000							50%	50%	
S4-West	21,000							75%	25%	
S4-North	26,000							50%	50%	
S6-South	28,000							50%	50%	
S6-West-lower	21,000							75%	25%	
S6-West-upper	6,000							75%	25%	
S9-G	40,000								100%	
S9-H	9,300								100%	
S9-I	42,916								100%	
S10	41,417								100%	
S11	15,300							50%	50%	
S12	3,300						25%		75%	

Table 2-5B – Levee Remediation Measures (by Length in Linear Feet)

Reach	Length (LF)	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9
S5-A-Upper	41,417				10,354		41,417			
S5-A-Lower	13,300				3,325		13,300			
S5-B	39,300				29,475		29,475			
S5-C	30,300				7,575		22,725			30,300
S5-D	31,300				3,130		15,650			31,300
S7-D	21,300				2,130		10,650			21,300
S7-E-Upper	9,100				910		6,825			9,100
S7-E-Middle	3,300				330		2,475			3,300
S7-E-Lower	5,900				590		4,425			5,900
S7-F-Upper	22,000				2,200		16,500			22,000
S7-F-Middle	15,300				1,530		11,475			15,300
S7-F-Lower	3,700				370		2,775			3,700
S7-G	40,000				4,000		40,000			
S7-H	9,300				930		9,300			
S7-I	42,916				4,292		42,916			
S7-J	24,400				2,440		12,200			
S4-South	28,000							14,000	14,000	
S4-West	21,000							15,750	5,250	
S4-North	26,000							13,000	13,000	
S6-South	28,000							14,000	14,000	
S6-West-lower	21,000							15,750	5,250	
S6-West-upper	6,000							4,500	1,500	
S9-G	40,000								40,000	

S9-H	9,300								9,300	
S9-I	42,916								42,916	
S10	41,417								41,417	
S11	15,300							7,650	7,650	
S12	3,300						825		2,475	

Assignment (dimension and extent) of the remediation measures (figure 2-1 to 2-9) for each reach are graphically presented in figure 2-10A through 2-29B. Also shown in these figure are the 20-foot landside and 15-foot waterside O&M corridors. The outer most limits of the O&M corridors define the project ROW. The heights of new levee segments (shown in figure 2-21A to 2-23B for Ring and J levee segments defined in table 2-2) were based on hydraulic design recommendations (enclosure 3, Design of New Levee Segments).

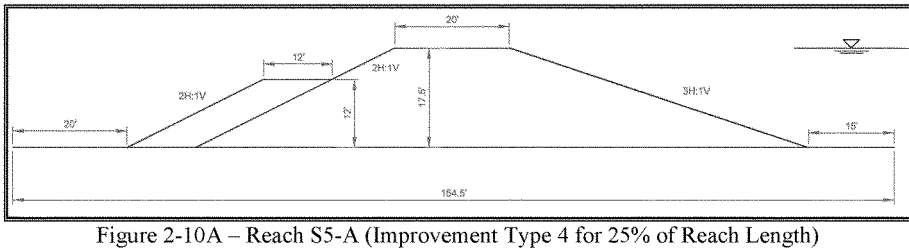


Figure 2-10A – Reach S5-A (Improvement Type 4 for 25% of Reach Length)

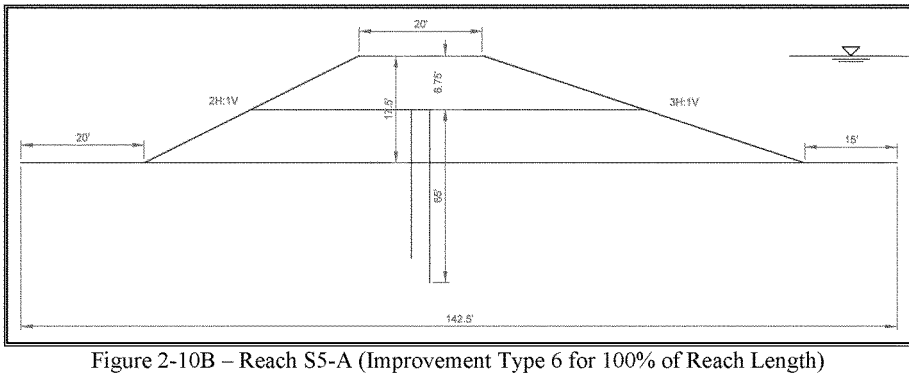


Figure 2-10B – Reach S5-A (Improvement Type 6 for 100% of Reach Length)

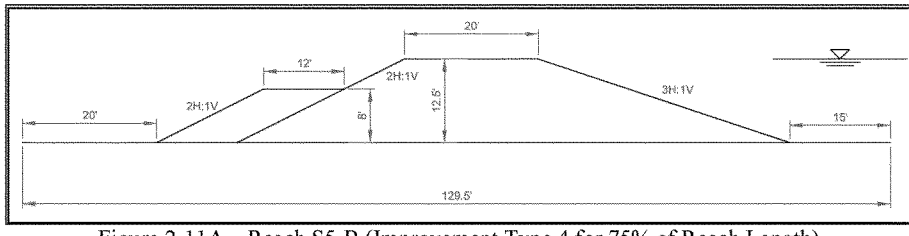


Figure 2-11A – Reach S5-B (Improvement Type 4 for 75% of Reach Length)

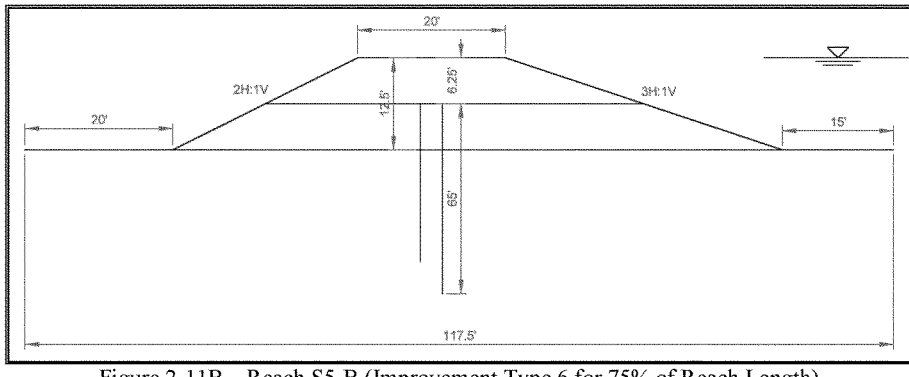


Figure 2-11B – Reach S5-B (Improvement Type 6 for 75% of Reach Length)

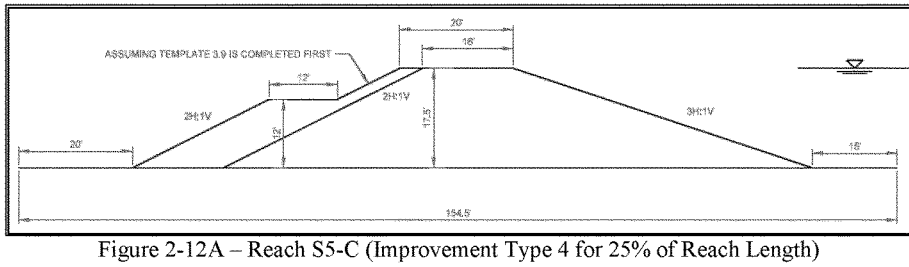


Figure 2-12A – Reach S5-C (Improvement Type 4 for 25% of Reach Length)

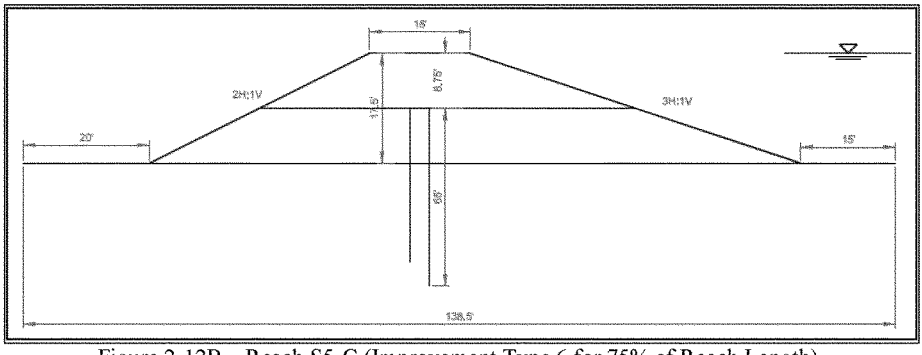


Figure 2-12B – Reach S5-C (Improvement Type 6 for 75% of Reach Length)

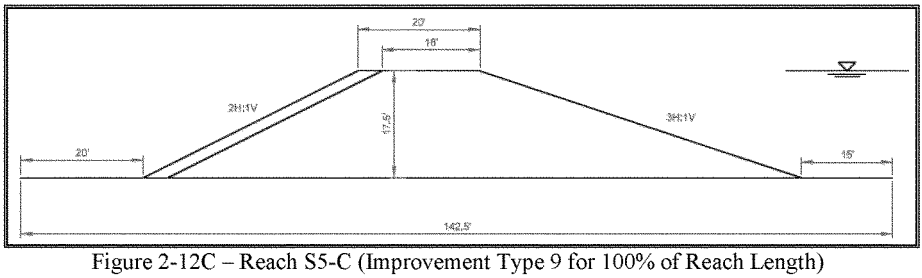


Figure 2-12C – Reach S5-C (Improvement Type 9 for 100% of Reach Length)

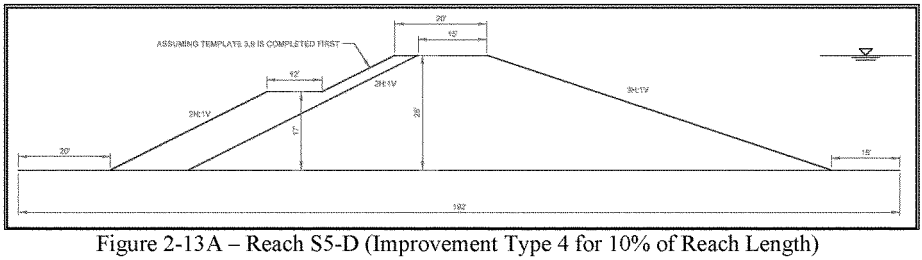


Figure 2-13A – Reach S5-D (Improvement Type 4 for 10% of Reach Length)

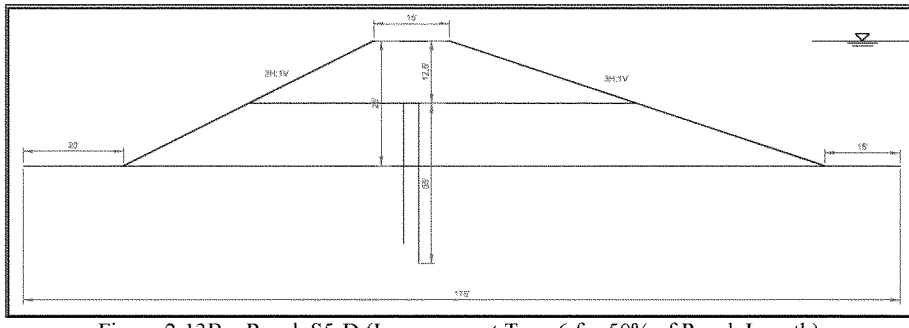


Figure 2-13B – Reach S5-D (Improvement Type 6 for 50% of Reach Length)

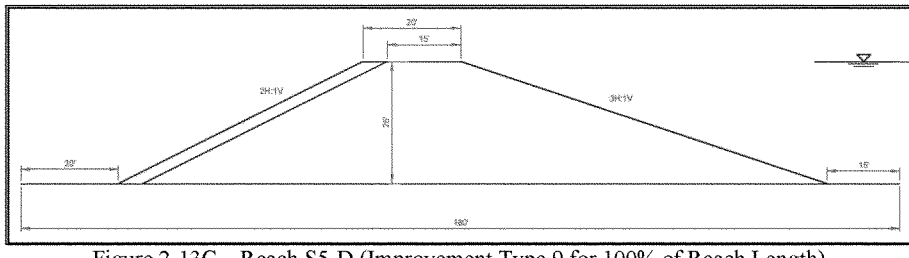


Figure 2-13C – Reach S5-D (Improvement Type 9 for 100% of Reach Length)

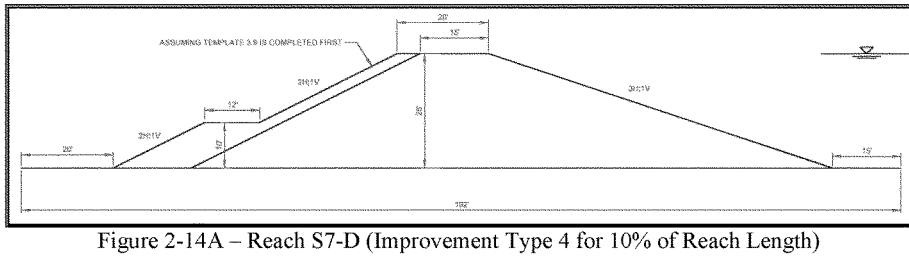


Figure 2-14A – Reach S7-D (Improvement Type 4 for 10% of Reach Length)

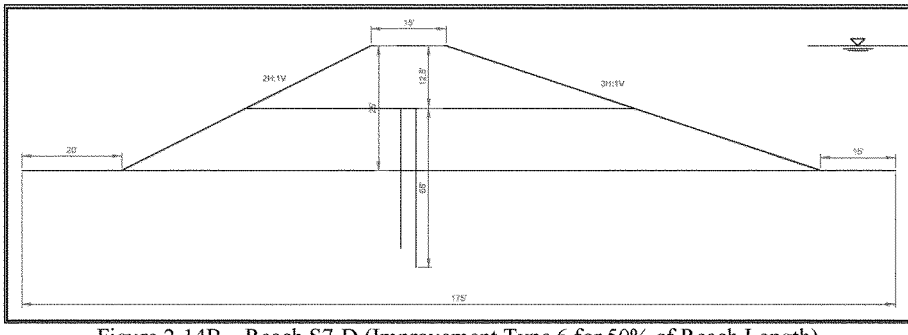


Figure 2-14B – Reach S7-D (Improvement Type 6 for 50% of Reach Length)

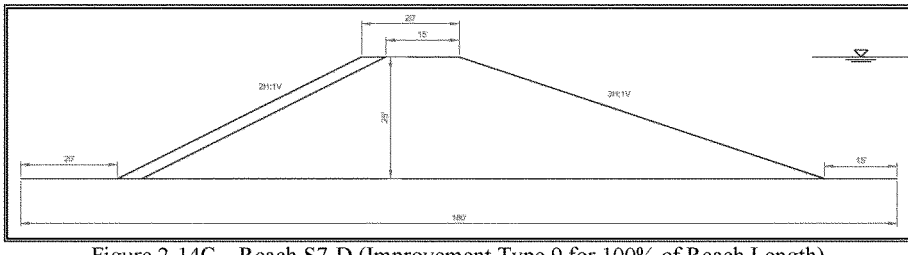


Figure 2-14C – Reach S7-D (Improvement Type 9 for 100% of Reach Length)

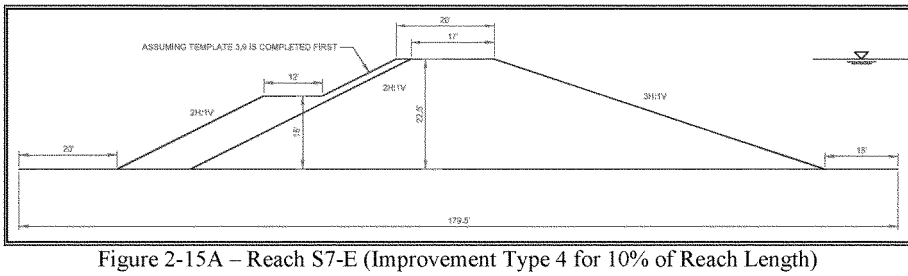


Figure 2-15A – Reach S7-E (Improvement Type 4 for 10% of Reach Length)

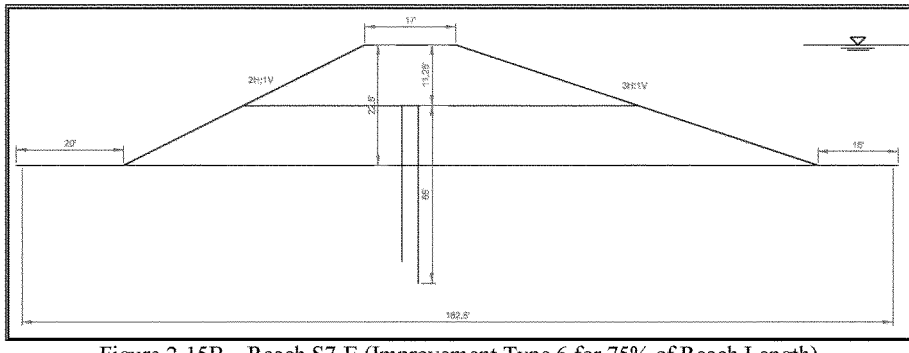


Figure 2-15B – Reach S7-E (Improvement Type 6 for 75% of Reach Length)

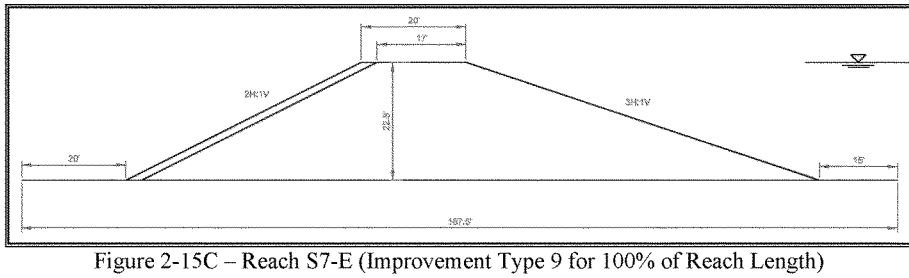


Figure 2-15C – Reach S7-E (Improvement Type 9 for 100% of Reach Length)

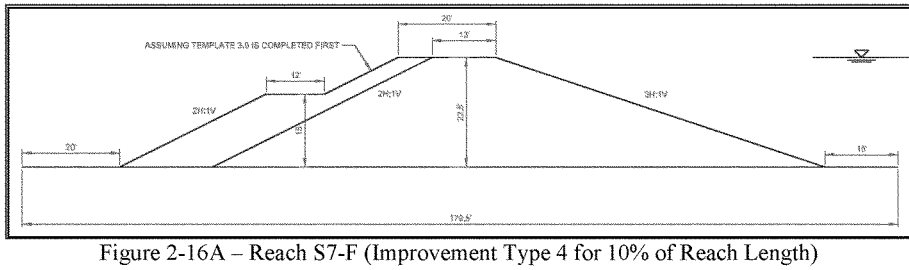


Figure 2-16A – Reach S7-F (Improvement Type 4 for 10% of Reach Length)

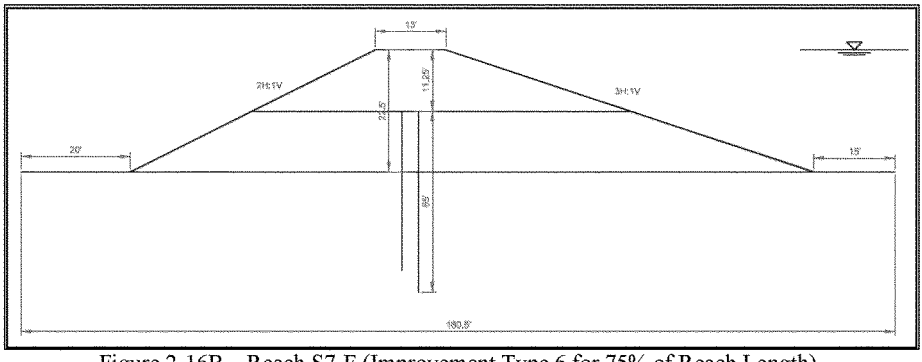


Figure 2-16B – Reach S7-F (Improvement Type 6 for 75% of Reach Length)

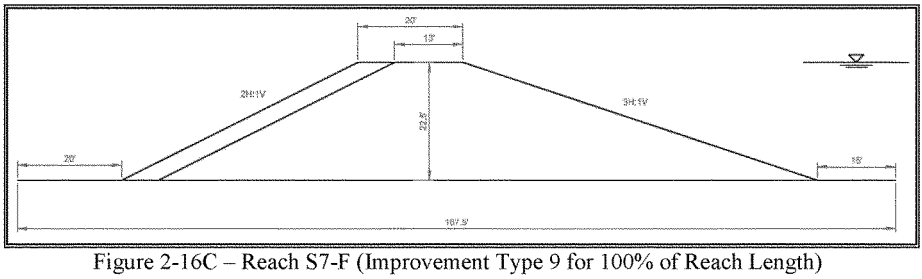


Figure 2-16C – Reach S7-F (Improvement Type 9 for 100% of Reach Length)

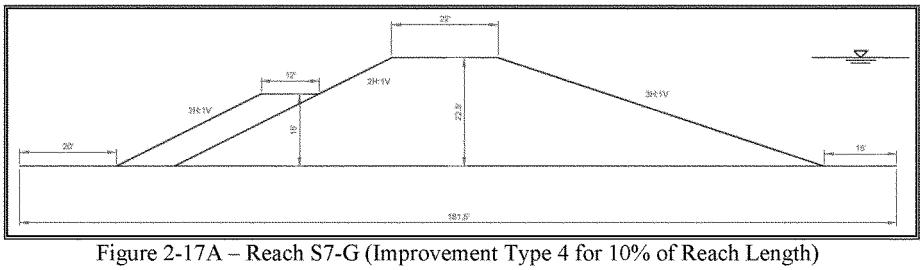


Figure 2-17A – Reach S7-G (Improvement Type 4 for 10% of Reach Length)

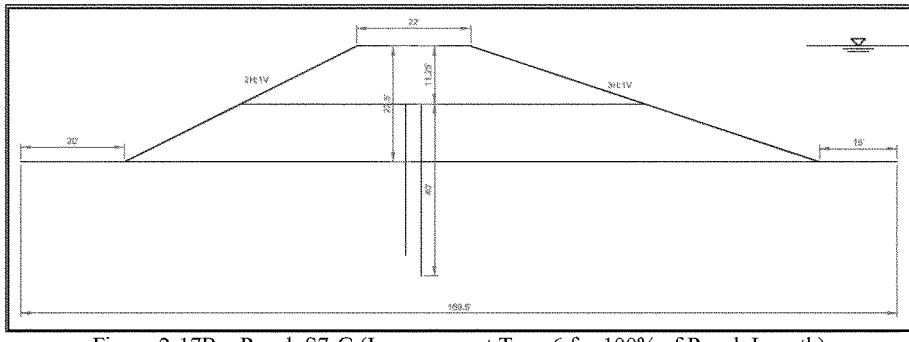


Figure 2-17B – Reach S7-G (Improvement Type 6 for 100% of Reach Length)

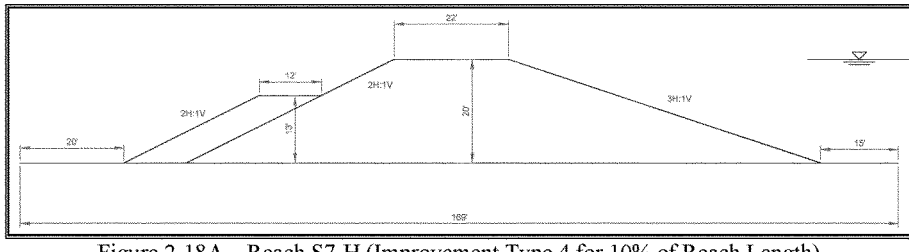


Figure 2-18A – Reach S7-H (Improvement Type 4 for 10% of Reach Length)

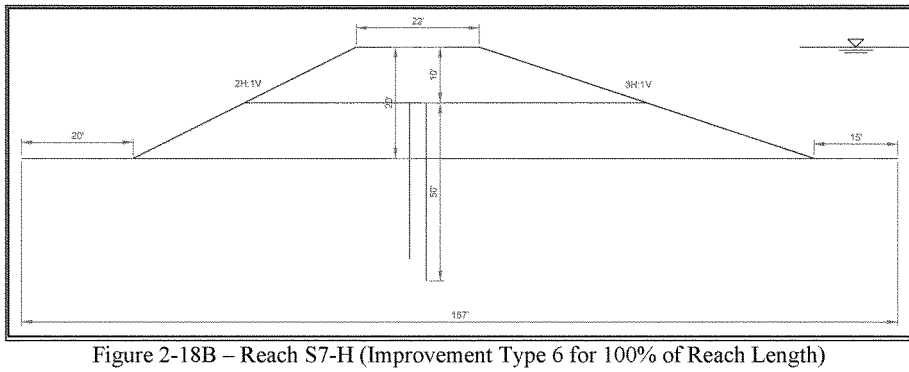


Figure 2-18B – Reach S7-H (Improvement Type 6 for 100% of Reach Length)

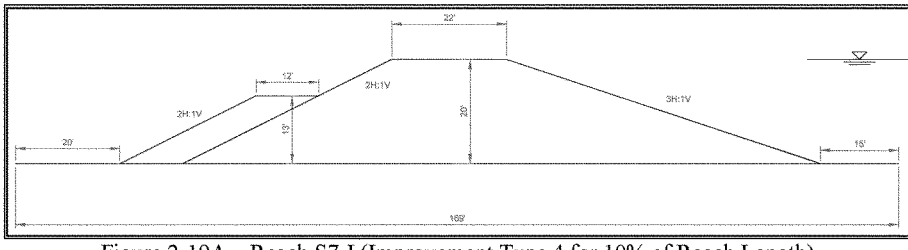


Figure 2-19A – Reach S7-I (Improvement Type 4 for 10% of Reach Length)

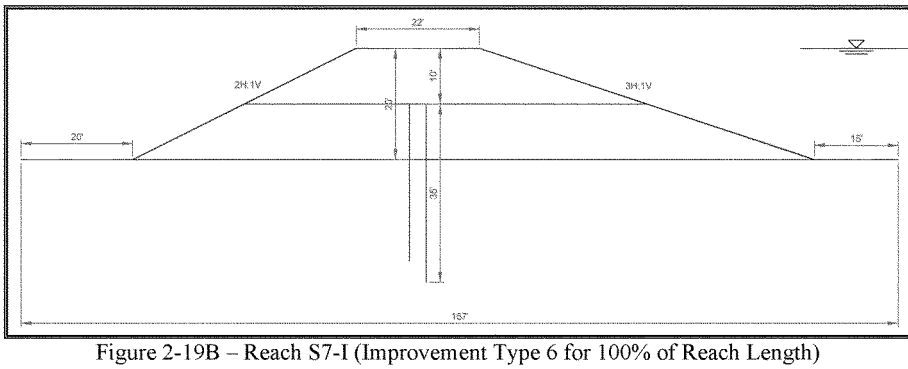


Figure 2-19B – Reach S7-I (Improvement Type 6 for 100% of Reach Length)

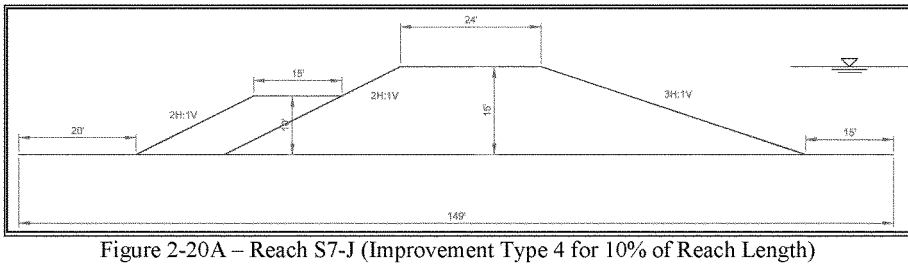


Figure 2-20A – Reach S7-J (Improvement Type 4 for 10% of Reach Length)

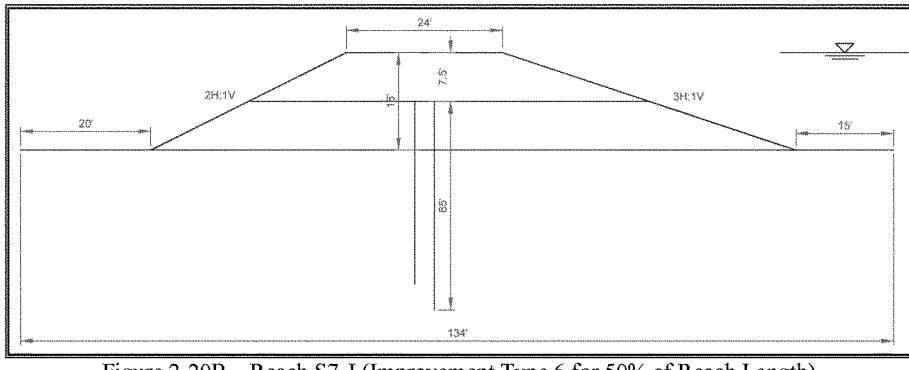


Figure 2-20B – Reach S7-J (Improvement Type 6 for 50% of Reach Length)

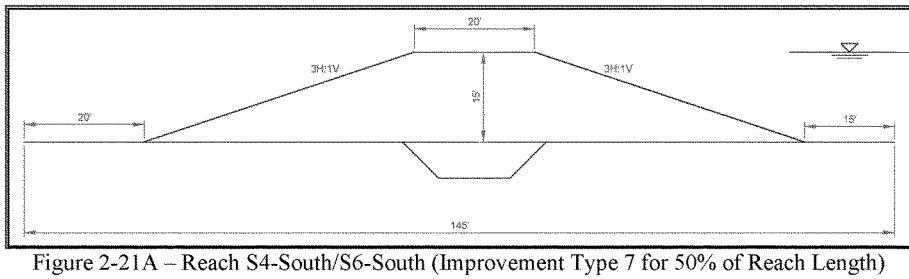


Figure 2-21A – Reach S4-South/S6-South (Improvement Type 7 for 50% of Reach Length)

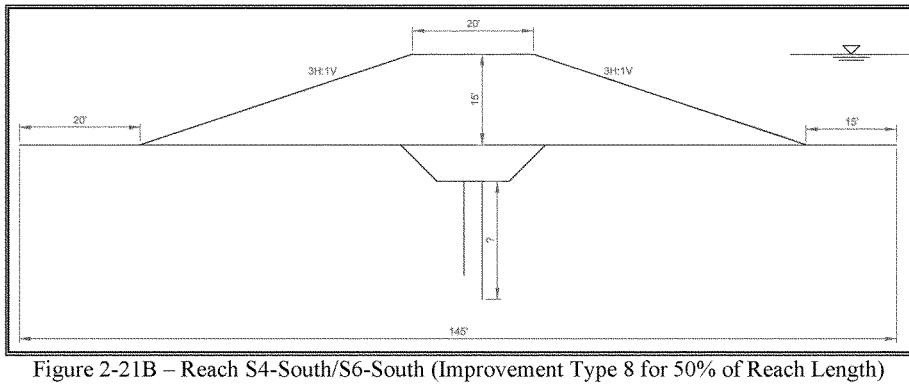


Figure 2-21B – Reach S4-South/S6-South (Improvement Type 8 for 50% of Reach Length)

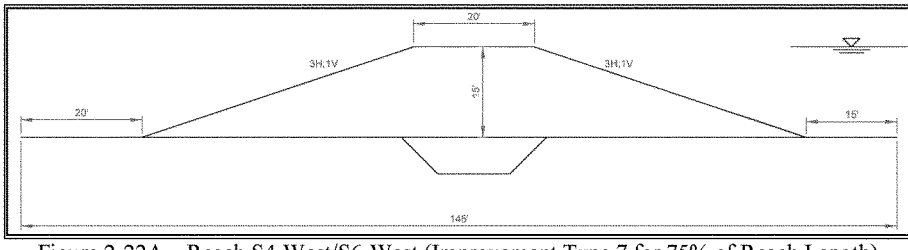


Figure 2-22A – Reach S4-West/S6-West (Improvement Type 7 for 75% of Reach Length)

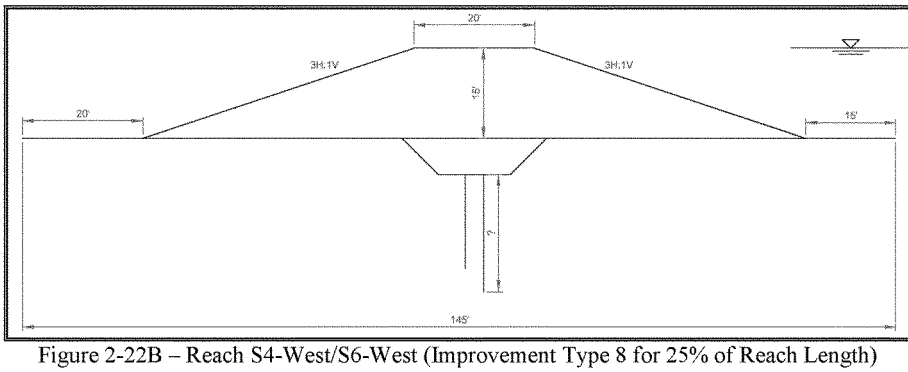


Figure 2-22B – Reach S4-West/S6-West (Improvement Type 8 for 25% of Reach Length)

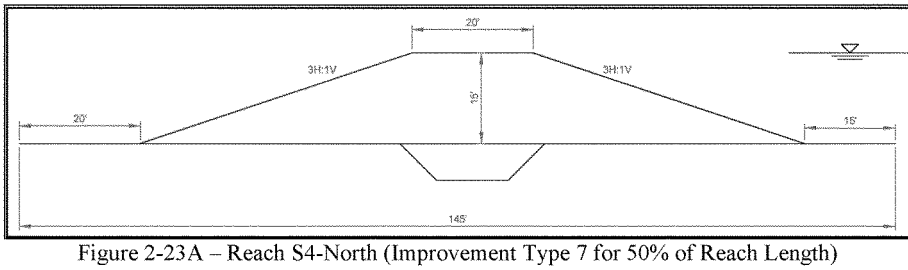


Figure 2-23A – Reach S4-North (Improvement Type 7 for 50% of Reach Length)

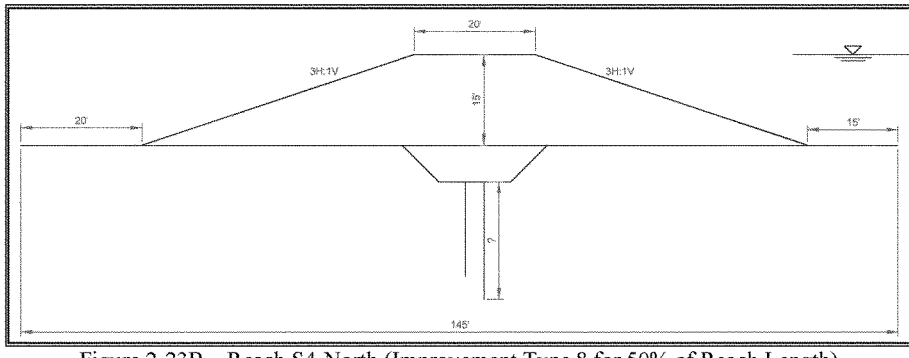


Figure 2-23B – Reach S4-North (Improvement Type 8 for 50% of Reach Length)

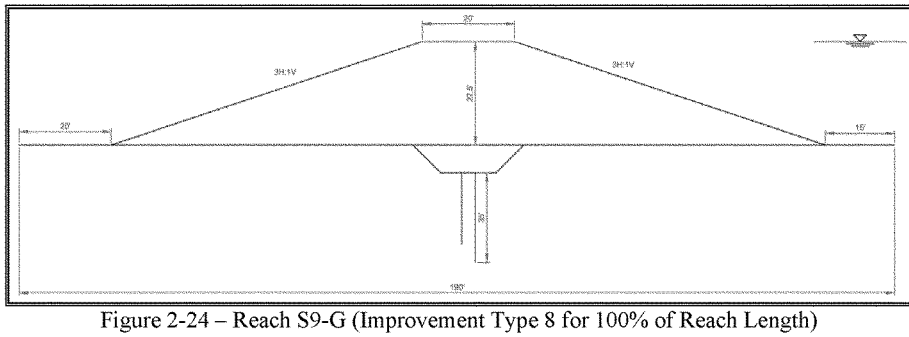


Figure 2-24 – Reach S9-G (Improvement Type 8 for 100% of Reach Length)

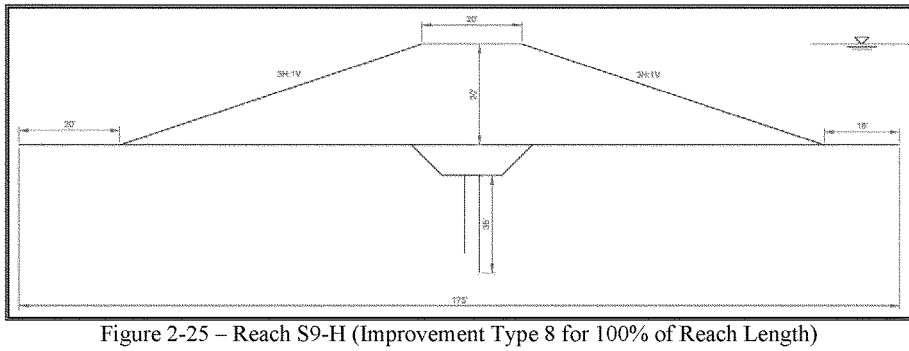


Figure 2-25 – Reach S9-H (Improvement Type 8 for 100% of Reach Length)

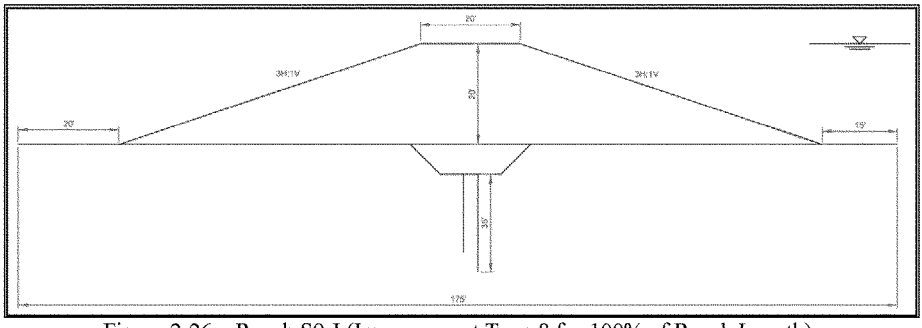


Figure 2-26 – Reach S9-I (Improvement Type 8 for 100% of Reach Length)

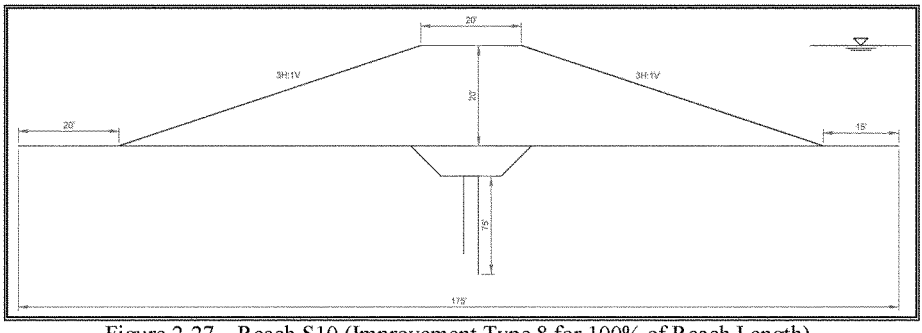


Figure 2-27 – Reach S10 (Improvement Type 8 for 100% of Reach Length)

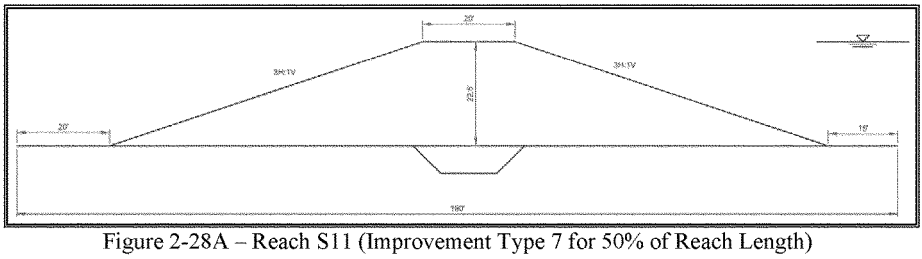


Figure 2-28A – Reach S11 (Improvement Type 7 for 50% of Reach Length)

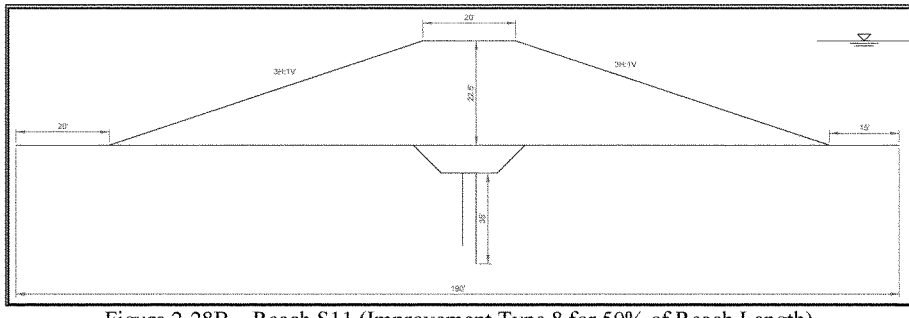


Figure 2-28B – Reach S11 (Improvement Type 8 for 50% of Reach Length)

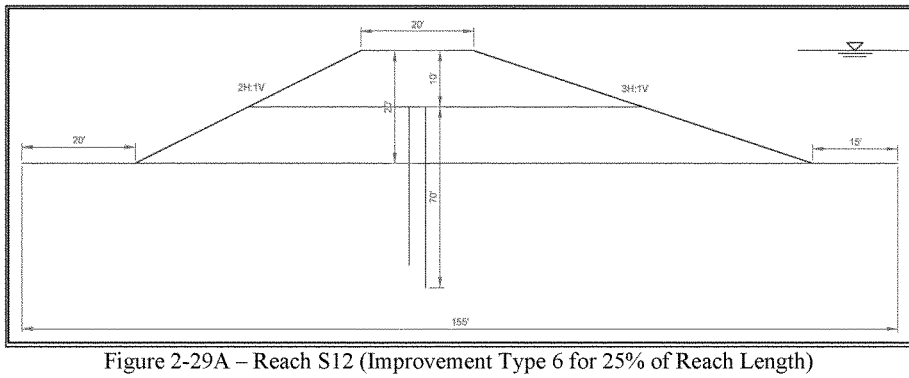


Figure 2-29A – Reach S12 (Improvement Type 6 for 25% of Reach Length)

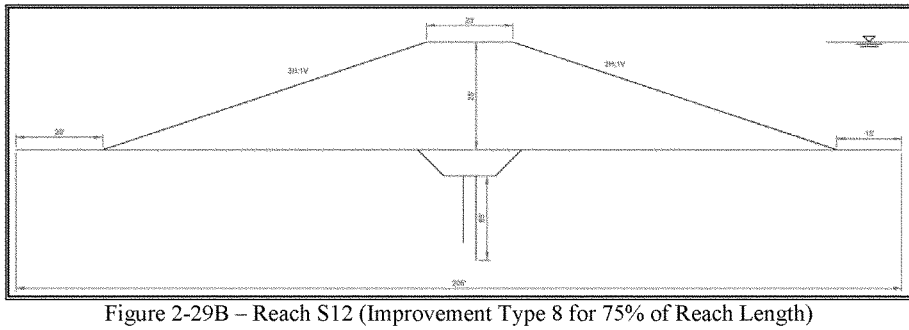


Figure 2-29B – Reach S12 (Improvement Type 8 for 75% of Reach Length)

2.5 Encroachments

The utilities (pipelines and conduits only) located within the proposed ROW for new levee segments (e.g. setback levees and ring levee segments) were not specifically addressed during this phase of the study and estimated as a lump sum percentage of the total utility cost. Physical structures located within the proposed ROW, roads and canals crossing the alignment of new levee segments were specifically addressed during this phase. New levee segments were defined in table 2-2 and shown in figure 1-1 of section 2.3.1.

A comprehensive inventory of all encroachments (utilities, physical structures and woody vegetations) located within the proposed ROW of the existing levee segments (see figure 2-10A to 2-20B) was completed based on existing data and field investigations. The existing encroachment data came from multiple sources including the CVFPB encroachment list, the USACE Periodic Inspection report and as-built of various projects located along the FRWL alignment. Field investigations were conducted to validate and improve the existing inventories.

The final encroachment list (enclosure 4, Encroachment Improvements & Estimates) shows numerous pipelines (both gravity and pressurized lines) and conduits (cables, electrical lines etc.) crossing the existing alignments of the FRWL, SBEL and WCEL. The record also indicated a number of utilities running parallel to the alignments (power poles, irrigation ditches, pipelines etc.), physical structures (public, residential and commercial buildings), and woody vegetation (mature trees) currently located within the proposed ROW of the existing levee segments. These encroachments were divided into 12 groups/types.

The following paragraphs outline the approach for addressing each type of encroachment. To avoid interference with construction of other project features, it is assumed that all levee penetrations will be removed prior to levee construction and disposed/replaced after the levee construction is completed. It is also assumed that temporary bypass will be provided at each utility improvement sites to avoid impacts to existing operations. All pipelines and conduits crossing the levee alignment will be modified to include positive closure devices and meet the USACE design criteria for levee penetrations in accordance with EM 1110-2-1913.

Refer to enclosure 4, Encroachment Improvements & Estimates, for the complete inventory, classification and remediation measures for all encroachments located within the proposed ROW of the existing levee segments.

2.5.1 Type 1

This group includes the major utilities those are crossing the levee prism and still in good condition. Relocation of these utility crossings above the DWSE would result in high construction cost and impacts. Therefore, the proposed remediation method is to construct jet grouting cutoff wall around the penetrations.

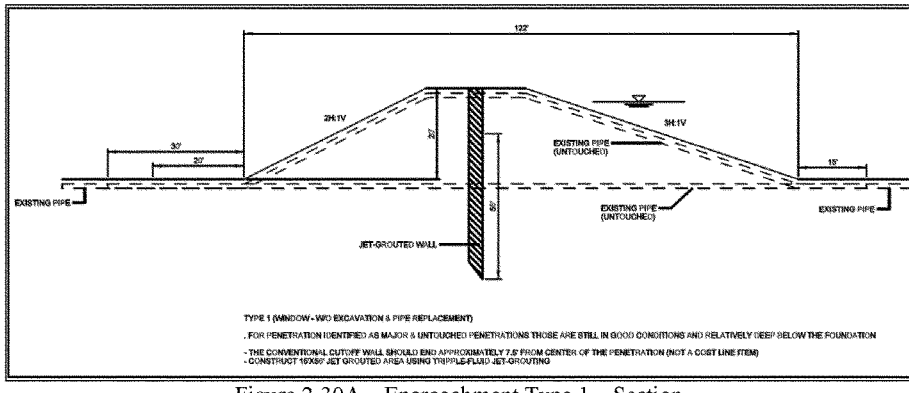


Figure 2-30A – Encroachment Type 1 – Section

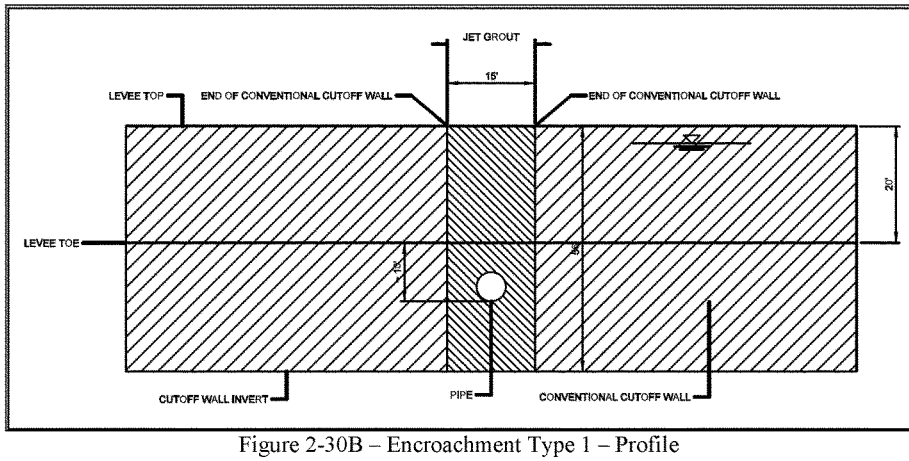


Figure 2-30B – Encroachment Type 1 – Profile

2.5.2 Type 2

This group includes the utilities those are crossing the levee prism (raised and through pipes/conduits) and abandoned. The proposed remediation method is to remove these abandoned penetrations.

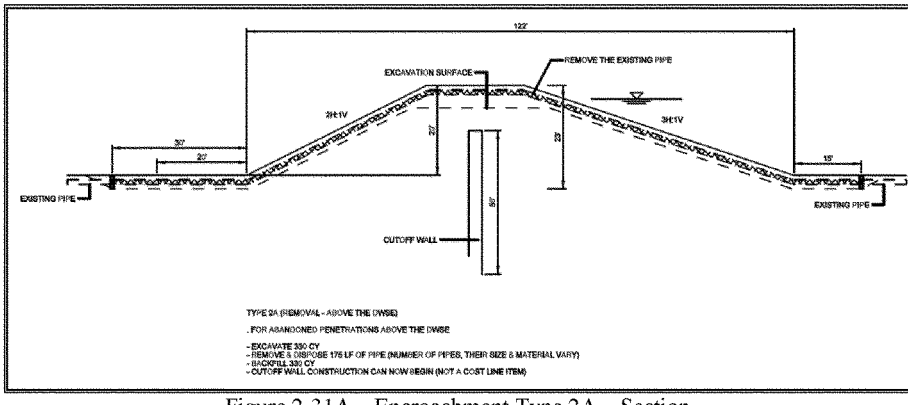


Figure 2-31A – Encroachment Type 2A – Section

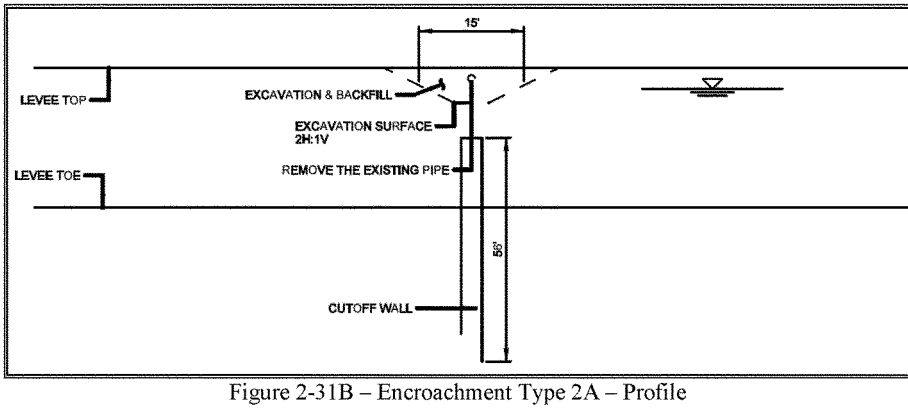


Figure 2-31B – Encroachment Type 2A – Profile

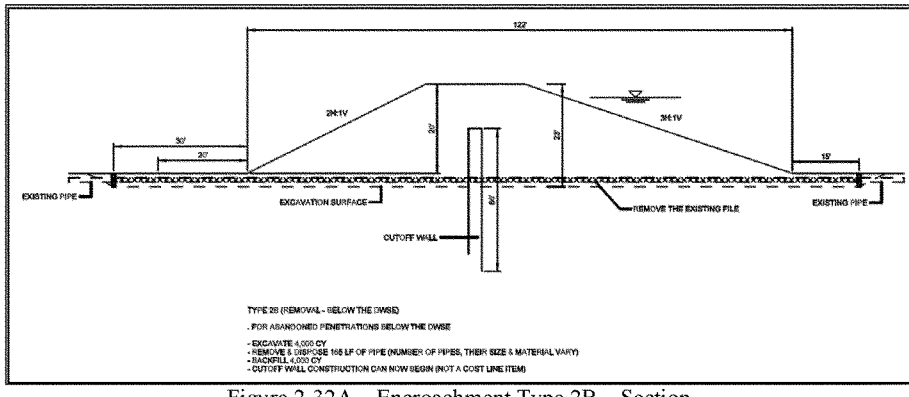


Figure 2-32A – Encroachment Type 2B – Section

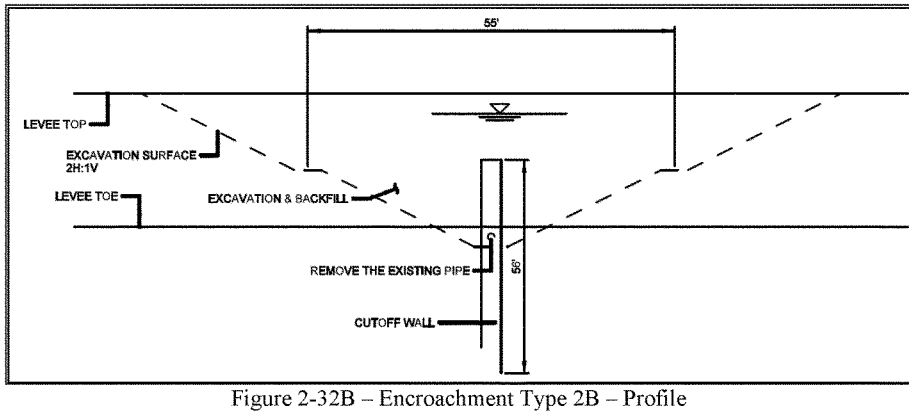


Figure 2-32B – Encroachment Type 2B – Profile

2.5.3 Type 3

This group includes utilities those are crossing the levee prism, dated and don't meet the current standard, include: (1) Communication conduits crossing the levee prism above the DWSE, (2) Minor pressurized pipelines crossing the levee prism above the DWSE, (3) Major pressurized pipelines crossing the levee prism below the DWSE, and (4) Gravity pipelines crossing the levee prism below the DWSE. These pipelines and conduits will be removed (before the cutoff wall construction begins) and replaced in-place (after the cutoff wall construction completes) with proper pipe materials and positive closure devices.

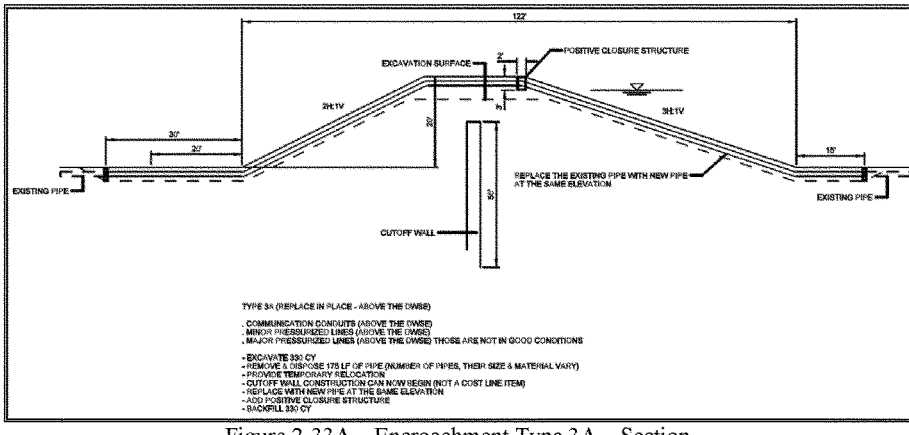


Figure 2-33A – Encroachment Type 3A – Section

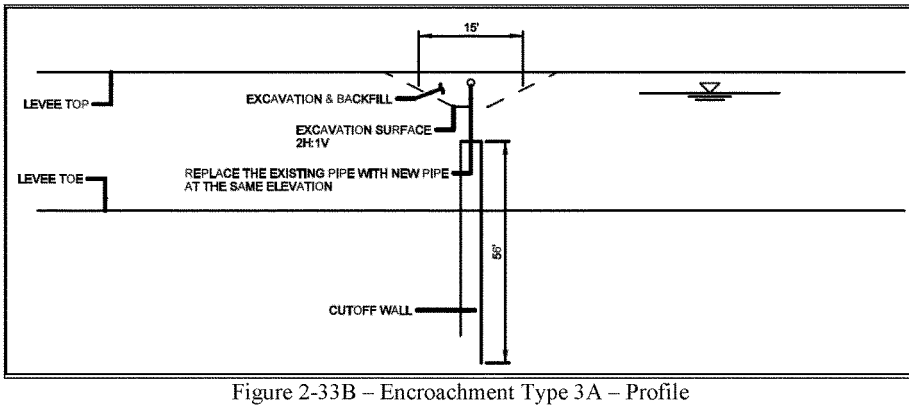


Figure 2-33B – Encroachment Type 3A – Profile

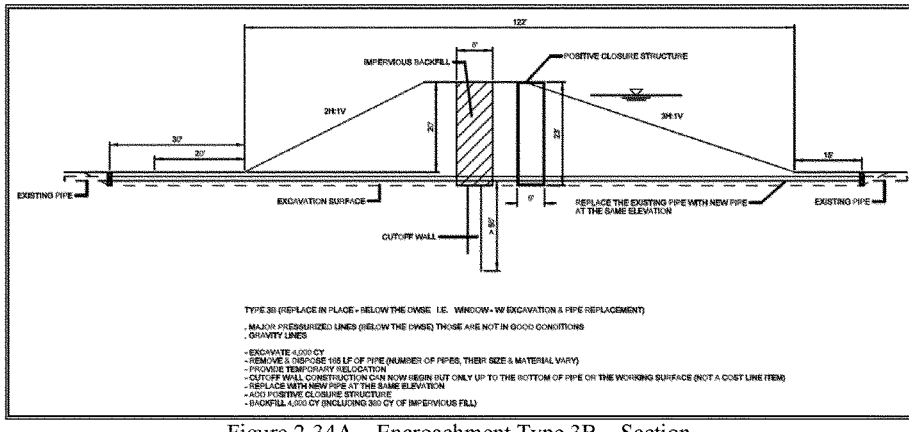


Figure 2-34A – Encroachment Type 3B – Section

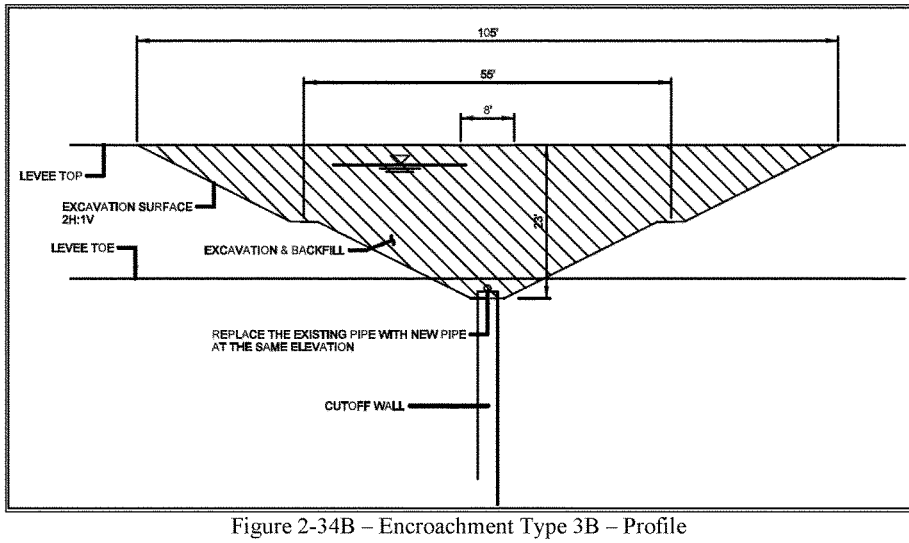


Figure 2-34B – Encroachment Type 3B – Profile

2.5.4 Type 4

This group includes utilities those are crossing the levee prism, dated and don't meet the current standard, include: (1) Communication conduits crossing the levee prism below the DWSE, and (2) Minor pressurized pipelines crossing the levee prism below the DWSE. These pipelines and conduits will be removed (before the cutoff wall construction begins) and replaced

and relocated above the DWSE (after the cutoff wall construction completes) with proper pipe materials and positive closure devices.

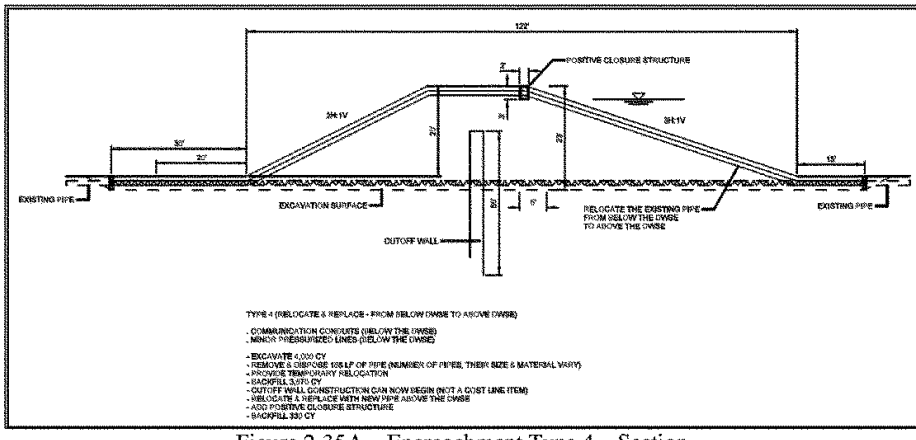


Figure 2-35A – Encroachment Type 4 – Section

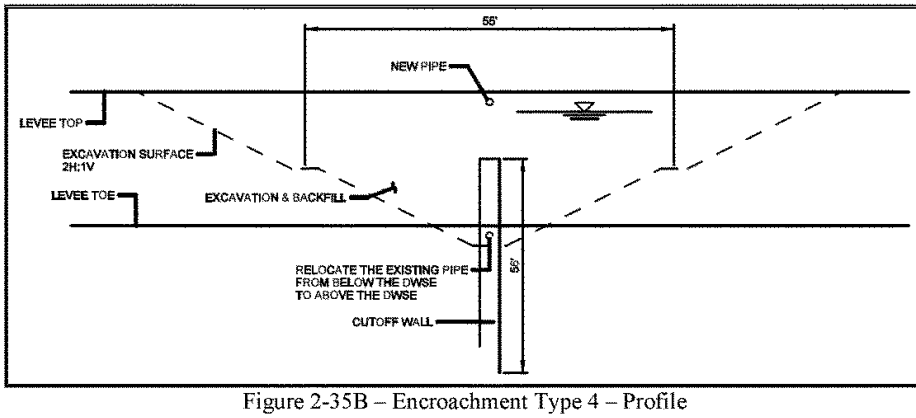


Figure 2-35B – Encroachment Type 4 – Profile

2.5.5 Type 5

This group includes bridges and railroads crossing the alignment of the existing levee. Deep Soil Mix (DSM) cutoff wall will be constructed at these locations.

2.5.6 Type 6

This group includes roads crossing the alignment of the new tall levee segments. Flood gate was initially considered as an option; however, because of the deep flood depth anticipated at these locations, these roads will be elevated up to the new top of levee.

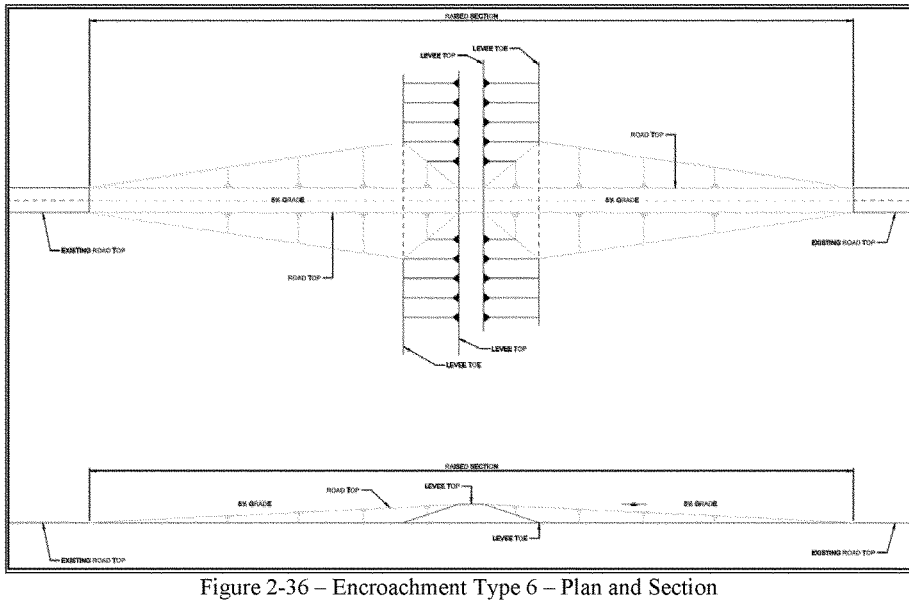


Figure 2-36 – Encroachment Type 6 – Plan and Section

2.5.7 Type 7

This group includes roads crossing the alignment of the new shallow levee segments. Because of the shallow flood depth anticipated at these locations, flood gate will be installed at these locations.

2.5.8 Type 8

This group includes canals crossing the alignment of the new levee segments. Relocation of these canals would result in high cost and impact. Therefore, the proposed remediation measure is to construct automatic closure structures at these canal crossings.

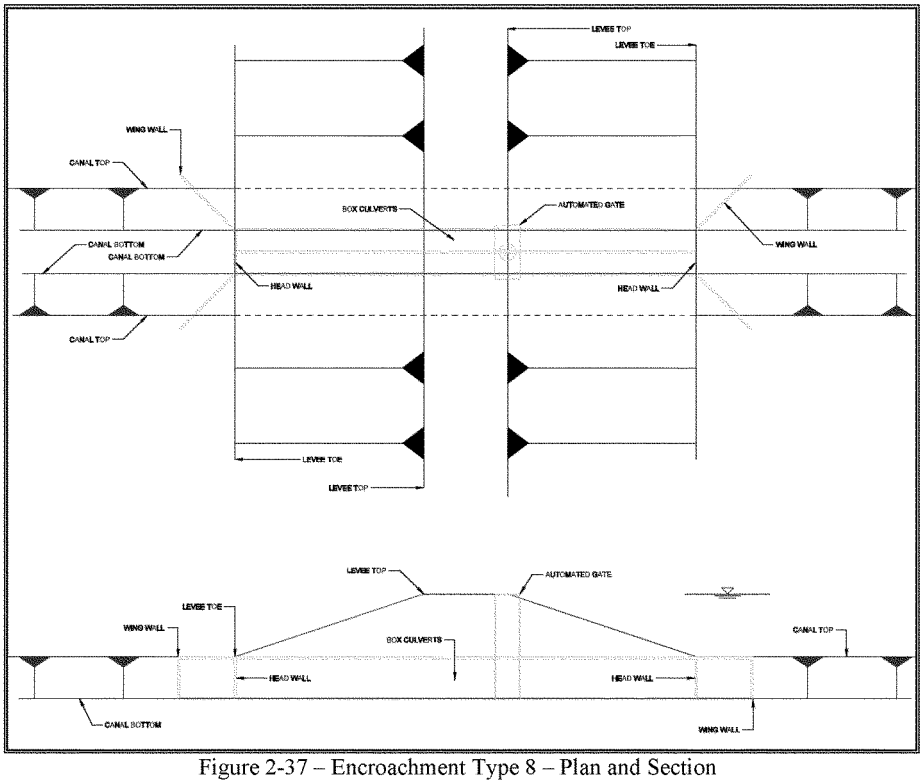


Figure 2-37 – Encroachment Type 8 – Plan and Section

2.5.9 Type 9

This group includes overhead power lines crossing the levee alignment. Temporary cutoff will be required to provide clearance for construction equipments where necessary. Power poles located within the proposed ROW will be relocated outside the proposed ROW, into a utility corridor.

2.5.10 Type 10

This group includes all physical structures (buildings, residential homes etc.) located within the proposed ROW of the existing and new levee segments. These structures will be relocated outside the proposed ROW.

2.5.11 Type 11

This group includes minor ditches and ponds located within the proposed ROW of the existing and new levee segments. These structures will be relocated outside the proposed ROW.

The Sutter Butte Main Canal (SBMC) falls within the proposed ROW at four locations along the FRWL alignment. Per Geotechnical Design recommendation, the SBMC encroachment was not specifically addressed during this phase of the study, however, captured as a part of the project's cost contingency during the Cost & Schedule Risk Analysis.

2.5.12 Type 12

This group includes all other overhead power poles, utility pipelines and conduits that are not crossing the levee alignment but located within the proposed ROW. These utilities will be relocated outside the proposed ROW, into a utility corridor.

2.6 Real Estate Requirement

The general Land, Easements, Rights-of-way, Relocation and Disposal Areas (LERRD)'s requirements include land acquisitions for levee footprint, O&M roads, utility corridors, temporary work areas, borrow and mitigation areas. The LERRD's requirements also include the relocation of physical structures (buildings, residential homes etc.) currently encroaching into the ROW.

The land acquisitions for levee footprint and O&M roads are necessary for construction, operation and maintenance of project features. The levee's and O&M road's footprints were established based on the final levee geometry (shown in figure 2-10A to 2-29B) and based on the distributions of typical levee improvement measures (shown in table 2-5A and 2-5B). In the figure, the levee footprint is the base width from the landside toe to the waterside toe of levee/berm. The landside O&M road is a 20-foot corridor along the landside toe of the levee/berm. The waterside O&M road is a 15-foot O&M corridor along the waterside toe of the levee/berm.

Additional land acquisitions for utility corridors, temporary work areas, borrow and mitigation areas were considered but not specifically addressed during this phase of the study. The utility corridor (approximately 20ft beyond the PRE for O&M roads) may be needed for relocation of utilities parallel to the project's alignment outside of the proposed ROW. Temporary work areas, borrow and mitigation areas are necessary for construction of the project features. These additional real estate requirements were not specifically identified and estimated as lump sum percentages of the total real estate requirements.

The number of physical structures to be relocated was estimated based on the ROW requirements (see paragraph 2.4.2).

2.7 Quantity Development

2.7.1 Levee and Cutoff Wall Constructions

The quantity estimates for levee and cutoff wall constructions (e.g. excavation and backfill, cutoff wall area etc.) were completed using the parametric approach. In this approach, the quantities were estimated as products of sectional area and length of different types of levee improvements. The sectional areas of levee improvements were based on the levee geometry shown in figure 2-10A to 2-29B. The lengths of the levee segment where a typical improvement measure applied were based on the distribution shown in table 2-5A and 2-5B. Refer to the URS Parametric Cost Estimating MII Toolbox for the quantity estimates for levee and cutoff wall constructions.

2.7.2 Improvements and Relocations of Encroachments

The quantity estimates for encroachments (type 1 through 12) are shown in enclosure 4, Encroachment Improvements & Estimates, based on the recommendations provided in paragraph 2.5.

CHAPTER 3 – ALTERNATIVE DESCRIPTIONS

3.1 General

Based on table 2-3 and 2-5B, the project features included in each potential alternative will be as follows:

Table 3-1 – Draft Array of Potential Alternatives

Reach	SB-1	SB-2	SB-3	SB-4	SB-5	SB-6	SB-7	SB-8
Stability Berm								
Stability Berm with Relief Wells								
Seepage Berm								
Gravel Stability Berm		14,075	3,130	10,705	57,229	73,581	16,865	60,019
Waterside Soil-Bentonite Slurry Cutoff Wall								
Centerline Soil-Bentonite Slurry Cutoff Wall		58,325	15,650	38,375	142,517	282,108	79,250	163,442
New Levee			42,750	34,250				
New Levee w/ Centerline SB Slurry Cutoff Wall			32,250	20,750				
Levee Crest Widening		95,300	31,300	61,600	95,300	142,200	123,200	123,200

Detailed description of the alternatives is discussed in paragraph 3.2

3.2 Alternative Descriptions

3.2.1 Alternative SB-1

Under this alternative, the Federal government would take no action toward implementing a specific flood risk remediation measures. See plate 1-1.

3.2.2 Alternative SB-2

This alternative includes fix-in-place Feather River levees from Sunset Weir to Star Bend (see plate 1-2), and includes fix-in-place levee structural measures and non-structural measures. The structural measures are shown in table 3-1.

3.2.3 Alternative SB-3

This is a primarily non-structural alternative that includes the construction of a new levee surrounding Yuba City (see plate 1-3) and utilizing fixed-in-place eastern sections of the existing levee, and includes fix-in-place levee, new ring levee structural measures and non-structural measures. The structural measures are shown in table 3-1. Two new pump stations were assumed to be required to address interior drainage.

3.2.4 Alternative SB-4

This alternative is a non-structural/structural hybrid that includes fixing-in-place the Feather River levees north of Yuba City from Shangahi Bend to Thermalito, and the construction of a new levee on the south and west of Yuba City (little J). See plate 1-4. Fix-in-place levee and new levee structural measures and non-structural measures are included in this alternative. The structural measures are shown in table 3-1. This alternative assumes two new pump stations to address interior drainage.

3.2.5 Alternative SB-5

This alternative is inclusive of alternative SB-2, and further extends levee fix-in-place improvements north to Thermalito Afterbay (see plate 1-5), and includes fix-in-place levee structural measures and non-structural measures. The structural measures are shown in table 3-1.

3.2.6 Alternative SB-6

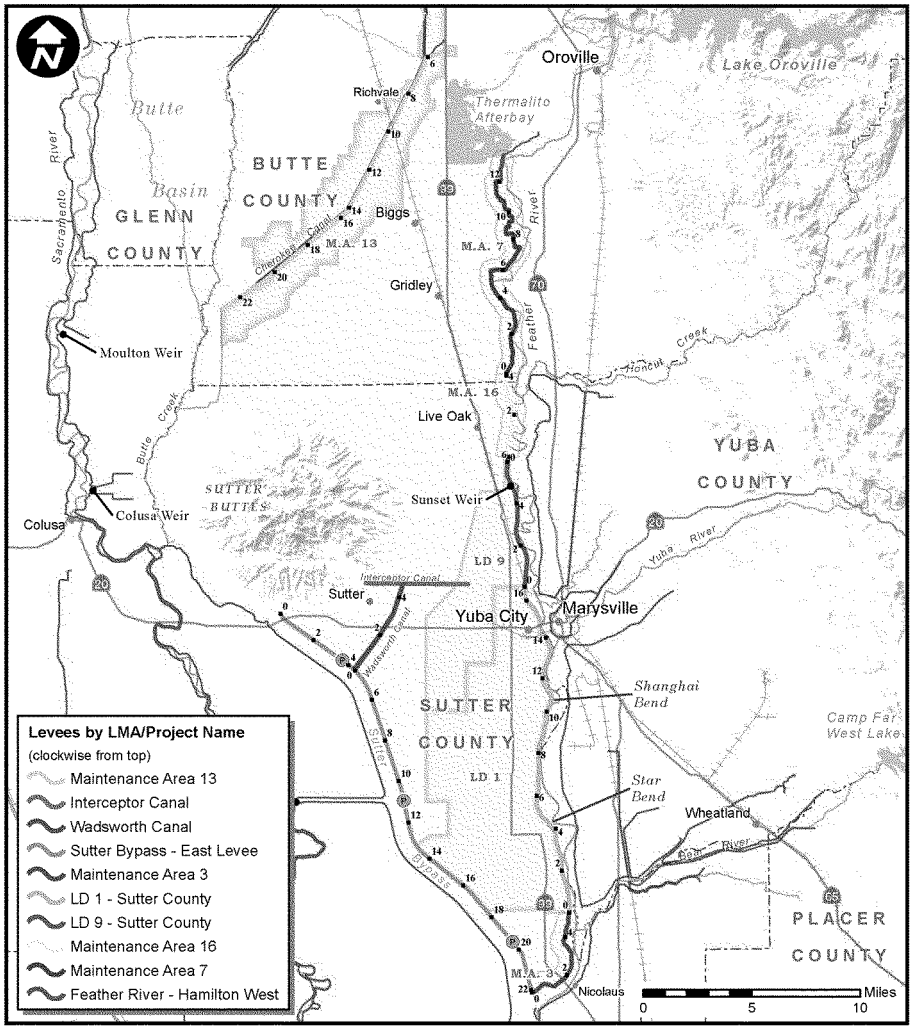
This alternative consists of the Sutter Bypass/Wadsworth Canal Levee fix-in-place improvements and fix-in-place levee improvements to all Feather River Levees (see plate 1-6), and includes fix-in-place levee structural measures and non-structural measures. The structural measures are shown in table 3-1.

3.2.7 Alternative SB-7

This alternative includes Alternative SB-2 and extends Feather River fix-in-place levee improvements south of Yuba City to Laurel Ave (see plate 1-7), and includes fix-in-place levee structural measures and non-structural measures. The structural measures are shown in table 3-1.

3.2.8 Alternative SB-8

This alternative is inclusive of Alternative SB-7 and extends Feather River levee improvements north to Thermalito (see plate 1-8), and includes fix-in-place levee structural measures and non-structural measures. The structural measures are shown in table 3-1.



Legend

- Study Area Extent
- Levee Maintenance Agency
- Federal Levee
- Levee Mile
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

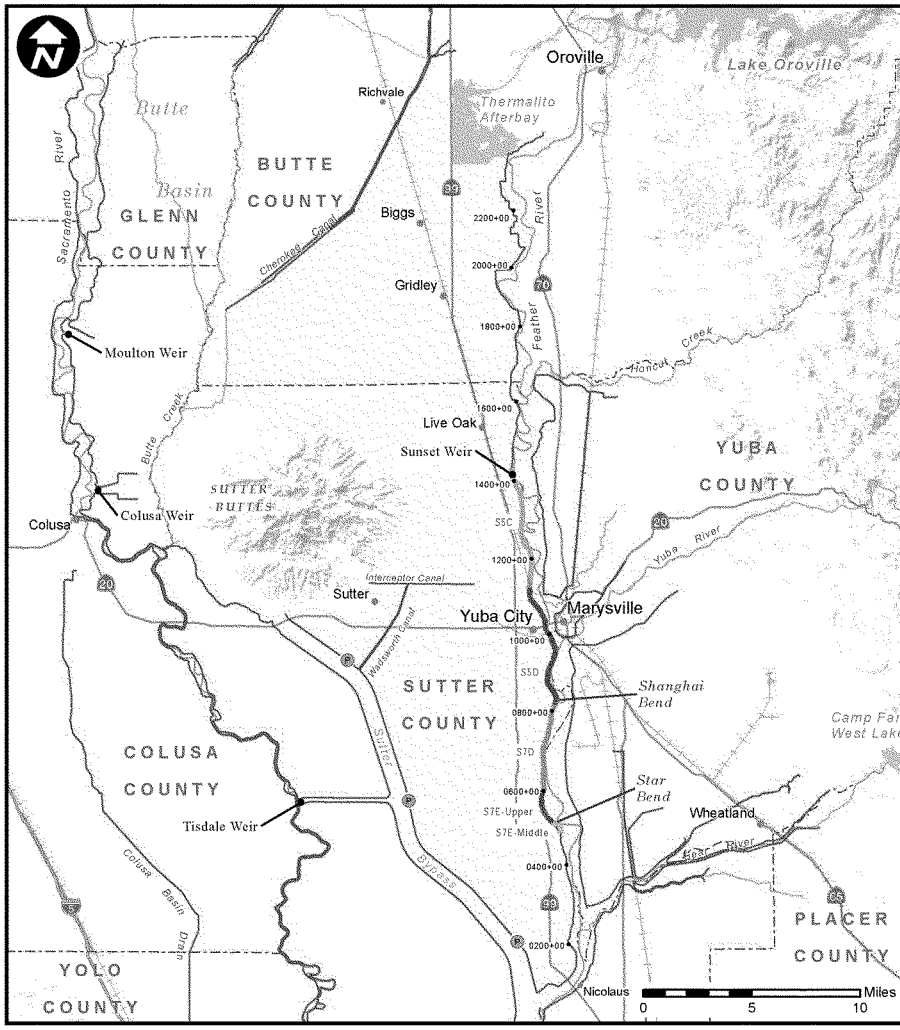
SUTTER BASIN PROJECT AREA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-1



Legend

Study Area Extent	Lake or Reservoir
SSB Project Reach	River or Stream
Federal Levee	Highway
Stationing Point	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

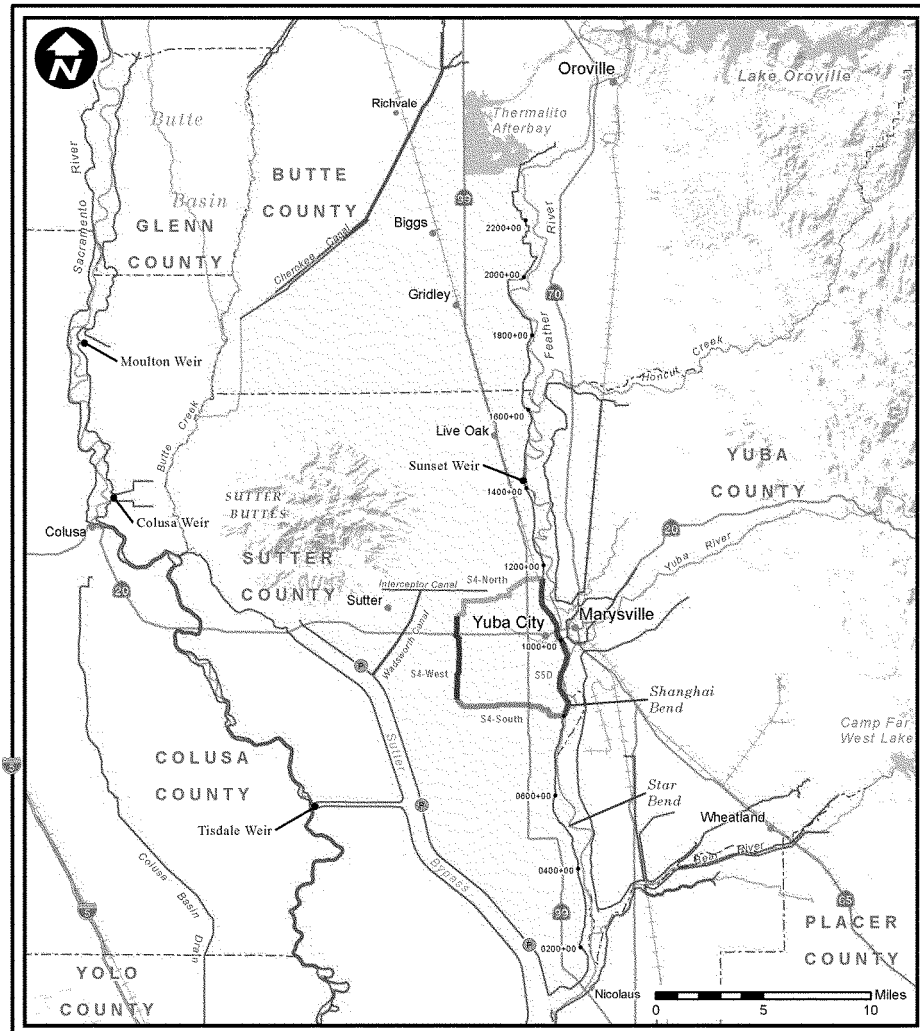
ALTERNATIVE SB-2:
MINMAL FIX-IN-PLACE
FEATHER RIVER LEVEES:
SUNSET WEIR TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-2



Legend

Study Area Extent	Lake or Reservoir
Project Reach	River or Stream
Federal Levee	Highway
Stationing Point	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

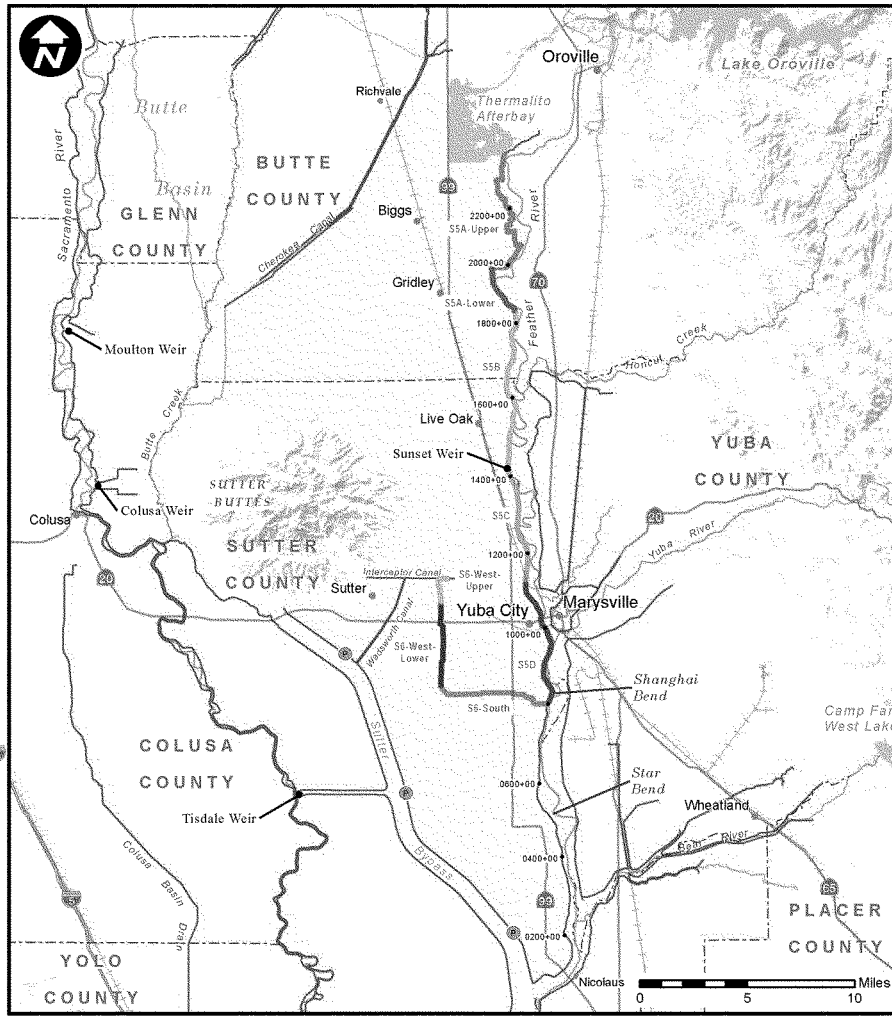
ALTERNATIVE SB-3: YUBA CITY RING LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-3



Legend

Study Area Extent	Lake or Reservoir
S5B Project Reach	River or Stream
Federal Levee	Highway
Stationing Point	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-4:
LITTLE J LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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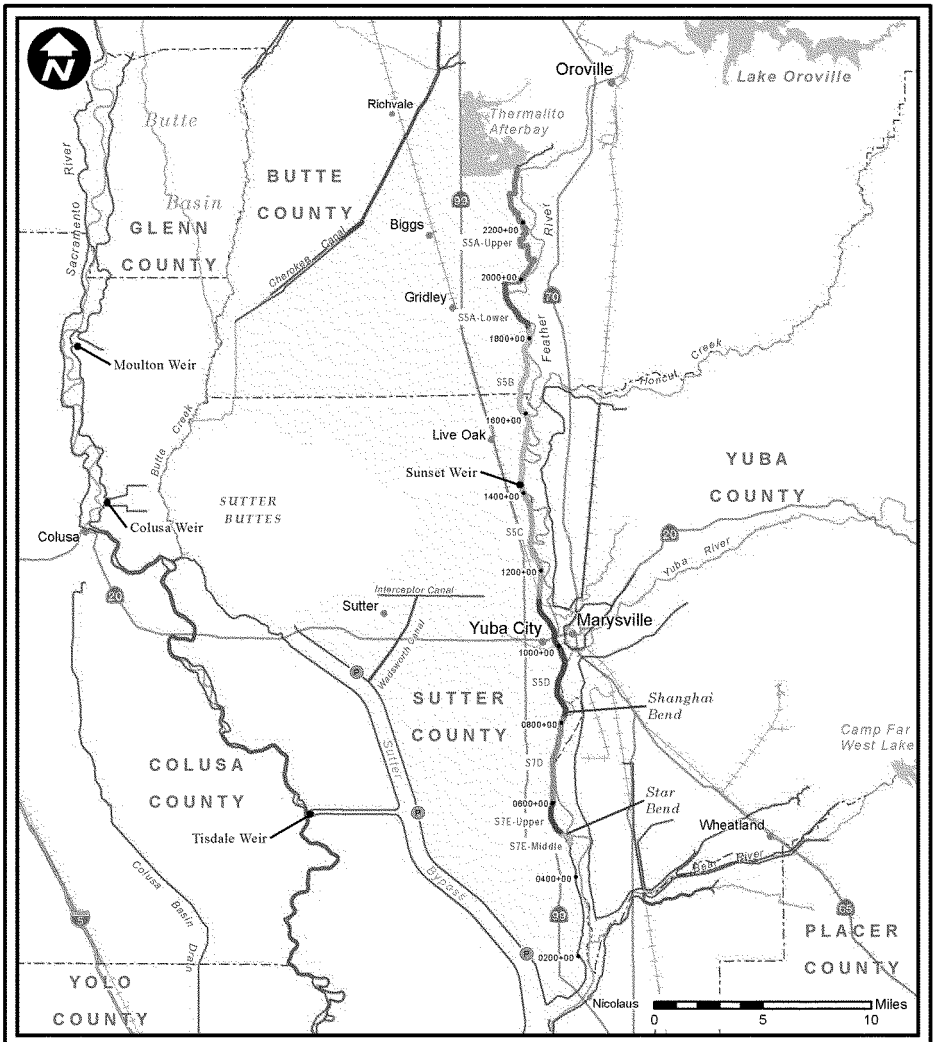
PLATE 1-4



Legend

- Study Area Extent
- S5B Project Reach
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-5:
FIX-IN-PLACE
FEATHER RIVER LEVEES:
THERMAILTO TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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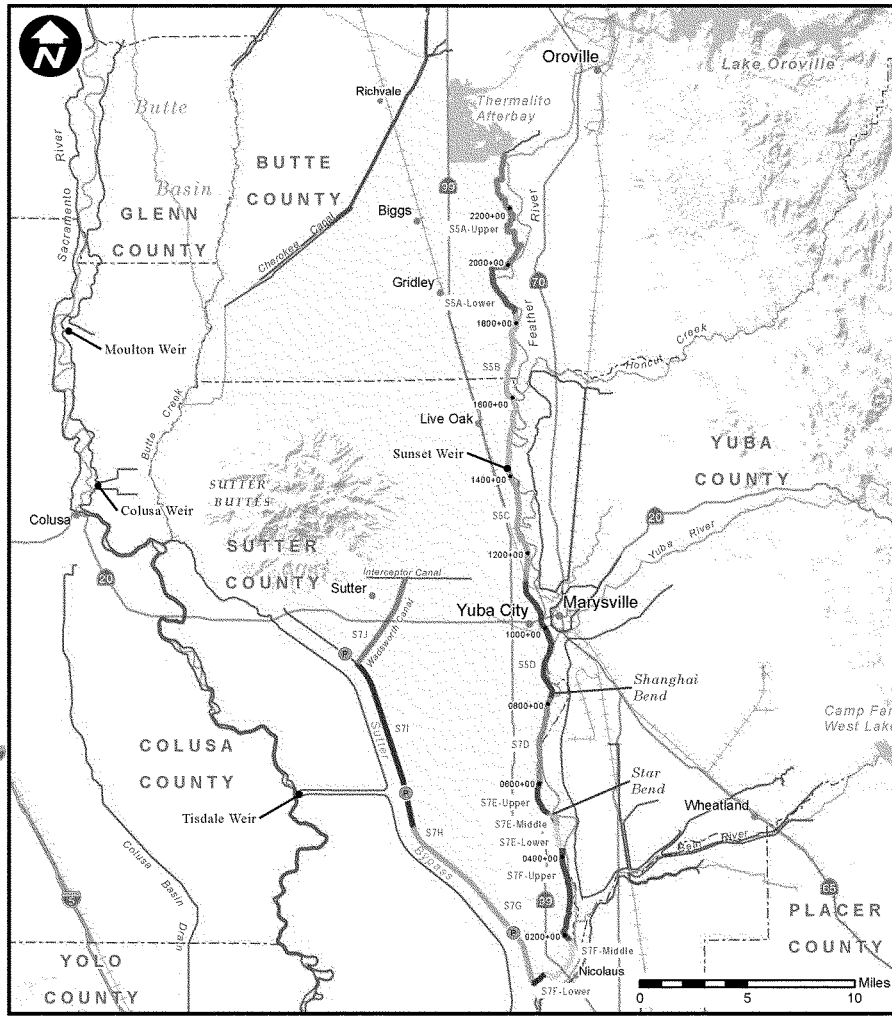
PLATE 1-5



SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-6:
FIX-IN-PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH CANAL LEVEES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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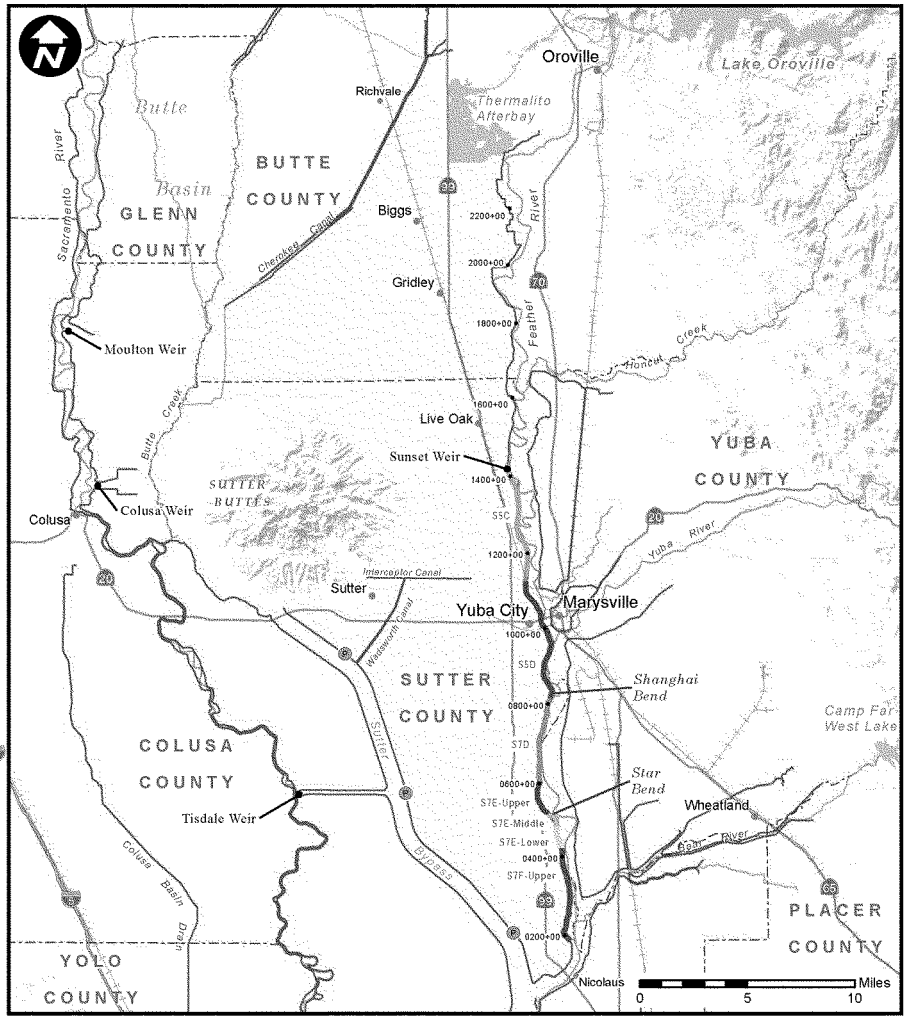
APR 2013

PLATE 1-6



Legend

- Study Area Extent
- Project Reach
- Federal Levee
- Stationing Point
- Pump Station
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

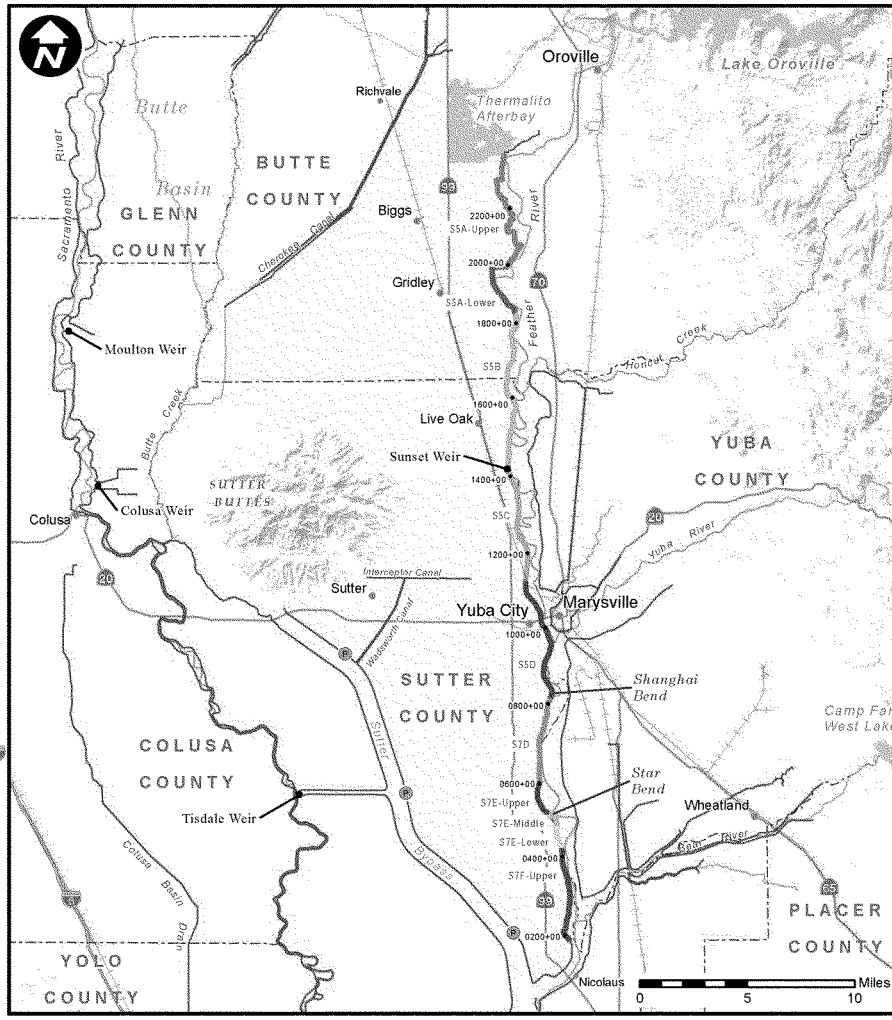
ALTERNATIVE SB-7:
FIX-IN-PLACE
FEATHER RIVER LEVEES:
SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-7



Legend

Study Area Extent	Lake or Reservoir
S5B Project Reach	River or Stream
Federal Levee	Highway
Stationing Point	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-8:
FIX-IN-PLACE
FEATHER RIVER LEVEES:
THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 1-8

US Army Corps
of Engineers®

Sacramento District

Engineering Division

Sutter Basin Pilot Feasibility Report - Environmental Impact Report / Supplemental Environmental Impacts Statement

Butte and Sutter Counties, California

GEOTECHNICAL APPENDIX

September 2013

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1 INTRODUCTION

This report presents the results of the geotechnical engineering evaluation of the levees associated with the Sutter Basin Feasibility Study (SBFS). The purpose of this report is to document the geotechnical existing condition of the levees within the study area and to provide geotechnical information in support of the final array of alternatives in the Feasibility Study.

The SBFS is a Pilot Study for the Corps of Engineers to further develop Planning concepts, methodologies, and processes. This report relies heavily on the massive volume of data gathered by the California Department of Water Resources (DWR) Urban Levee Evaluation (ULE) study described in Section 1.3.2, and (for the Feather River levees) supplemented by the Sutter-Butte Flood Control Agencies (SBFCA) Feather River West Levee (FRWL) Improvement Project described in Section 1.3.3. The reports prepared for the ULE and FRWL Improvement Project are included as Enclosure M of this report, but are provided as separate files for ease of use by reviewers.

1.1 Project Description

The Sutter Basin system consists of a mainline levee system (hereafter referred to as the Sutter Basin Levee System or SBLS) surrounding the communities of Yuba City, Live Oak, Gridley, Biggs and other smaller towns in Sutter and Butte Counties, California. There are several Local Maintenance Authority (LMA) entities: Levee District (LD) 1 of Sutter County, LD 9 of Sutter County, and California Department of Water Resources (DWR) Maintenance Areas (MA) (3, 7, 13, 16, Wadsworth Canal, and Sutter Bypass). These entities maintain all levees within the study area. Other than the high ground at the Sutter Buttes and where the upstream end of the Feather River ties into the southern dike of the Thermalito Afterbay Dam, these levees completely surround and protect the interior area. Plate 1 shows the SBLS and the nearby surrounding area. The levee segments in the study area are shown on Plate 1 and are listed below:

- **Wadsworth Canal Left Levee:** Left levee (on the south bank) of the Wadsworth Canal from Project Levee Mile (PLM) 0.00 at the confluence with the Sutter Bypass upstream to PLM 4.66 at the East Interceptor Canal

- **Sutter Bypass:** Left levee (on the east bank) of the Sutter Bypass from the confluence with the Wadsworth Canal at PLM 4.40 downstream to PLM 22.11 at the confluence with the Feather River

- **Feather River – MA 3:** Right levee (on the west bank) of the Feather River from PLM 0.00 at the Sutter Bypass confluence upstream to PLM 5.19 at the downstream boundary of the LD 1 segment

- **Feather River – LD 1:** Right levee (on the west bank) of the Feather River from PLM 0.00 at the boundary of MA 3 upstream to PLM 16.65 at the downstream boundary of the LD 9 segment

- **Feather River – LD 9:** Right levee (on the west bank) of the Feather River from PLM 0.00 at the LD 1 boundary upstream to PLM 6.24 at the downstream boundary of the MA16 segment

- **Feather River – MA 16:** Right levee (on the west bank) of the Feather River from PLM 0.00 at the LD 9 boundary upstream to PLM 4.09 at the downstream boundary of the MA 7 segment

- **Feather River – MA 7**: Right levee (on the west bank) of the Feather River from PLM 0.00 at the MA 16 boundary upstream to PLM 12.07 at the downstream boundary of the Hamilton Bend segment

- **Feather River – Hamilton Bend Area**: Right levee (on the west bank) of the Feather River from PLM 0.00 at the MA 7 boundary upstream to PLM 1.20 at the Thermalito Afterbay outlet channel.

- **Cherokee Canal – MA 13:** Left levee (on the south bank) of the Cherokee Canal from PLM 9.90 at the Southern Pacific Railroad bridge upstream to PLM 6.10 at the Western Canal crossing (this partial segment is not part of the ULE program)

At the request of the local sponsor, a second levee system was added to the project. The area within this levee system is referred to as "the Sutter triangle" because the protected area is roughly triangular-shaped between two levee segments and the high ground of the Sutter Buttes and it includes the small town of Sutter. This system is also shown on Plate 1. This levee system is not part of the ULE program. The levee segments of this system are:

- **Wadsworth Canal Right Levee:** Right levee (on the north bank) of the Wadsworth Canal from PLM 0.00 at the Sutter Bypass confluence upstream to PLM 4.66 at the West Interceptor Canal

- **Sutter BypassUpstream of Wadsworth Canal:** Left levee (on the east bank) of the Sutter Bypass from the high ground at the Sutter Buttes at PLM 0.00 downstream to the confluence of the Wadsworth Canal at PLM 4.31

Photos of the levee segments covered under the ULE program are in Enclosure A of this Geotechnical Appendix.

1.2 General Levee Descriptions

This section provides a general description of the geometry, soil conditions, performance history, and modifications/improvements of each levee segment. This section is a summary of the more detailed descriptions found in chapter 2 of the ULE Phase 1 Preliminary Geotechnical Evaluation Report (P1GER) for levee segments covered under the ULE program, Appendix C of the DWR Non-Urban Levee (NULE) Geotechnical Assessment Report (GAR) for the Cherokee Canal, and Appendix E of the NULE GAR report for the Sutter triangle levees. Explorations conducted for the ULE program are presented in detail in the ULE Phase 1 Geotechnical Data Report (P1GDR) and Supplemental Geotechnical Data Report (SGDR). Explorations conducted for the Feather River West Levee (FRWL) Improvement project are presented in detail in the Geotechnical Data Report (GDR). Tables summarizing the performance history and modifications/improvements of the SBLS from Periodic Inspection Report No. 1 (2010) are in Enclosure B of this Geotechnical Appendix.

1.2.1 Wadsworth Canal Left Levee

1.2.1.1 General Description

The Wadsworth Canal and its associated levees were constructed by the State of California in 1924. The levees were constructed primarily with soil excavated from the canal. The canal was deepened and the levees were enlarged by the Corps of Engineers in 1942. The left levee of the Wadsworth Canal extends from PLM 0.00 at the confluence with the Sutter Bypass to the northeast (upstream) to PLM 4.66 at the East Interceptor Canal. The levee crest elevation varies between 60 feet NAVD at the downstream end to 65 feet NAVD at the upstream end. The levee height varies between 6 feet at the upstream end and 26 feet at the downstream end. The crest width varies between 12 feet at the upstream end and 27 feet at the downstream end. The waterside slope varies between 3H:1V and 3.5H:1V. The landside slope varies between 2H:1V and 2.5H:1V. There is a relatively flat bench 10 to 35 feet wide between the waterside levee toe and the excavated canal sideslopes. There are a few houses and outbuildings near the landside levee toe over the downstream half-mile of the levee segment.

1.2.1.2 Soil Conditions

The levee soils consist of interbedded lean clay, fat clay, sand, and silty sand. Sand and silty sand are the dominant soils over the downstream 1.4 miles of the levee segment. Clay soils dominate in the upstream 3.3 miles of the levee. The levee is founded on Basin deposits, generally 4 to 9 feet thick, consisting mostly of lean and fat clay with occasional lenses of silt and sand. The Modesto Formation underlies the Basin deposits. The upper contact of the Modesto Formation is characterized by very stiff to hard clays, called "hardpan" locally. Below the hardpan, the Modesto Formation consists of silt, lean clay, and fat clay, with 1 to 9 foot thick layers of sand and silty sand.

1.2.1.3 Performance History and Levee Improvements

Excessive through-levee seepage, underseepage, and boils occurred between PLM 0.00 and 1.25 during the 1986 and 1997 flood events. The Corps constructed a soil-cement-bentonite cutoff wall between PLM 0.00 and 0.57 in 2008. The depth of the cutoff wall varied between 42 and 63 feet.

1.2.2 Sutter Bypass Left Levee (downstream of Wadsworth Canal)

1.2.2.1 General Description

The Sutter Bypass was constructed in 1924 by the State of California to convey flood water diverted from the Sacramento River. This levee was constructed primarily with soil excavated from the bypass channel. This segment was raised and enlarged by the Corps in 1941-1942. The levee extends from the confluence with the Wadsworth Canal left bank levee at PLM 4.4 to the south (downstream) along the left bank of the Sutter Bypass to the confluence with the Feather River right bank levee at PLM 22.12. The levee crest elevation varies from 52 feet NAVD at the downstream end to 60 feet NAVD at the upstream end. The levee height varies between 14 and 22 feet with an average height of 19 feet. The crest width varies between 17 and 30 feet. The waterside slope varies between 3H:1V and 4H:1V and the landside slope varies between 2.7H:1V and 4H:1V. There is a 1-foot high, 50-foot wide berm at the landside levee toe, with a drainage ditch located at the toe of the berm over most of this segment. There are a few houses and outbuildings located near the landside levee toe. There is a small bench with an access road between the waterside levee toe and the sideslope of the excavated channel.

1.2.2.2 Soil Conditions

The levee soils consist mostly of lean and fat clays with occasional lenses of silt, sand, and silty sand up to 4 feet thick. Subsurface soil conditions are variable over the Bypass alignment, due to the geomorphology of the levee alignment cutting across numerous historic small drainage channels at approximately 90 degree angles. The foundation consists of a clay blanket 10-60 feet thick, with the layer thickness generally lower towards the downstream end of the segment. A portion of the clay blanket is cemented at some locations, locally called "hardpan". There are pockets of sand and silty sand within the clay blanket, varying between 4 and 20 feet thick. The top of some of these pockets is 6 feet below the top of the impervious blanket layer. A widespread sand, silty sand, and gravel layer is underneath the clay blanket.

1.2.2.3 Performance History and Levee Improvements

The landside toe area of this levee segment was under water during the 1955 flood due to the break in the Feather River levee near Shanghai Bend. Performance history and levee improvements during subsequent floods are detailed below.

- During the 1958 flood numerous types of levee distress were observed between PLM 5.4 and 13 (McClatchy Road to Gilsizer Slough). Ground heaving with mud flowing from the center of the mounds, accompanied by longitudinal cracking and movement towards the drainage ditch was observed along the landside toe berm and sand boils were observed in the drainage ditch. Longitudinal cracking along the landside levee slope about 4 feet below the crest was observed at the downstream portion of this reach. During the flood, sandbag rings were constructed at the five worst locations. After the flood, the Corps of Engineers constructed a 2-foot wide, 15-foot deep toe drain trench.
- During the 1986 flood, wavewash and county maintenance equipment induced erosion at the waterside toe and halfway up the waterside slope between PLM 20 and 22.37. This erosion was repaired by the Corps of Engineers under a PL84-99 action.
- During the 1986 flood, seepage and boils in the landside drainage ditch occurred between PLM 12.7 and 14.6 (Gilsizer Slough to Everglade Road). The Corps of Engineers constructed a pervious toe drain and overlying stability berm at this site under Sacramento River Flood Control Project Phase II Levee Reconstruction, Site 12.
- Heavy seepage and soil heaving was observed between PLM 4.4 and 5.4 (Wadsworth Canal to McClatchy Road) during the 1997 flood. After the flood the Corps of Engineers constructed a toe drain trench and berm at this location under a PL84-99 rehabilitation action.
- Seepage occurred at PLM 17.6 during the 1997 flood. The Corps of Engineers constructed a 2-foot wide, 5-foot deep pervious toe trench with an overlying stability berm at this site in 2001 under a PL 84-99 rehabilitation action.
- During the 1997 flood seepage, boils, and a sinkhole were observed in a "berm" (an abandoned railroad embankment) on the landside of the levee between PLM 21.88 and 22.07 (Feather River confluence to 1,000 feet upstream). The Corps of Engineers constructed a pervious vertical drain in the berm in 2001 under a PL84-99 rehabilitation action.

1.2.3 Feather River – MA 3

1.2.3.1 General Description

The Feather River is a meandering river that flows from the Sierra Nevada Mountains down to the confluence with the Sacramento River. The MA 3 levee segment goes along the right bank of the Feather River from PLM 0.00 at the Sutter Bypass left bank levee to the north (upstream) to PLM 5.19. This levee segment was originally constructed by local residents, date unknown. The Corps enlarged the portion of the segment downstream of the Highway 99 bridge in 1942. The Corps of Engineers also relocated a landside drainage ditch 20 to 50 feet away from the toe over the upstream (northern) half of the segment in 1962. The ditch is 5 feet wide at the bottom and 6 feet deep, with 1.5H:2V sideslopes. The levee crest elevation varies between 52 feet NAVD at the downstream end to 66 feet about half a mile downstream of the upstream end of the segment. The levee height varies between 18 and 26 feet, with an average height of 22 feet. The crest width varies between 20 and 30 feet. The waterside slope varies between 1.6H:1V and

2.5H:1V. The landside slope varies between 1.5H:1V and 3H:1V. There are a few outbuildings near the landside levee toe. The waterside bench between the levee toe and the riverbank varies between 300 and 3,700 feet wide. There are waterside borrow pits near the levee toe at some locations.

1.2.3.2 Soil Conditions

The levee soils consist mostly of alternating layers of silty sand and silt, with lesser amounts of lean clay and sandy clay. The foundation consists of a sandy clay/clay/sandy silt blanket 1 to 50 feet thick. In general, the blanket layer thickness decreases moving upstream along the segment. There is no hardpan within the blanket layer. The underlying pervious layer consists of sand, silty sand, and gravel.

1.2.3.3 Performance History and Levee Improvements

The performance history and levee improvements on this segment are listed below.

- A breach was reported between approximate PLM 3.64 and 3.70, date unknown (pre-1955).
- The levee was deliberately cut and reconstructed between PLM 0.72 and 0.82 to drain floodwater from the levee breach near Shanghai Bend after the 1955 flood.
- After the 1986 flood, a "sinkhole" was discovered at the waterside levee toe at PLM 1.2. The sinkhole was 30 feet long, 10 feet wide, and 10 feet deep. No distress was observed on the landside during the flood at this location. The sinkhole was filled with gravel.
- Heavy seepage, mostly running clear, was observed over much of the segment during the 1986 and 1997 floods. Boils were observed in a few isolated locations, primarily in the bottom of the drainage ditch along the upstream half of the segment. After the 1997 flood, pervious toe drains with overlying stability berms were constructed by the Corps of Engineers between PLM 2.28 and 2.43 (Sacramento River Flood Control Project Phase II Levee Reconstruction, Site 11) and between PLM 3.46 and 3.83(PL84-99 rehabilitation).
- During the 1997 flood heavy seepage into the drainage ditch caused sloughing of soil into the ditch between PLM 3.76 and 4.45. During the flood, the ditch was filled with sandbags placed on plastic sheeting. After the flood the ditch was converted to a pervious toe drain.
- Erosion of the waterside levee slope occurred at two locations during the 1997 flood and one location during the 2006 flood. These locations were repaired after the floods.

1.2.4 Feather River – LD 1

1.2.4.1 General Description

The LD 1 segment of the Feather River goes along the right bank of the Feather River from PLM 0.00 at the upstream end of the MA 3 segment to the north (upstream) to PLM16.65 at the

downstream end of the LD 9 segment. The city of Yuba City is adjacent to the upstream 6 miles of this segment. This levee segment was originally constructed by local residents, date unknown. The Corps raised and enlarged the segment in the late 1930's. The crest elevation varies between 62 feet NAVD at the downstream end and 88 feet NAVD about 200 feet downstream of the upstream end of the segment. The levee height varies between 19 and 25 feet, with an average height of 22 feet. The crest width varies between 15 and 22 feet. The waterside slope varies between 2H:1V and 3.5H:1V. The landside slope varies between 1.8H:1V and 3.1H:1V. There are waterside borrow pits near the levee in some locations. Within Yuba City buildings, swimming pools, and retaining walls have been built at and near the landside levee toe and, in some cases, cutting into the landside levee slope. The waterside bench between the levee toe and the riverbank varies from about 30 to 4,500 feet wide.

1.2.4.2 Soil Conditions

The levee soils consist of sandy silt, sandy clay, and clay with occasional zones of silty sand downstream of Star Bend (PLM 0.00 to 5.7) and sand, silty sand, and clayey sand with some zones of sandy silt and sandy clay upstream of Star Bend. The foundation soils are highly variable and consist of a clay, sandy clay and sandy silt blanket between 2 and 62 feet in thickness. Occasional, discontinuous zones of the blanket are cemented into hardpan. The blanket layer overlies a sand and gravel pervious layer that is up to 45 feet thick.

1.2.4.3 Performance History and Levee Improvements

The performance history and levee improvements within this segment are listed below.

- The levee breached just upstream of Shanghai Bend in the southern part of Yuba City (approximate PLM 11.0 to 12.4) in 1909, 1911, and 1955. The 1955 breach resulted in 38 fatalities. The Corps reconstructed the levee to the landside of its original alignment and installed relief wells in 1955-1957. Boils in this area required sandbagging during the 1986 flood. The City of Yuba City installed additional relief wells between the old relief wells in the southern portion of the relief well area in 1991 to reduce seepage into a new housing development. Floodfighting was required for boils in the northern portion of the relief well area during the 1997 flood. The Corps of Engineers installed new relief wells between the original relief wells in the northern portion of the relief well area in 2000.
- Seepage and boils occurred at Shanghai Bend during the 1986 and 1997 floods. The levee alignment had a horseshoe bend at this location. The Corps of Engineers constructed a setback levee with a 25-foot deep cutoff wall through the foundation after the 1997 flood under a PL84-99 action. The setback levee cut off the horseshoe bend.
- During the 1986 flood the landside levee slope became saturated and bulged within downtown Yuba City (approximate PLM 14.00 to 15.5) , and water flowed through cracks in pavement and floor slabs near the levee toe. Yuba City constructed an emergency berm during the flood. A permanent stability berm was constructed after the flood by LD 1. After the 1997 flood the Corps constructed a cutoff wall 40 to 55 feet

deep between PLM 12.76 and 14.54. The southern portion of the wall was constructed under the Marysville/Yuba City Levee Reconstruction Project. The northern portion of the wall was constructed under a PL84-99 rehabilitation action.

- Waterside levee erosion occurred near the Fifth Street Bridge in Yuba City during the 1986 and 1997 floods (PLM 14.27 to 14.57). The erosion was repaired with riprap.
- Floodfighting was required for seepage and boils just north of Star Bend during the 1986 and 1997 floods (PLM 4.56 to 5.42). The Corps of Engineers installed relief wells after the 1997 flood. Light seepage was noted between the upstream 3 relief wells during the 2006 flood.
- LD 1 constructed a setback levee with a 40 to 65-foot deep soil-bentonite cutoff wall through the foundation in 2008 at Star Bend (PLM 3.76 to 4.58). The setback cut off a 90-degree bend in the levee alignment.
- During the 1997 flood the waterside levee slope became unstable between PLM 5.55 to 5.66. The instability was believed to be due to a rapid drawdown situation after the levee on the opposite bank of the Feather River breached. The Corps repaired the slope after the flood under a PL 84-99 rehabilitation action.
- At PLM 1.5, a crack in the levee occurred during the 1986 flood and boils occurred during the 1997 flood. The Corps constructed a stability berm after the 1997 flood under a PL84-99 rehabilitation action after the 1997 flood.

1.2.5 Feather River – LD 9

1.2.5.1 General Description

The LD 9 segment goes along the right bank of the Feather River from PLM 0.00 at the upstream end of the LD 1 segment to the north (upstream) to PLM 6.24 at the downstream end of the MA 16 segment. An active railroad embankment crosses the levee alignment at the LD1/LD 9 boundary. The railroad embankment is about 4 feet lower than the levee; this opening is sandbagged during flood events. This levee segment was originally constructed by local residents, date unknown. Portions of this segment were raised and enlarged by the Corps in 1933 and 1944. The levee crest elevation varies between 83 feet NAVD at the downstream end and 91 feet NAVD near the upstream end of the segment. The levee height varies between 11 and 21 feet, with an average height of 19 feet. The crest width varies between 16 and 25 feet. The waterside slope varies between 1.9H:1V and 3H:1V. The landside slope varies between 1.4H:1V and 2.6H:1V. An irrigation canal (Sutter Butte Canal) is adjacent to the landside levee toe over a portion of this segment. The Sutter Butte Canal is about 30 feet wide at the bottom and varies between 5 and 8 feet deep. Smaller, localized drainage ditches are at the landside levee toe in some areas where the Sutter Butte Canal is not adjacent to the toe. There are also a few houses and outbuildings near the landside levee toe. Width of the waterside bench between the levee toe and the riverbank varies between 5 and 3,800 feet.

1.2.5.2 Soil Conditions

The levee soils consist of silt, sandy silt, sandy lean clay with occasional silty sand. The clay soils predominate at the downstream end of the segment and the silty and sandy soils predominate towards the upstream end of the segment. The foundation soils consist of a sandy clay/sandy silt blanket of variable thickness (average thickness 12 feet), sometimes cemented into a hardpan, overlying a sand/silty sand pervious layer. The pervious layer has some gravel lenses in the downstream half of the segment.

1.2.5.3 Performance History and Levee Improvements

The performance history and levee improvements on this segment are listed below.

- Boils were observed at PLM 2.12 and 3.60 during the 1955 flood. The landside levee slope at those locations was rebuilt with a gravel filter.
- Boils were observed between PLM 4.63 and 4.91 in 1957.
- Several waterside "sinkholes" appeared near the levee toe between PLM 0.1 and 0.46 in 1966. The sinkholes were attributed to improper removal of tree stumps and they were filled in.
- A "sinkhole" was observed at PLM 0.81 in 1986; documentation does not show the location (waterside or landside).
- Seepage and boils were observed in an irrigation ditch at PLMs 3.75 and 5.13 during the 1986 flood.
- Trench drains were placed at the landside levee toe between PLM 3.0 and 3.83 and between PLM 4.33 and 4.9 by LD 9 in 1992. The trenches were 4-5 feet deep and 2 feet wide and consisted of a geotextile lining around drain rock, with a perforated PVC pipe near the bottom of the trench.
- Seepage and boils were observed at several locations during the 1997 flood. At most of these locations, LD 9 personnel report that seepage quantities were "significantly higher" than during previous flood events. These locations included PLM 0.0 and 1.3; PLM 2.80 and 3.07; and PLM 4.50 and 5.30. There is no evidence of post-flood repairs at those locations. Boils also occurred between PLM 2.43 and 2.59; the Corps of Engineers constructed a toe drain with a concrete V-ditch collector at this location in 1998.
- Heavy seepage into the Sutter Butte Canal caused landside levee toe sloughing into the canal and a longitudinal crack in the levee slope between PLM 5.44 and 5.65 during the 1997 flood. The canal was filled with gravel during the flood. The canal was relocated into a pipeline away from the levee toe after the flood.

1.2.6 Feather River – MA 16

1.2.6.1 General Description

The MA 16 segment goes along the right bank of the Feather River from PLM 0.00 at the upstream end of the LD 9 segment to the north (upstream) to PLM 4.09 at the downstream end of the MA 7 segment. This levee was originally constructed by local residents, date unknown. Portions of this segment were raised by the Corps in 1933 and 1944. The levee crest elevation

varies between 91 feet NAVD at the downstream end to 96 feet NAVD at the upstream end. The levee height varies between 7 and 14 feet, with an average height of 10 feet. The crest width varies between 15 and 25 feet. The waterside slope varies between 1.9H:1V and 3.2H:1V. The landside slope varies between 1.3H:1V and 3H:1V. The Sutter Butte Canal is adjacent to the landside levee toe over a portion of this segment. The Canal is about 30 feet wide at the bottom and the depth varies between 5 and 8 feet. There are a few houses and outbuildings near the landside levee toe. The waterside bench between the levee toe and the riverbank varies between 30 and 3,100 feet wide.

1.2.6.2 Soil Conditions

The levee soils consist mostly of sandy silt, with some zones of sandy clay. The foundation consists of a clay/sandy silt blanket, at some locations cemented into hardpan, between 0 and 50 feet thick (average thickness about 20 feet) overlying a pervious sand layer. The pervious layer contains gravel in the upstream half of the segment.

1.2.6.3 Performance History and Levee Improvements

There is no documented history of performance problems and subsequent levee modifications to this segment.

1.2.7 Feather River – MA 7

1.2.7.1 General Description

The MA 7 segment goes along the right bank of the Feather River from PLM 0.00 at the upstream end of the MA 16 segment to the north (upstream) to PLM 12.07 at the downstream end of the Hamilton Bend segment. This levee was originally constructed by local residents, date unknown. The Corps reconstructed this levee in 1954. The levee crest elevation varies between 96 feet NAVD at the downstream end and 135 feet NAVD at the upstream end. The levee height varies between 5 and 22 feet, with an average height of 15 feet. The crest width varies between 15 and 25 feet. The waterside slope varies between 1.9H:1V and 3.2H:1V. The landside slope varies between 1.3H:1V and 3H:1V. The Sutter Butte Canal is adjacent to the landside levee toe over a portion of this segment. The Canal has a bottom width of about 30 feet and is between 5 and 8 feet deep. There are a few houses and outbuildings near the landside levee toe. The waterside bench between the levee toe and the riverbank varies between 5 and 4,800 feet wide. Dredge tailings, consisting primarily of cobbles and gravel, have been placed on the waterside bench over the upstream 4 miles of the segment.

1.2.7.2 Soil Conditions

The levee soils consist mostly of sandy silt, with some zones of sandy clay and occasional lenses of sand. The foundation consists of a blanket of clay/sandy in the southern portion of the

segment and silt/silty sand in the northern portion of the segment. Thickness of the blanket varies between 0 and greater than 80 feet; the average thickness is about 15 feet, and in general the thickness decreases moving upstream along the segment. The pervious layer consists of sand and gravel. The pervious layer is almost entirely gravel upstream of PLM 3.2.

1.2.7.3 Performance History and Levee Improvements

The performance history and levee improvements/modifications to this segment are listed below.

- During the 1955 flood, waterside slope erosion caused the west span of the Gridley bridge across the Feather River to collapse, although the levee did not breach due to floodfighting efforts. The levee and the bridge were rebuilt by local residents after the flood. The bridge was replaced by a new bridge about 450 feet downstream of the old bridge in the mid-1960's.
- Boils were observed between PLM 0.1 and 0.9 during the 1955 flood event.
- During the 1986 flood, seepage and boils were observed between PLM 2.68 and 2.82. The Corps constructed a 50-foot deep cutoff wall at this location (plans not found).
- Seepage and boils were also observed between PLM 9.7 and 9.8 during the 1986 flood.
- The Corps raised the levee about 2 feet and reworked the landside slope between PLM 9.9 and 10.4 in 1998 under the Sacramento River Flood Protection Project Phase II System Evaluation.
- During the summer dry season, when the Feather River is low and the Sutter Butte Canal is full, seepage flows from the canal and exits on the waterside of the levee between PLM 0.0 and 1.0.

1.2.8 Feather River – Hamilton Bend

1.2.8.1 General Description

The Hamilton Bend segment goes along the right bank of the Feather River from PLM 0.00 at the upstream end of the MA 7 segment to the north (upstream) to PLM 1.20 at the Thermalito Afterbay outlet channel. This levee was originally constructed by the Corps of Engineers in 1947. The Corps raised the levee in the mid-1950's and widened the downstream mile of the levee in 1963. The Sutter Butte Canal crosses the levee alignment at PLM 1.05-1.06. A concrete headgate structure was built across the canal alignment. The headgate structure is 36 feet tall, 50 feet long, and 13.5 feet wide. The headgate structure was abandoned after construction of the upstream Oroville Dam in 1968. The levee crest elevation varies between 134 feet NAVD at the downstream end and 139 feet NAVD at the upstream end. The levee height varies between 3 and 24 feet, with an average height of 14 feet. The crest width is 15-20 feet upstream of the headgate structure and 60-70 feet downstream of the headgate structure. The waterside slope varies between 2H:1V and 2.5H:1V. The landside slope varies between 1.5H:1V and 3H:1V. There is one small outbuilding near the landside levee toe. The waterside bench between the levee toe and the riverbank varies between 50 and 1,100 feet wide. The downstream 0.8 miles of the segment was built through dredge tailings piles. The dredge tailings

consist of silty sand, gravel, and cobbles and are higher than the levee crest elevation at some locations.

1.2.8.2 Soil Conditions

The levee is constructed of clay upstream of the headgate structure and silty sand, gravel, and cobbles (dredge tailings) downstream of the headgate structure. There is a thin clay blanket underlying less than half of this levee segment. The pervious layer consists of silty sand, gravel, and cobbles (dredge tailings) about 80 feet thick.

1.2.8.3 Performance History and Levee Improvements

This segment experienced seepage and boils downstream of the headgate structure during the 1955 flood, which was floodfought by local residents. This portion of the levee was widened by the Corps of Engineers in 1963. The Sutter Butte Canal Headgate Structure was also floodfought for overtopping during the 1955 flood; the crest elevation of the structure is lower than the crest elevation of the adjacent levee, and water was reportedly 16 inches below the crest of the structure.

1.2.9 Cherokee Canal (MA 13)

1.2.9.1 General Description

The Cherokee Canal and its associated levees were constructed by the Corps of Engineers in the late 1950's. The Cherokee Canal is located in the northwest portion of the project area. The Canal discharges water into the Butte Sink, a low-lying area between the Sacramento River and the Sutter Buttes. The entire canal is 23.1 miles long; this Feasibility Study only includes the left bank levee from PLM 9.90 at the Southern Pacific Railroad bridge to the northeast (upstream) to PLM 6.10 at the Western Canal confluence. This portion of the levee would flood the town of Biggs if it breached or overtopped. The levee height is 6-10 feet and the crest width is 10-20 feet. The waterside slope varies between 3H:1V and 3.5H:1V and the landside slope varies between 2.5H:1V and 3H:1V. An irrigation ditch is present at the landside toe.

1.2.9.2 Soil Conditions

The levee is constructed of lean and fat clay, silt, and elastic silt. The foundation soils consist of a silt and sandy silt blanket between 3 and 19 feet thick, overlying a pervious layer of silty sand, clayey sand, and clean sand. Where the pervious layer consists of clean sand, it generally contains silt lenses that are 2-4 feet thick.

1.2.9.3 Performance History and Levee Improvements

This section of levee overtopped during the 1986 flood due to debris buildup at the railroad bridge. There is no documentation of any other performance problems during floods or improvements/modifications to this portion of the segment.

1.2.10 Wadsworth Canal Right Levee

1.2.10.1 General Description

This levee segment extends from PLM 0.00 at the confluence with the right bank levee of the Sutter Bypass to the northeast (upstream) along the right bank of the Wadsworth Canal to PLM 4.66 at the West Interceptor Canal. The levee height varies between 20 feet at the downstream end to 5 feet at the upstream end. The crest width is 10-20 feet. The waterside slope varies between 3H:1V and 3.5H:1V. The landside slope varies between 2H:1V and 2.5H:1V. A small drainage canal is located at the landside levee toe over most of this segment. The DWR Sutter Maintenance Yard is located at the landside of the levee immediately south of Highway 20.

1.2.10.2 Soil Conditions

There are no known explorations in this levee segment. Since the canal is fairly small (about 300 feet from levee crest centerline to levee crest centerline), it is anticipated that soil conditions would be similar to the left bank levee of the Wadsworth Canal, discussed in section 1.2.1.2 of this report.

1.2.10.3 Performance History and Levee Improvements

This segment has experienced seepage and boils between PLM 0.00 and 2.4 during floods, and waterside bank erosion encroaching into the levee toe has been reported at PLM 3.2. No modifications or improvements have been constructed on this segment.

1.2.11 Sutter Bypass Upstream of Wadsworth Canal

1.2.11.1 General Description

This levee segment extends along the right bank of the Sutter Bypass from PLM 0.00 at high ground at the Sutter Buttes to the southeast (downstream) to the confluence of the right bank levee of the Wadsworth Canal at PLM 4.31. The levee height varies between 15 feet at the upstream end and 23 feet at the downstream end. The crest width is 20 feet. The waterside slope varies between 3.5H:1V and 4H:1V and the landside slope varies between 2.5H:1V to 3H:1V. A project pump plant at PLM 2.7 pumps interior drainage water over the levee into the Bypass. There are some outbuildings near the landside toe of the levee. There is also a drainage canal on the landside of the levee. The canal is located 15 to 50 feet from the landside toe and is about 5 feet deep and 12 feet wide at the bottom.

1.2.11.2 Soil Conditions

There are no existing explorations on this levee segment.

1.2.11.3 Performance History and Levee Improvements

Moderate seepage, not carrying material, was reported at PLM 2.68 during the 1997 flood; no remedial action was undertaken. Also during the 1997 flood, heavy seepage and soil heaving occurred between PLM 3.7 to 4.3. A pervious toe drain and overlying stability berm were constructed by the Corps of Engineers under a PL84-99 rehabilitation action.

1.3 Previous Geotechnical Studies

Over the years, many geotechnical studies have been performed on the Sutter Basin, particularly on the Feather River levee in the vicinity of Yuba City. The major geotechnical engineering studies for the Sutter Basin area in recent years include:

- The original Sutter Basin Feasibility Study without project condition report (i.e. F3 report) completed in 2004.
- The State of California Department of Water Resources (DWR) Urban Levee Evaluation (ULE), ongoing.
- The Sutter-Butte Flood Control Agency (SBFCA) Feather River West Levee (FRWL) Improvement Project, ongoing.
- The State of California DWR Non-Urban Levee Evaluation (NULE), ongoing.

1.3.1 Initial Sutter Basin Report

The initial Sutter Basin report had a different study area, and included all levees within Sutter County, as identified in Sutter County, California Feasibility Study Feasibility Scoping Meeting (F3 Milestone) Report (2004). That study area did not include any complete levee systems; the levees studied stopped at the Sutter County boundaries. That assemblage of segments and partial segments did not fully protect any one area completely, and relied on levees that were not located within Sutter County. The initial study did not include any new explorations and it was done before the DWR ULE program began, so it relied on a limited amount of historical explorations and reports.

1.3.2 DWR Urban Levee Evaluation (ULE)

DWR initiated the ULE study in 2007. The ULE study, which is ongoing, is a major geotechnical evaluation of all the levee systems protecting urban areas within the Central Valley of California. The definition of the Urban Levees for the DWR project is a levee system protecting more than a population of 10,000. The Sutter Basin part of the ULE program includes most of the same levee segments as this project. The levees along the right bank of the

Cherokee Canal, the right bank of the Wadsworth Canal, and the left bank of the Sutter Bypass upstream of Wadsworth Canal were not included in the ULE program because they do not protect a large enough population. The DWR ULE study was partially funded by this project as in-kind services for geotechnical explorations and geotechnical deterministic evaluations.

1.3.3 SBFCA Feather River West Levee (FRWL) Improvement Project

SBFCA is a consortium of Sutter and Butte Counties, the Cities of Yuba City, Live Oak, Gridley, and Biggs, and Levee Districts 1 and 9 of Sutter County. The agency was formed in 2007 to finance and construct regional levee improvements. The FRWL Improvement Project's goal is to improve the 44 miles of the right bank levee of the Feather River from the Thermalito Afterbay outlet to the confluence with the Sutter Bypass under a Section 408 permit. The FRWL Improvement Project design team works closely with the DWR ULE team and much of the geotechnical design of the FRWL Improvement project is based on the geomorphic study and the explorations and laboratory testing done for the ULE project. The FRWL project did additional explorations and laboratory testing to fill in data gaps at specific locations and to have the information necessary for a design project. The additional data, including subsurface investigation and deterministic analyses provided by the study for the FRWL Improvement Project was also used for development of this Feasibility Study geotechnical evaluation. Currently the FRWL Improvement Project is at 90 % design for what has been designated the Contract C area (between Shanghai Bend and Live Oak, LD 1 PLM 11.1 to MA16 PLM 2.87). SBFCA plans to construct that contract in 2013. The areas designated as Contract A1 (Laurel Avenue to Star Bend, MA3 PLM 3.64 to LD 1 PLM 3.76), Contract B (Star Bend to Shanghai Bend, LD1 PLM 4.56 to LD 1 PLM 10.62), and Contract D (Live Oak to Thermalito Afterbay, MA 7 PLM 0.00 to Hamilton Bend PLM 1.20) are at the 65% design level.

1.3.4 DWR Non-Urban Levee Evaluation (NULE)

The NULE study, which is ongoing, is a major geotechnical evaluation of all the levee systems protecting non-urban areas within the Central Valley of California. The levees along the Cherokee Canal, the right bank levee of the Wadsworth Canal, and the left bank levee of the Sutter Bypass upstream of the Wadsworth Canal (between PLM 0.00 and 4.31) are included in the DWR NULE study. The DWR NULE study is just beginning; a Geotechnical Assessment Report (GAR), a collection of existing exploration, geomorphology, and levee performance information was prepared in April 2011, but no new explorations have currently taken place.

1.4 Use of DWR ULE/NULE and SBFCA FRWL Improvement Project Studies

This geotechnical report uses the ULE/NULE and SBFCA FRWL Improvement Project reports as the source for the majority of data upon which this geotechnical evaluation is based. The purpose of this report is not to duplicate the efforts of the ULE/SBFCA project reports, especially due to the massive volume of data gathered by those projects and the restraints of the Feasibility Pilot Study process. This report is an independent evaluation (analysis and conclusions); though in many cases the evaluations of the ULE/SBFCA projects were used to

facilitate this report. The geotechnical explorations, the geomorphic study, and the deterministic analyses developed in the ULE/SBFCA projects were used as the basis for the geotechnical risk-based analysis in this Feasibility Study. The design plans and cost estimate for the SBFCA project were used to prepare the design and cost estimates for the alternatives carried forward in this study.

2 PROJECT DATUM AND STATIONING

The project study used existing topographical data, which was previously developed for the Sacramento/San Joaquin Rivers Comprehensive Study (Comp Study). The Comp Study topography was surveyed using the National Geodetic Vertical Datum of 1929. Comp Study elevations which were not surveyed in NAVD88 were converted to NAVD88 as discussed in section 2.2 of this report.

2.1 Horizontal Control

Index point locations are referenced in relation to the Project Levee Mile (PLM) system as provided in paragraph 1.1 and with northing and easting coordinates. All northing and eastings provided herein are referenced to the NAD83 Horizontal datum. All horizontal coordinates are projected to the California State Plane Zone II coordinate system. PLMs have been established by the Project Sponsor and the LMAs and are shown in the existing Operations and Maintenance (O&M) Manuals. The SBFCA FRWL Improvement Project has set up a stationing system along the FRWL that is used in their plans and design reports. Table 2-1 shows a correlation between PLMs and the SBFCA stationing for each levee segment on the Feather River.

Table 2-1 PLM and SBFCA Stationing

LMA	PLM	SBFCA Station
MA 3	0.00	10+00
	5.11	280+60
LD 1	0.00	280+60
	16.65	1131+00
LD 9	0.00	1131+00
	6.24	1460+40

LMA	PLM	SBFCA Station
MA 16	0.00	1460+40
	4.09	1674+30
MA 7	0.00	1674+30
	12.07	2303+50
Hamilton Bend	0.00	2303+50
	1.20	2367+00

2.2 Topographical Base

As required by ER 1110-2-8160 all elevations provided herein are referenced to the NAVD88 vertical datum at an appropriate level of accuracy. The geotechnical deterministic and risk-based analysis done for this report used topography originally developed by the Sacramento/San Joaquin Rivers Comprehensive Study (Comp Study), with the exception of Cherokee Canal. The Comp Study topography was collected in the NGVD 29 vertical datum. The Comp Study topography was converted to the NAVD 88 vertical datum by HJW GeoSpatial, Inc. (2010) following the requirements in ER 1110-2-8160 and the uncertainty in the conversion has been recognized in the study results. The report on the datum conversion is in Enclosure C of this report. The conversion between NGVD29 and NAVD88 ranges from -2.3 to -2.4 feet over the study area. The levee crest elevations at the index point locations were verified with the levee crest elevations in the National Levee Database, which was surveyed in the NAVD 88 vertical datum. The Cherokee Canal channel and levee cross-sections use LiDAR data provided by DWR.

3 PAST FLOODS AND LEVEE PERFORMANCE

Significant high water events in recent years include the Floods of 1986 and 1997. Significant seepage and large sand boils were observed along the right bank of the Feather River, left bank of the Wadsworth Canal, and Sutter Bypass levees during these two flood events. A catastrophic levee break occurred on the right bank of the Feather River near Shanghai Bend at the southern end of Yuba City during the 1955 flood event with severe economic effects and the loss of 38 lives. Moderately high water events occurred in 1995 and 2006. Light seepage and pin boils developed during these two events. Section 1.2 of this report gives a summary of the levee performance history during flood events. More detailed information may be found in chapter 2 of the ULE P1GER report for levee segments covered under the ULE program and Appendix E of the NULE GAR report for the Sutter triangle levees. Tables summarizing the performance history and constructed modifications/improvements of the SBLS from Periodic Inspection Report No. 1 (2010) are provided in Enclosure B of this report. Table 3-1 shows the peak river stage for the Feather River at Yuba City gage station. The peak stage of record for the Feather River occurred during the December 1955 Flood with a peak stage of about 78.5 feet at the Yuba City gage station.

Table 3-1 Peak River Stages at the Feather River Yuba City Gage

Event	Peak River Stage at the Feather River Yuba City Gage (Elevation in feet, NAVD 1988)
1986	75.3
1995	66.8
1997	77.5
1999	52.3
2000	51.8
2006	66.8

Note: Normal river level elevation is 36 to 37 feet.

4 GEOLOGY, GEOMORPHOLOGY, GROUNDWATER, AND SEISMICITY

The following discussion of regional and local geology was taken from Chapter 3 of the ULE P1GER report, with minor modifications.

4.1 Regional Geology

The levees within the SBFS are located in the central portion of the Sacramento Valley, which comprises the northern half of the Great Valley Geomorphic Province of California. The SBFS includes levees near the center of the Sacramento Valley (Wadsworth Canal and Sutter Bypass), levees near active river channels (Feather River) as well as some levees near the east margin of the valley (Feather River North). The Wadsworth Canal sits on the flanks of the Sutter Buttes, a small isolated volcanic range located in the center of the Sacramento Valley.

The Sacramento Valley lies between the northern Coast Ranges to the west and the northern Sierra Nevada to the east, and was a depositional basin throughout most of the late Mesozoic and Cenozoic. An estimated 2+ vertical miles of sediments were deposited in the Sacramento area during cyclic transgressions and regressions of a shallow sea that once inundated the valley. This thick sequence of clastic sedimentary rock units, derived from erosion of the adjoining easterly and westerly highlands from the Late Jurassic, with interspersed Tertiary volcanics, form the bedrock units now deeply buried in the mid-basin areas of the valley. These bedrock units were covered by coalescing alluvial fans during the Pliocene-Pleistocene era by the major ancestral rivers of the Sacramento Valley (Sacramento, Feather, Yuba, Bear, and American) that funneled huge volumes of sediments into the Sacramento basin. Periodically, volcaniclastic sediments and tuffs were also broadly deposited during this time. Late Pleistocene and Holocene alluvial deposits now cover the low-lying areas, consisting mainly of reworked fan and stream materials that were deposited by meandering rivers prior to the construction of the existing flood control system.

From the mid-1800's to the early 1900's, hydraulic mining in the Sierra Nevada introduced massive amounts of mining debris into the Feather, Yuba, and Bear Rivers. This debris backfilled river channels and raised channel elevations. Mining debris was also transported and deposited atop the more consolidated Pleistocene-to Holocene-age deposits during numerous flood events. Many (although not all) levees along the major ancestral rivers of the Sacramento Valley were deliberately built near the river channel to increase the flow velocity during flood events to "flush out" the mining debris. Much (although not all) of that debris has been flushed out, resulting in the rivers eroding the bottom and sides of their channels. Erosion of the bottom and sides of the river channel tends to worsen underseepage over time.

4.2 Local Geology

State-sponsored regional geologic mapping, at a scale of 1:250,000, of the Chico Quadrangle (Saucedo and Wagner, 1992) and Sacramento Quadrangle (Wagner, Jennings, Bedrossian, and Bortugno, 1987) indicate within the project area geologically recent (Quaternary-age) alluvial/fluvial deposits fill the floodplains of the Sacramento and Feather Rivers. These deposits consist of Holocene Alluvium and Holocene Basin Deposits, as well as late Pleistocene alluvial fan and terrace deposits of the Modesto and Riverbank Formations. Per Helley and Harwood (1985), these Quaternary deposits are variably dissected and overlain by younger Quaternary (Historical) deposits consisting of channel, floodplain, and artificial fill (levees and mine tailings). The Historical deposits date from approximately 1800 to 1937.

Cropping out adjacent to the younger fluvial deposits of the north-westerly portion of the project area are the Pleistocene volcanic rock and sediments of the Sutter Buttes. To the north and east of the younger fluvial deposits are outcrops of Plio-Pleistocene volcanic sediments informally known as the "Tuffs of Oroville." Additionally, fluvial deposits of the Pliocene Laguna Formation occur as scattered outcrops located at the base of the easterly-adjoining highlands and are the oldest geologic unit in the local project vicinity.

The generalized geologic map units in the project region are detailed below with descriptions typically summarized from Helley and Harwood (1985). The map symbol for each mapped geologic unit is noted after the formal name of the unit. Typically, each younger geologic unit is deposited into broad channels cut into the progressively older geologic units. Map symbols used on plan and profile drawings in the DWR ULE reports and SBFCA FRWL Improvement Project are slightly different since they are based on the geomorphologic mapping (see paragraph 4.3 below), which is more detailed.

- **Holocene (Historical) Artificial Fill (L, T).** Historical Artificial Fills (less than 150-years old) are culturally-emplaced deposits of varying amounts of clay, silt, sand, and gravel from local sources. These deposits include levee structures (L) and dredge tailings (T). Dredge tailings are located along the northern-most reach of the Feather River.
- **Holocene (Historical) Alluvial Deposits (Ra).** Historical Alluvial Deposits occur generally between the Feather River channel levees and on the land side. These deposits also occur in historical stream and overflow channels that transport high stage water flow across the ground surface outboard of the levees. The deposits consist of silt and sand with traces of gravel. The upper few feet of these deposits (particularly those derived from the Feather River) are anticipated to be filled with debris derived from upstream hydraulic mining activities.
- **Holocene Alluvium (Qa).** Holocene (<11,000 years before present [ybp]) alluvial deposits are present within the floodplains of the Sacramento River, Feather River, and lesser streams and water courses in the area. These sediments were deposited into and long channels incised into the older latest-Pleistocene formations of similar fluvial origin. The alluvium includes sand and gravel deposits of the active and abandoned stream

channels, as well as sands, silts, and minor gravel lenses deposited as overbank deposits during high-water stages.

- **Holocene Basin Deposits (Qb).** Basin Deposits primarily dominate in the western portion of the project area. The Wadsworth Canal and a majority of the Sutter Bypass are underlain by these deposits. Closer to the Feather River, Basin Deposits are less extensive and are mapped as scattered exposures overlying the Modesto and Riverbank formations. These fluvial sediments consist of fine-grained silt and clay, and represent the distal facies of Holocene alluvial deposits in the area.
- **Pleistocene Modesto Formation (Qm).** The youngest Pleistocene fluvial deposits in the project area are termed the Modesto Formation. The Modesto Formation is exposed at the ground surface predominantly along the landside of most of the Feather River levees and to a lesser degree along the eastern edge of the Sutter Buttes. This formation underlies the younger Basin Deposits east of Sutter Buttes and most of the Feather River channel alluvium. These deposits are recognized by distinct alluvial terraces, alluvial fans and abandoned channel ridges that lie topographically above and outboard of the Holocene alluvial deposits. The Modesto Formation generally consists of unconsolidated gravel, sand, silt and clay and can be divided into two members; an upper member (12,000 to 26,000 ybp) showing poor soil development and a lower member (30,000 to 50,000 ybp) characterized by thicker soils with a developing argillic B horizon. Hardpan may be present near the top of each member of the Modesto Formation as an indicator of the upper boundary with the overlying alluvium. On the western side of the Feather River, the Modesto Formation is a common source of fresh water, as coarse-grained deposits are thick and have good hydraulic connection.
- **Pleistocene Riverbank Formation (Qr).** The Riverbank Formation has limited exposures on the western side of the Feather River at the extreme northern and southern ends of the river. However, the Riverbank Formation is predominantly separated from the Feather River alluvial deposits by the Modesto Formation. The Riverbank Formation consists primarily of gravel, sand and silt and can typically be distinguished from the Modesto by topographic position and presence of a thick, well-developed soil horizon. The Riverbank Formation is subdivided into the Upper and Lower members, each associated with periods of geologic stability (Helley and Harwood, 1985). Hardpan may be present near the top of each member. The Riverbank formation is estimated to be 130,000 to 450,000 years old. The Riverbank Formation can be a source for fresh water in the Feather River North area, but the interbedded nature of the fine- and coarse-grained units and the varying degree of connectivity between coarse-grained beds may limit groundwater production at some locations.
- **Pleistocene Sutter Buttes Volcanic Sediments (QPs) and Rocks (QPv).** These deposits primarily occur as a peripheral topographic ring that surrounds the Sutter Buttes and are separated from the Basin Deposits of the SBFS area by the Modesto and Riverbank Formations. These deposits consist predominantly of volcaniclastic sediments and lahars and to a lesser degree andesitic rocks.

- **Plio-Pleistocene Tuffs of Oroville (QPto).** The "Tuffs of Oroville" consist of interbedded volcaniclastic deposits of gravel, sand, and tuff (volcanic ash) deposited to the south and west of the town of Oroville.

4.3 Geomorphology

A detailed geomorphology study was conducted for the Wadsworth Canal, Sutter Bypass, and Feather Rivers under the DWR ULE program. Results of that study are in Enclosure D of this report. A preliminary geomorphology study of the Cherokee Canal and the Sutter Triangle levees has been conducted under the DWR NULE program, although no reports or maps will be prepared until a more detailed study of those levees has been conducted.

4.4 Groundwater

The SBFS project area is located along the eastern boundary of the East Butte and Sutter Subbasin, which comprises part of the greater Sacramento Valley Groundwater Basin. Historical mine tailing deposits and historical to Holocene stream channel and floodplain deposits upon which the levees were constructed are highly permeable and allow for large volumes of groundwater recharge within the subbasin.

DWR maintains an internet water data library (http://www.water.ca.gov/waterdatalibrary/), which includes groundwater depth measurements from monitoring wells throughout the state. The DWR data and additional information from the Butte County Groundwater Management Plan indicate groundwater within the project area typically flows from north to south. The data also show relatively stable groundwater elevations within the last 40 to 60 years, although there is a typical seasonal fluctuation in groundwater elevation with peaks typically in the winter to spring months and drops in the summer and fall months. The winter and spring peaks indicate groundwater recharge during the precipitation season, and the summer and fall drops indicate the lack of rainfall and extraction of groundwater for domestic and irrigation uses. The DWR water data library indicates groundwater levels within the project area vary between 3 and 30 feet below ground surface. Pore-pressure dissipation tests completed during cone penetration test (CPT) advancement show groundwater levels in the Feather River south area vary between 10 and 32 feet below ground surface and groundwater levels in the Feather River north area vary between 8 and 46 feet below ground surface. Groundwater levels are expected to fluctuate due to variations in precipitation, nearby river stage, irrigation, and withdrawal.

4.5 Seismicity

The SBFS project area is located in a relatively low area of seismic risk for California. Nearby faults, such as those of the Foothills Fault System are located 10 to 20 miles east in the foothills of the Sierra Nevada; however, these faults are considered to have a small likelihood for seismic activity, and may be considered active over very long periods. A portion of this fault was active

after the first filling of Oroville Dam. The Great Valley Fault System is a blind thrust fault on the western edge of the Sacramento Valley, about 34 miles from the SBFS levees. This fault system is also considered to be active.

5 GEOTECHNICAL RISK-BASED ANALYSIS METHODOLOGY

The following sections discuss the risk-based geotechnical analyses performed to evaluate the existing levees. Effects of utility penetrations, encroachments, erosion and animal activity were considered in the engineering judgment portion of the analysis. Underseepage and slope stability analyses were primarily used to develop the expected performance of each reach.

5.1 Risk Based Analysis Method

The probability of poor performance was evaluated by assessing the foundation and embankment materials and assigning values for the probability moments of the random variables considered in the analyses. The First-Order-Second-Moment (FOSM) method, as recommended in ETL 1110-2-556, "Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies" dated 28 May 1999, was followed during the evaluation of the existing conditions of each levee unit. In this approach, the uncertainty in performance is taken to be a function of the uncertainty in model parameters. The standard deviations of a performance function were estimated based on the expected values (means) and the standard deviation of the random variable means. The performance functions considered were slope stability and underseepage piping stability. Through-levee seepage is discussed in section 5.4 of this report.

The final result of the FOSM is a reliability index, Beta (β), representing the amount of standard deviation of the performance function by which the expected value exceeds the limit equilibrium state. The limit equilibrium state for the slope stability and underseepage piping stability was defined using a factor of safety of 1.0. The standard deviation and variance of the performance function are calculated from the standard deviation and variance of the foundation and embankment parameters using the Taylor's series method based on a Taylor's series expansion of the performance function about the expected values. The partial derivatives were calculated numerically using an increment of plus and minus one standard deviation centered on the expected mean value. The variance of the performance function was obtained by summing the products of the partial derivatives of the performance function considering the variance of the corresponding parameters. For the existing condition of the levee, the probability of failure Pr(f) was expressed as a function of the river water elevation and other factors including soil strengths, permeabilities, and subsurface stratification. Reliability (R) is defined as:

$$R = (1 - \Pr(f))$$

The combined geotechnical conditional probability of poor performance, considering the probability of poor performance due to underseepage failure, slope stability and judgment probability is

$$\Pr(f) = 1 - ((1-\Pr(f)_{us})*((1-\Pr(f)_{st}) * (1-\Pr(f)_{jd}))$$

Where: $Pr(f)$ = total probability of poor performance

$Pr(f)_{us}$ = probability of poor performance due to underseepage

$Pr(f)_{st}$ = probability of poor performance due to slope stability (in steady state condition)

$Pr(f)_{jd}$ = judgment probability of poor performance

A set of conditional-probability-of-poor performance versus floodwater-elevation graphs were developed as related to underseepage piping, stability and judgment.

The probability of geotechnical poor performance of a levee is conditional on the uncertainties associated with hydrologic and hydraulic aspects of determining the water surface profile during a flood. These uncertainties can be combined with the geotechnical uncertainties in the @RISK model. This is accomplished, for economic purposes, through estimation of two index elevations for each levee reach within the study area. These index elevations are defined as follows:

The Probable Non-Failure Point (PNP) is the water elevation below which it is highly likely that the levee would not fail.

The Probable Failure Point (PFP) is the water elevation above which it is highly likely that the levee would fail.

The terms "highly likely that the levee would fail" is defined by the ETL as having 85% probability of occurrence. Therefore, the probability of failure at the PNP is 15% and the probability of failure at the PFP is 85%. It should be noted that only for flood damage economic studies the probability of poor performance curve at 85% should be assumed to correspond to PFP and probability of poor performance of 15% shall be assumed to correspond to PNF. These performance curves shall be not used to predict failure for studies other then flood damage economic studies.

The Probability of Poor Performance of the stability of a slope (P_{rf}) is defined as the probability that the critical failure surface could be loaded to the limit equilibrium state. This infers the slope is loaded to its maximum capacity.

The reaches to be analyzed were selected considering the soil profiles based on the available subsurface investigation and the deterministic calculations on cross sections where the geotechnical conditions were considered critical (such as thin impervious blanket, thick aquifer, soft material in the levee or top foundation layer).

5.2 Underseepage Reliability

Subsurface conditions based on past investigations as described previously, geomorphology of the area, and past history were considered in selection of the most critical reaches of each levee unit. Generally the conditions in the Sutter Basin consist of a natural waterside berm of sands and silts and a natural top blanket consisting of silts grading to clay in the basin with the permeability decreasing with distance to the basin. The impervious blanket thickness, soil types (for determination of the permeability ratio), and aquifer thickness were considered for selection of the cross section representing a characteristic reach of every levee unit. Existing subsurface investigation showing the location of the borings, soil profiles and boring logs are those used by the ULE study and the FRWL Improvement Project and are provided in Enclosure J. The expected value, standard deviation and the coefficient of variation of the permeability ratios between the horizontal permeability through the sandy aquifer and vertical permeability of the impervious blanket, blanket thickness and thickness of the sandy aquifer for each reach and for the each index point are provided in Enclosure D. The information was based on soil profiles developed using existing subsurface investigation. Underseepage analysis was performed using the blanket theory as described in the Corps ETL 1110-2-556. Finite element analyses using SEEP2D program part of the GMS version 6 were developed to independently check the blanket theory results. Statistical analysis was used for each reach in determination of the coefficients of variation of the permeability ratios an, blanket thickness and thickness of the underlying aquifer as shown on Enclosure C. A critical gradient $i_c = 0.80$ was used considering the unit weight of the blanket 112pcf. The unit weight of the blanket was considered the same for all sections analyzed. The standard deviation for the blanket thickness and the thickness of the sand layer in the foundation was calculated for each index point of each levee unit and was used in underseepage reliability evaluation. The phreatic line obtained by the SEEP2D program using the finite element method was also used in the stability analysis for each water elevation.

Reliability analysis was performed using Taylor's Series Method. In the Taylor method, random variables are quantified by their expected values, standard deviations, and correlation coefficients. The variables used in the generalized equation for underseepage analysis are shown on Figure 5-1 and are as follows:

$$X_3 = \sqrt{z * d * \left(\frac{k_f}{k_b}\right)}$$

$$i_o = \frac{h_0}{D_b} = \frac{H\left(\frac{k_f}{k_b} D_f D_b\right)}{D_b\left[C_R \frac{e^{2L_R} - 1}{e^{2L_R} + 1} + x_2 + \left(\frac{K_f}{K_{bL}} D_f D_{bL}\right)\right]}$$

Where

$$h_0 = \frac{H * L_e}{L_1 + L_2 + L_e}$$

$$L_1 = C_R * \frac{e^{2L_R} - 1}{e^{2L_R} + 1}$$

$$Pr(F) = P(i_{critical} < i_o)$$

Where: X_3 = C_R = effective exit distance

z = D_b = blanket thickness (it is assumed that the blanket thickness is the same on the waterside and landside D_b=D_{bl}=D_{br})

d = D_f = aquifer thickness

k_f = horizontal permeability of the aquifer

k_b = vertical permeability of the blanket

k_f/k_b = permeability ratio between horizontal permeability of the aquifer and vertical permeability of the impervious blanket

L_R = actual length of the riverside blanket

L_L = actual length of landside blanket assumed infinite (∞)

H = total head on levee

h_0 = water head at the landside levee toe

i_0 = upward seepage gradient through the landside blanket

L_1 = effective length of the waterside blanket

L_2 = X_2 = base width of natural blanket beneath the levee embankment (X_2)

L_e = C_R when the landside length of the natural blanket is assumed infinite

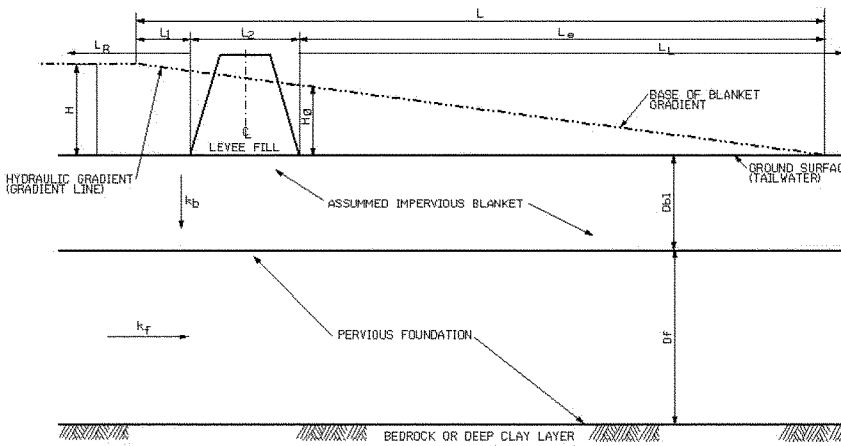

Figure 5-1 Underseepage Analysis – Blanket Theory

Seepage gradients were calculated for a range of river stages from the landside toe elevation to the top of the levee. From previous studies, the Taylor Series method appears to be more conservative and appropriate for this level of investigation. The index points for the risk analysis were selected based on deterministic analyses using the final element method developed by the SEEP2D program.

Permeability ratios between the horizontal permeability of the sand layer and vertical permeability of the impervious blanket, used in the blanket R&U analyses were based on a statistical analysis of the permeability of different foundation soils shown in the borings within the considered reach based the subsurface investigation and recommendations of the previous studies listed in Section 1.3.

The Sacramento District has developed a standard EXCEL workbook for the preparation of fragility curves. The mean, standard deviation, and coefficient of variation for the blanket

thickness, pervious layer thickness, and the permeability ratio (horizontal permeability of the pervious layer divided by the vertical permeability of the blanket layer) are calculated for each index point using nearby soil borings on the first sheet in the workbook. Those parameters are then transferred to the second sheet in the workbook for the actual blanket theory calculations, with one potential exception. If the standard deviation is higher than the mean, then the mean minus one standard deviation will be a negative number, which is not physically possible. In that case, the coefficient of variation will be over 100. To avoid this problem, the workbook limits the coefficient of variation to a maximum of 98. If the coefficient of variation is 98, then the standard deviation is recalculated on the second sheet in the workbook based on the maximum allowed coefficient of variation. For this study, the permeability ratio was the parameter most often impacted by a large standard deviation. Soils deposited by river systems are highly variable compared to engineered materials like concrete and steel, and high standard deviations are not unexpected when dealing with soil materials.

Exit gradients calculated using blanket theory are highly sensitive to blanket layer thickness. For meandering river systems, it is not uncommon to have large differences in the blanket layer thickness; in this study, two soil borings along the Feather River show blanket layer thicknesses greater than 100 feet. Unusually large blanket layer thickness values will significantly impact the mean and cause the standard deviation to be large. To eliminate this effect, soil borings near the index points with unusually large blanket layer thickness (over 31 feet) were not used to calculate the random variables and statistical parameters. Soil borings with blanket layer thickness greater than 31 feet are the exception and not the rule in the SBLS. Basing the calculations on the borings with the thinner blanket layer is more representative of the conditions that are likely to cause an underseepage failure.

The detailed results of the underseepage reliability analyses for each index point are provided in Enclosure E.

5.3 Slope Stability Reliability

A sensitivity study was done to determine which parameters in the slope stability calculations were most influential. For this study, those variables are soil strength and unit weights of the soil in the levee embankment and in the foundation. Statistical descriptors for these variables were determined using available site-specific information and published statistical data. The piezometric lines or pore pressures for each water elevation were determined using the finite element program SEEP2D.

5.3.1. Cases Analyzed and Methods Used for Analyses

The cases analyzed for stability risk analyses considered long-term conditions with steady state seepage along the landside slope of the levee. The phreatic surface developed for the steady state condition was determined using the SEEP2D finite element computer program developed as part of the GMS. The limit equilibrium computer program "UTEXAS4" was used to perform the

stability analyses. Circular failure surfaces were assumed and the embankment was modeled as homogeneous. All analyses consisted of running a search routine to identify the critical failure surface using the Spencer's Method. Five random variables were defined for each unit. Stability analyses were performed for different assumed river stages. Details of the results of the stability risk analysis are provided in Enclosure E.

5.3.2 Soil Strength Parameters

Soil strength parameters used in the stability analyses were the drained soil parameters as determined in previously studies listed. The coefficient of variation for soil strength parameters and unit weight of the fill material in the levee or the top impervious blanket were obtained using methodologies outlined in ETL 1110-2-556, and those proposed by Harr in the "Reliability-Based Design in Civil Engineering", and Duncan in the "Manual for Geotechnical Engineering Reliability Calculations". Cohesion of 50 psf was considered for the embankment fill when the levee embankment was constructed of sandy materials, to avoid shallow slipping surfaces close to the infinite slope failure.

5.4 Through Seepage Analysis

The through-levee seepage performance mode was not included in the development of fragility curves. The levees along the Wadsworth Canal and the Sutter Bypass are comprised mostly of clays and sandy clays with some zones of silty sand. The west levee of the Feather River is variable with regards to soil type. The Maintenance Area 3 segment and the southern portion of the Levee District 1 segment are composed of sandy silt and sandy clay. The upstream portion of the Levee District 1 segment is composed of silty sand, sandy silt, and some zones of sand. The Levee District 9, Maintenance Area 16, and Maintenance Area 7 segments are composed of sandy silt and sandy clay. The Hamilton Bend segment is composed of gravel and sand, with a fines content between 2 and 10 percent, but this segment has a crest width of about 60 feet. The Cherokee Canal levee is composed mostly of clay, silt, and sandy silt, with occasional small pockets of silty sand. Clay, sandy clay, and sandy silt levees are unlikely to experience through-levee seepage distress due to the low permeability of those soils. While silty sand and sand levees can be susceptible to through-levee seepage distress, there is almost no history of this performance mode causing levee distress in the two levee systems covered under the SBFS. The only reported incidence of distress due to through-levee seepage in these levees was saturation and bulging of the landside levee slope of the Feather River in downtown Yuba City during the 1986 flood. A landside stability berm was constructed in this area by the local sponsor after that flood, and a cutoff wall was constructed through the levee in this area by the Corps of Engineers after the 1997 flood. Due to the mosty fine-grained levee soils, the lack of history of through-levee seepage distress, the levee improvements in the only reported location of through-levee seepage distress, and the enlarged levee section of the pervious Hamilton Bend segment, it was determined that through-levee seepage is unlikely to be a major contributor to the probability of failure of the levees in this study.

5.5 Judgment Base Reliability Analysis

A judgment based conditional probability function was based on existing conditions of the levee such as the impact of encroachments, vegetation, existing cracks and holes due to animal burrows, and based on the past history of sand boils, or slope failures. Generally past experience with poor performance at utility crossing and rodent activity indicates the risk of failure is pretty significant in the analyzed areas. Impact of erosion on the levee performance was also included in the judgmental reliability analysis. The judgment-based curve is included for each analyzed levee cross section and in the combined curve.

In June 2009, an expert elicitation was conducted for the purpose of developing the geotechnical judgment portion of the curves for the American River Common Features project for various conditions of the levee regarding vegetation, encroachments, rodents activity, penetrations and erosion. This expert elicitation was conducted in accordance with ETL 1110-2-561, "Appendix E, Expert Elicitation in Geological and Geotechnical Applications" 31 January 2006. The members of the expert elicitation team were highly recognized professional specialists, representing the LMAs of those levee systems, and specialists in erosion and in geotechnical issues. The expert elicitation focused on the judgment part of the geotechnical risk and uncertainty curves for the flood control structures. The expert elicitation was conducted over a three-day period in which the most representative reaches of each basin of the study were discussed. The expert elicitation team discussed and reached consensus on the impact of different factors of the judgment curve, such as:

a) the vegetation on the levees and within the levee right of way
b) penetrations through the levee and foundation
c) encroachments into the levee and levee right-of-way
d) erosion of the riverbank and waterside slopes of the levee
e) animal burrows

The expert elicitation also concluded that up to a certain water elevation, the risk of poor performance as determined by analyses or considered in the judgment portion of the curves may not necessarily coincide with the risk of failure. Based on historical performances of the levees, it appears that the risk of failure as determined in the analyses may be conservative and the poor performance of a levee may not lead to a catastrophic levee failure, even if damage to the levee embankment needs to be repaired after the flood to bring the levee back to the pre-flood performance. Consequently, the risk of catastrophic failure may be reduced based on the historical past performance, and consequently the curves may be altered. The conclusion reached by the panel was that the risk of failure as a function of stage of the river may be reduced by 50% when the river reached 4-5 feet above the landside toe, by 30% when the river stage is up to 8-9 feet above the landside levee toe, and by 10% when the river reaches 11-12 feet above the landside toe. Geotechnical R&U curves for poor performance and risk of failure considering the conclusions of the expert elicitation were provided for further analysis in HEC-FDA. The judgmental curves for the existing conditions are provided in Enclosure E.

5.6 Combined Reliability Analysis

The total conditional probability of failure as a function of floodwater elevation has been developed by combining the probability of failure functions for three failure modes; underseepage, slope instability, and judgment. The reliability is the probability of no failure due to each mode considered in the calculations. The analysis also assumed that no flood fighting is employed.

5.7 Soil Parameter Selection

The soil parameters used for underseepage and slope stability were assigned function of the type of the materials in the upper impervious blanket and in the aquifer underneath. The expected values were selected based on design charts in the EM 1110-2-1913, values used by the geotechnical report for the Feather River West Levee Improvement Project, and on values recommended by the Guidance for the DWR ULE program. All presumptive relationships were considered when selecting initial values (note that they are all very similar); however, seepage modeling was performed by varying these presumptive values to produce flow nets, which realistically match the generalized subsurface conditions. Therefore, the final values utilized may not be the same as the presumptive value used to begin the modeling process.

5.8 Reach Selection

Reaches were selected based on a geotechnical evaluation of the subsurface profile boring logs. The critical points are locations in each project phase that have the most significant risk of failure. The reaches were chosen to represent sections of levee with similar levee and foundation conditions.

Reaches were identified using the following criteria:

- Similar foundation blanket type (e.g. clay, silt, etc, a change may indicate a different reach)
- Similar foundation blanket or pervious layer thickness (e.g. the absence of a blanket or the absence of a pervious layer constitutes a difference reach)
- Significant changes in layer thickness, such those that result of a geomorphology difference (e.g. soil deposits with a major change in layer heterogeneity)

Experience has also shown that smaller reaches provide more consistent means and standard deviations, which represent actual geomorphological related subsurface conditions.

6 EVALUATION OF EXISTING GEOTECHNCIAL CONDITIONS

The SBLS levees completely encircle the Sutter Basin (Plate 1). The levee system is approximately 65 miles long. This levee system is broken into reaches by the ULE P1GER report, except for the Cherokee Canal levee, which is not included in the ULE study.

The Sutter Triangle levees tie into high ground at both ends at the Sutter Buttes (Plate 1). This levee system is approximately 10 miles long. This system is not included in the ULE study.

The height of the levees ranges from 4to 30 feet. The landside slopes are typically2H:1V. Portions of the system have landside slopes as steep as 1.5H:1V. The waterside slopes are typically 2.5H:1V to 4H:1V, with a typical slope of 3H:1V. The levee crown width ranges from 10 to 70 feet and are typically 16 to 20 feet. In the highly urbanized area of Yuba City, the Levee District 1 Sutter County segment has buildings, fences, roads, and utility poles located in close proximity to the levee. In rural areas, unpermitted fence encroachments are common. More detailed descriptions of the levees in the ULE study are in Section 2 of the ULE P1GER report. More detailed descriptions of the levees in the NULE study are in Appendix C (Cherokee Canal) and Appendix E (Sutter Triangle) of the NULE GAR report.

6.1 Past Performance and Levee Modifications/Improvements

Section 1.2 of this report gives a brief summary of the levee performance history during flood events. More detailed information may be found in chapter 2 of the ULE P1GER report for levee segments covered under the ULE program and Appendix E of the NULE GAR report for the Sutter triangle levees. Tables summarizing the performance history and constructed modifications/improvements of the SBLS from Periodic Inspection Report No. 1 (2010) are in Enclosure B of this report.

6.2 Explorations

The ULE P1GDR (2008) and SGDR (2010) and the SBFCA GDR (2012) reports summarize explorations for the majority of the project. The Cherokee Canal left levee, Wadsworth Canal right levee, and the Sutter Bypass left levee upstream of Wadsworth Canal are included in the DWR NULE project, but no NULE explorations have been conducted at this time. Nine soil borings were conducted for the Cherokee Canal left levee for this Feasibility Study. The boring logs are included in Enclosure F of this report.

6.3 SBLS Seismic Evaluation

The fragility curves were developed following ETL 1110-2-566, which does not include a seismic component. The Sacramento District has developed a draft manual for seismic deformation evaluation of levees which is currently under review by Corps Headquarters, the Risk Management Center (RMC) and the Engineering Research and Development Center (ERDC) for nationwide implementation. The recommendation of the proposed manual is to design for seismic loading only levees loaded permanently by high water levels. Levees subject to intermittent loading will only be evaluated for liquefaction potential and seismic deformation. We recommend the Sponsor identify an emergency borrow area to reconstruct the levee within 3 months to a limited level of protection (10% (1/10) Annual Chance Exceedance (ACE)). Additional information on the seismic evaluation is given in section 8.6.3 of this report.

6.4 Deterministic Analysis

Deterministic slope stability and foundation underseepage analyses were conducted at thirteen cross-sections along the Sutter system corresponding to the reaches identified in Paragraph 6.1 as the basis for the risk based analyses and to identify the index points for each reach. In some cases, the deterministic analyses were conducted at the index points for this study and in other cases the deterministic analyses were conducted a short (half-mile or less) distance away from the index point. The purpose of the deterministic analysis was to verify the deterministic analyses conducted under the two outside studies and as a "check" for the fragility curves prepared under this study.

The Groundwater Modeling System (GMS) computer program was used for all analysis seepage and stability analysis. GMS is a model wrapper program that incorporates a graphical user interface (GUI). The modeler builds the subsurface model in GMS and the subsurface model is exported to the appropriate analysis module. The GMS program includes modules such as SEEP2D for finite-element seepage modeling, and UTEXAS4 for slope stability analysis.

For this project, topographic cross-sections were cut from triangulated irregular network (TIN) 3D surfaces using AutoCAD, which derived the TIN surface from the Comp Study topography identified in Section 2.0. This CADD cross section was combined with boring stick logs exported to CADD format from the gINT boring log program. The combined CADD file containing the appropriate boring logs and topographical cross-section was imported into the GMS program. Once in GMS the modeler imported the topography layer from CADD to object layers in GMS.

Enclosure G presents the graphical output from the deterministic analyses.

7 GEOTECHNICAL FRAGILITY CURVES

7.1 Reach Selection

The ULE P1GER (2008) report divides the SBLS into forty reaches. Reach selection grouped portions of the levee into segments with similar performance, previous repairs, or geomorphology. For the purposes of the SBFS, we grouped the ULE-developed reaches into ten larger reaches with similar subsurface conditions, and added one reach each for the Cherokee Canal left levee, Wadsworth Canal right levee, and Sutter Bypass left levee upstream of Wadsworth Canal, which are not in the ULE study. The resulting thirteen reaches were developed in consultation with the project hydraulic engineer and economist. Note that the levee reaches used to develop the fragility curves are different than the levee segments listed in section 1.1 of this report. The levee segments are determined by levee maintaining agency, while the levee reaches were developed for analysis based on the criteria listed in section 5.6 of this report.

The thirteen reaches are as follows:

Wadsworth Canal (left): ULE A and B

Sutter Bypass Upper: ULE C, D, E, and F

Sutter Bypass Lower: ULE H, I, J, K, and L

Feather River South (near Bear) = ULE M, N, O, P,Q ,and R

Feather River Abbot/Connor Lakes: ULE S, T1, and T2

Feather River Shanghai Bend: ULE U, V, W, X, Y, Z1, Z2, Z3, and Z4

Feather River North LD9: ULE AA, BB, CC, DD, and EE

Feather River North Middle: ULE FF, GG, HH, II, JJ, KK, and LL

Feather River North Canal: ULE JJ, KK, and LL

Feather River North Hamilton Bend: ULE MM, NN, OO, QQ, RR, and SS

Cherokee Canal: ULE Not applicable

Wadsworth Canal (right): ULE Not applicable

Sutter Bypass (upstream) : ULE not applicable

Table 7-1 provides a location summary of the index points associated with these reaches. The index point locations are shown on Plates 2 through 9 of this report. These reaches are described in subsections of 7.2 through 7.14, including a short explanation of the rationale of the reach selection.

Table 7-1. Index Point Location Information

Index Point Number	Reach Name	PLM	NAD83_N	NAD83_E
1	Wadsworth Canal (left)	0.84	2170954.8600	6629916.3000
2	Sutter Bypass Upper	6.20	2158851.0000	6631970.0000
3	Sutter Bypass Lower	17.30	2113476.9763	6655398.0817
4	Feather River South (near Bear)	4.92	2106963.5800	6679261.2400
5	Feather River Abbott/Connor Lakes	3.99	2127081.8143	6676331.1294
6	Feather River Shanghai	9.31	2156078.1800	6673804.9800
7	Feather River North LD9	0.52	2188213.8800	6668679.4100
8	Feather River North Middle	0.90	2224154.3700	6664999.3400
9	Feather River North Canal	2.90	2233626.2500	6664328.5400
10	Feather River North Hamilton Bend	0.51	2288660.9600	6662820.2400
11	Cherokee Canal	9.50	2301045.9480	6637006.2610
12	Wadsworth Canal (right)	0.50	2168750.0000	6627910.0000
13	Sutter Bypass (upstream)	4.0	2168110.0000	6626590.0000

7.2 Wadsworth Canal (left)

The section describes the reach selection and modeling criteria for the Wadsworth Canal left levee from the Sutter Bypass (PLM 0.00) upstream to the East Interceptor Canal (PLM 4.66).

Reach Selection: The ULE report identifies two reaches for this levee: Reaches A and B. In Reach A, the levee is shorter, and the height reduces toward the upstream end. Reach B south of Franklin Road is a taller levee and is characterized by relatively thin sand layers layers in the foundation. The critical index point for the Wadsworth Canal left bank levee was considered towards the downstream (taller) end since the hydraulic head is greater and more susceptible to underseepage than a shorter levee. The statistical parameters for blanket and pervious layers were developed using soil types identified in soil borings from the ULE P1GER report. There is a forty to fifty foot deep, 3000 feet long, soil-cement-bentonite cutoff wall at the southern end of this reach. The index location is situated upstream from the cutoff wall at PLM 0.83.

Selection of Cross-Section: The cross-section at PLM 0.83, was selected to represent the portion of the reach not protected by a cutoff wall; however, the statistical variation of the parameters of the blanket and sand (thickness and permeability) considered all borings within the reach, including those in the area with a cut-off wall.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the impervious blanket in the vicinity of the selected index point varies between 3 and 10.5 feet and consists of clay and silt blanket overlaying a silty sand aquifer 2-11 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-2.

Table 7-2 Permeabilities, Wadsworth Canal (left)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Thin Clay Blanket	3.9×10^{-4}	1.12	9.8×10^{-4}	0.28	4
Thick Clay Blanket	9.8×10^{-6}	0.028	2.5×10^{-6}	0.0071	4
Silty Sand (SM)	9.8×10^{-3}	2.8	9.8×10^{-4}	0.28	10
Sand with Silt (SP-SM)	4.02×10^{-3}	11.4	4.02×10^{-4}	1.14	10

The standard deviation and coefficient of variation for the permeability ratios (between the horizontal permeability of the sandy aquifer and vertical permeability of the impermeable upper blanket), blanket thickness and sandy aquifer thickness are summarized in Table 7-3 as follows.

Table 7-3 Random Variables, Wadsworth Canal (left)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	7	2	29

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permeability Ratio (k_f/k_b)	493	455	92
Foundation Sand thickness (d)	7	3	43

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-4

Table 7-4 Stability Random Variables, Wadsworth Canal (left)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	31	4	12
Levee Unit Weight γ (pcf)	125	6	5
Blanket Layer Cohesion c (psf)	150	50	33
Blanket Layer Unit Weight γ(pcf))	115	6	5
Blanket Layer Φ(degrees)	28	3	12

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-1. The underseepage performance mode accounts for most of the risk of failure for this levee segment. This is consistent with the performance history of excessive seepage and boils over the downstream portion of this levee, where it is tallest.

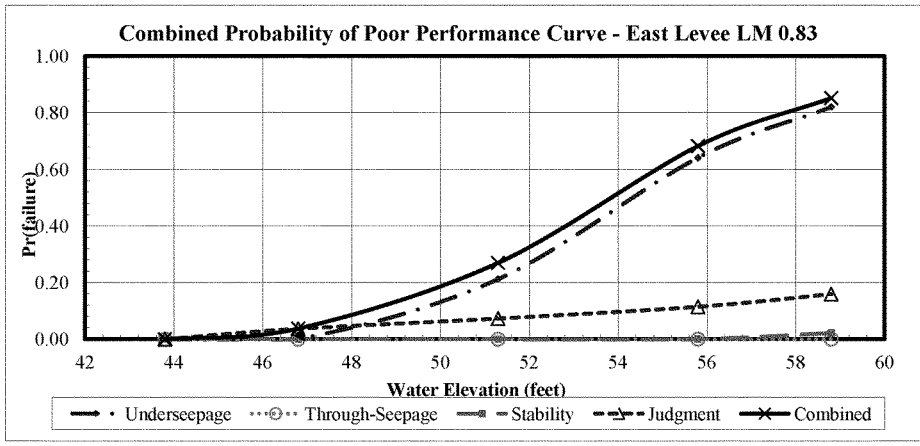

Figure 7-1 Combined R&U, Wadsworth Canal (left)

7.3 Sutter Bypass; Upper Reach

The section describes the reach selection and modeling criteria for the Sutter Bypass Upper Reach, from PLM 4.40 at the Wadsworth Canal downstream to PLM 12.7 at Gilsizer Slough.

Reach Selection:

The Sutter Bypass has experienced many seepage problems over the years. The channel was blasted out of the hardpan clay and the levees were built adjacent to the cut. This reduces the waterside blanket to almost zero. The Bypass channel crosscuts the geology of the region, with the orientation of the natural flood overbank deposits from the Feather, Yuba and Bear Rivers passing roughly perpendicular to the channel and levee. The results are that the Sutter Bypass has similar subsurface conditions and performance during flood events over the entire segment.

Within the Sutter Bypass, geomorphically, Gilsizer Slough stands out as a place to separate reaches. Gilsizer Slough is an historically major drainage in the Sutter Basin, and intersects the bypass near the midpoint. For this reason, the bypass was divided into two reaches; the Upper Reach and the Lower Reach.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the impervious blanket in the vicinity of the upper reach index point varies between 4.8 and 14 feet and consists of clay, sandy clay, and occasional silty sand

overlaying a sand and silty sand aquifer 3-10 feet thick. The borings used for the R&U analyses for the upper reach are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-5.

Table 7-5 Permeabilities, Sutter Bypass (Upper)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay/Sandy Clay Blanket (CL)	$9.8x10^{-6}$	0.028	$2.5x10^{-6}$	0.007	4
Silty Sand Blanket (SM)	$4.2x10^{-4}$	1.2	$1x10^{-4}$	0.3	4
Silty Sand Aquifer(SM)	$1x10^{-3}$	3	$1x10^{-4}$	0.3	10
Sand with Silt Aquifer (SP-SM)	$3.5x10^{-3}$	10	$3.5x10^{-4}$	1	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-6 as follows.

Table 7-6 Random Variables, Sutter Bypass (Upper)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	10	4	40
Permeability Ratio (k_f/k_b)	725	650	90
Foundation Sand thickness (d)	10	6	60

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-7

Table 7-7 Stability Random Variables, Sutter Bypass (upper)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	31	4	12
Levee Unit Weight γ (pcf)	125	6	5
Blanket Layer Cohesion c (psf)	150	50	33
Blanket Layer Unit Weight γ(pcf))	115	6	5
Blanket Layer Φ(degrees)	28	3	12

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-2. The underseepage performance mode accounts for most of the risk of failure for this levee reach. This is consistent with the performance history of excessive seepage, boils and ground heaving near the toe of this levee.

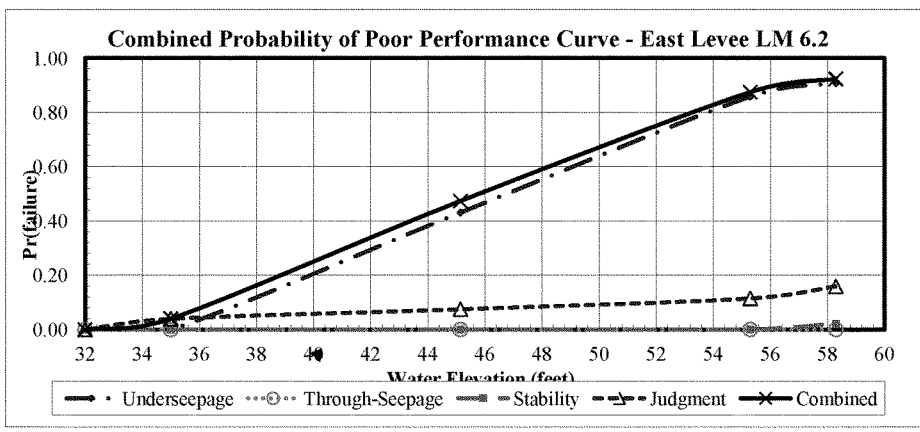

Figure 7-2 Combined R&U, Sutter Bypass (Upper)

7.4 Sutter Bypass (Lower)

The section describes the reach selection and modeling criteria for the Sutter Bypass Lower Reach.

Reach Selection:

The Sutter Bypass has experienced many seepage problems over the years. The channel was blasted out of the hardpan clay and the levees were built adjacent to the cut. This reduces the waterside blanket to almost zero. The Bypass channel crosscuts the geology of the region, with the orientation of the natural flood overbank deposits from the Feather, Yuba and Bear Rivers passing roughly perpendicular to the channel and levee. The results are that the Sutter Bypass has similar subsurface conditions and performance during flood events over the entire segment.

Within the Sutter Bypass, geomorphically, Gilsizer Slough stands out as a place to separate reaches. Gilsizer Slough is an historically major drainage in the Sutter Basin, and intersects the bypass near the midpoint. For this reason, the bypass was divided into two reaches; the Upper Reach and the Lower Reach.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the impervious blanket in the lower reach varies between 4 and 26.4 feet and consists of clay, silt, sandy clay, and sandy silt overlaying a sand and silty sand aquifer 3-28 feet thick. The borings used for the R&U analyses for the lower reach are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-8.

Table 7-8 Permeabilities, Sutter Bypass (Lower)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay/Sandy Clay Blanket (CL)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Silty Sand Blanket (SM)	1.4×10^{-4}	0.4	3.5×10^{-5}	0.1	4
Silty Sand Aquifer(SM)	1×10^{-3}	3	1×10^{-4}	0.3	10
Sand with Silt Aquifer (SP-SM)	3.5×10^{-3}	10	3.5×10^{-4}	1	10
Sand Aquifer (SP)	9.8×10^{-3}	28	9.8×10^{-4}	2.8	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-9 as follows.

Table 7-9 Random Variables, Sutter Bypass (Lower)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	15	10	67
Permeability Ratio (k_f/k_b)	1117	1095	98
Foundation Sand thickness (d)	13	13	98

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-10.

Table 7-10 Stability Random Variables, Sutter Bypass (lower)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	31	4	12
Levee Unit Weight γ (pcf)	125	6	5
Blanket Layer Cohesion c (psf)	150	50	33
Blanket Layer Unit Weight γ(pcf))	115	6	5
Blanket Layer Φ(degrees)	28	3	12

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-3. The underseepage performance mode accounts for most of the risk of failure for this levee reach.

This is consistent with the performance history of excessive seepage, boils and ground heaving near the toe of this levee.

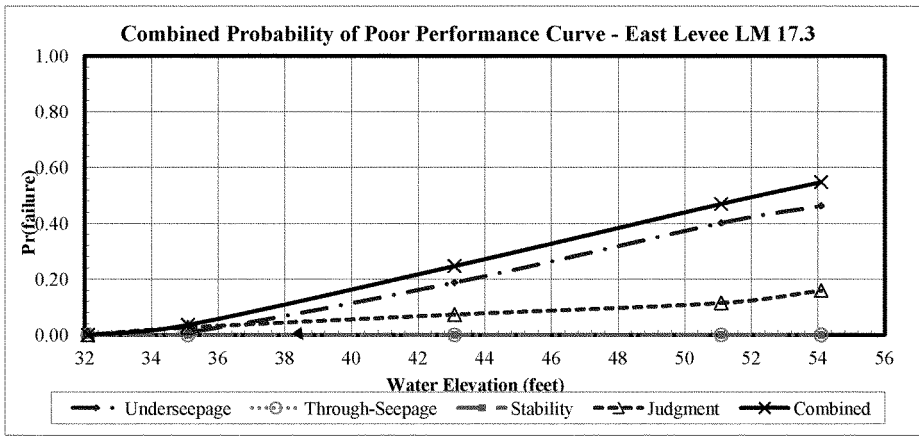

Figure 7-3 Combined R&U, Sutter Bypass (Lower)

7.5 Feather River South (near Bear)

The section describes the reach selection and modeling criteria for the Feather River South (near Bear) reach.

Reach Selection:

This reach is characterized by geomorphology dominated by the interaction between the Bear and Feather River systems since the Pleistocene, and therefore is named after the Bear River.

Selection of Cross-Section: The cross-section FEATHER RIVER SOUTH (near Bear) was selected to represent the most vulnerable location in the reach and is located at PLM 4.92.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the impervious blanket in the vicinity of the index point varies between 14 and 26 feet and consists of silt, clay, sandy silt, and sandy clay overlaying a sand, gravel, and silty sand and gravel aquifer 17-89 feet thick. The borings used for the R&U analyses for the upper reach are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-11.

Table 7-11 Permeabilities, Feather River South (near Bear)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Thick Clay/Sandy Clay/Sandy Silt Blanket (CL, ML)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Sandy Silt Blanket (ML)	1.97×10^{-4}	0.56	4.9×10^{-5}	0.14	4
Silty Sand Aquifer(SM)	3.5×10^{-4}	1	3.5×10^{-5}	0.1	10
Sand Aquifer	3.5×10^{-3}	10	3.5×10^{-4}	1	10
Sand and Gravel Aquifer (SP-SM, GW-GM)	1×10^{-2}	30	1×10^{-3}	3	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-12 as follows.

Table 7-12 Random Variables, Feather River South (near Bear)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	22	5	23
Permeability Ratio (k_f/k_b)	2172	1977	91
Foundation Sand thickness (d)	73	28	38

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-13

Table 7-13 Stability Random Variables, Feather River South (near Bear)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	29	1	5
Levee Unit Weight γ (pcf)	120	6	5
Blanket Layer Cohesion c (psf)	150	17	11.5
Blanket Layer Unit Weight γ(pcf))	120	6	5
Blanket Layer Φ(degrees)	31	4	11.5

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-4. The underseepage performance mode accounts for much of the risk of failure for this levee reach. This is consistent with the performance history of excessive seepage and boils during flood events.

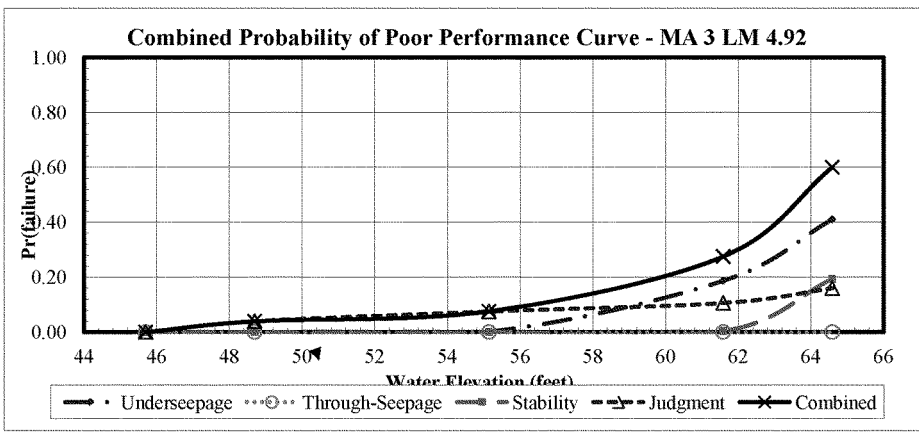

Figure 7-4 Combined R&U, Feather River South (near Bear)

7.6 Feather River South – Abbot/Conner Lakes Reach

The section describes the reach selection and modeling criteria for the Feather River South – Abbot/Connor Lakes reach.

Reach Selection:

This reach of levee was constructed near historic marshland (Abbot and Connor Lakes). The levees here have typically had underseepage problems. Relief wells and a recent setback levee with a cutoff wall in the foundation was constructed to mitigate for hydraulic and underseepage concerns over a portion of this reach; however most of this reach does not have any seepage mitigation measures in place. This reach is located from PLM 6.25 (LD1) downstream to PLM 2.74 (LD1) and is about 4.4 miles long.

Selection of Cross-Section: The cross-section was selected to represent the portion of the reach most likely to breach. This section is located at PLM 3.99.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 5 and 25.5 feet and consists of clay, sandy clay, and silty sand overlaying a silty sand and gravel aquifer 3-97 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-14.

Table 7-14 Permeabilities, Feather River South (Abbott/Connor Lakes)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Thin or Sandy Clay Blanket (CH, CL, ML)	1.4×10^{-5}	0.04	3.5×10^{-6}	0.01	4
Clay Blanket (CL)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Silty Sand Blanket (SM)	3.5×10^{-4}	0.4	3.5×10^{-5}	0.1	4
Silty Sand Aquifer (SM)	9.8×10^{-4}	2.8	9.8×10^{-5}	0.28	10

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Sand Aquifer	$3.5x10^{-3}$	10	$3.5x10^{-4}$	1	10
Sand and Gravel Aquifer (SP-SM, GW-GM)	$2.5x10^{-2}$	70	$2.5x10^{-3}$	7	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-15 as follows.

Table 7-15 Random Variables, Feather River South (Abbott/Connor Lakes)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	14	9	66
Permeability Ratio (k_f/k_b)	10526	10315	98
Foundation Sand thickness (d)	26	25	98

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-16

Table 7-16 Stability Random Variables, Feather River South (Abbott/Connor Lakes)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	29	1	5

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Unit Weight γ (pcf)	120	6	5
Blanket Layer Cohesion c (psf)	150	17	11.5
Blanket Layer Unit Weight γ(pcf))	120	6	5
Blanket Layer Φ(degrees)	31	4	11.5

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-5. The underseepage performance mode accounts for much of the risk of failure for this reach. This is consistent with the performance history of excessive seepage and boils during flood events.

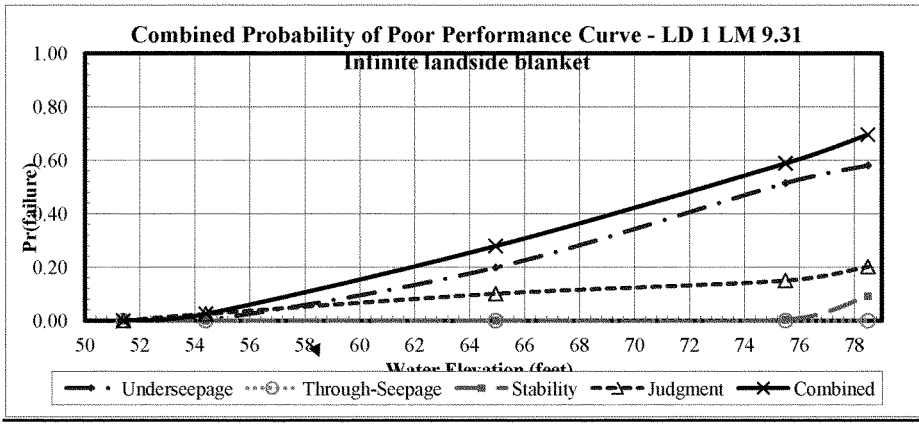

Figure 7-5 Combined R&U, Feather River South (Abbott/Connor Lakes)

7.7 Feather River South – Shanghai Reach

The section describes the reach selection and modeling criteria for the Feather River South – Shanghai Reach.

Reach Selection:

This segment represents the reach nearest to Yuba City where several previous levee strengthening projects have been completed from PLM 16.65 (LD1) downstream to PLM 6.25 (LD1) and is about 9.9 miles long. Levee strengthening projects include relief wells just upstream of Shanghai Bend, a cutoff wall upstream of the relief wells (with a slight overlap), and a stability berm within downtown Yuba City. This levee breached just north (upstream) of Shanghai Bend at approximate PLM 11.8 during the 1955 flood. Portions of this reach have had no levee strengthening projects.

Selection of Cross-Section: The cross-section at PLM 9.31 of LD1 was selected to represent the portion of the reach not protected by a cutoff wall or relief wells; however, the parameters of the blanket and sand thickness were partially derived from the borings in these areas solely for the purpose of developing reasonable statistical parameters.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 8.5 and 31 feet and consists of clay, silt, and sandy silt overlaying a sand and silty sand aquifer 2.5-30 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-17.

Table 7-17 Permeabilities, Feather River South (Shanghai)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay Blanket (CL)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Silt/Clay Blanket (CL, ML)	1.4×10^{-5}	0.04	3.5×10^{-6}	0.01	4
Sandy Silt Blanket (ML)	1.9×10^{-4}	0.56	4.9×10^{-5}	0.14	4
Silty Sand Aquifer (SM)	9.8×10^{-4}	2.8	9.8×10^{-5}	0.28	10
Silty Sand Aquifer (SM)	4.2×10^{-4}	1.2	4.2×10^{-5}	0.12	10
Sand Aquifer (SP)	4.9×10^{-3}	14	4.9×10^{-4}	1.4	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-18 as follows.

Table 7-18 Random Variables, Feather River South (Shanghai)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	17	9	53
Permeability Ratio (k_f/k_b)	773	758	98
Foundation Sand thickness (d)	15	13	87

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-19.

Table 7-19 Stability Random Variables, Feather River South (Shanghai)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	29	1	5
Levee Unit Weight γ (pcf)	120	6	5
Blanket Layer Cohesion c (psf)	150	17	11.5
Blanket Layer Unit Weight γ(pcf))	120	6	5
Blanket Layer Φ(degrees)	31	4	11.5

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-6. The underseepage performance mode accounts for much of the risk of failure for this reach. This is consistent with the performance history of excessive seepage and boils during flood events.

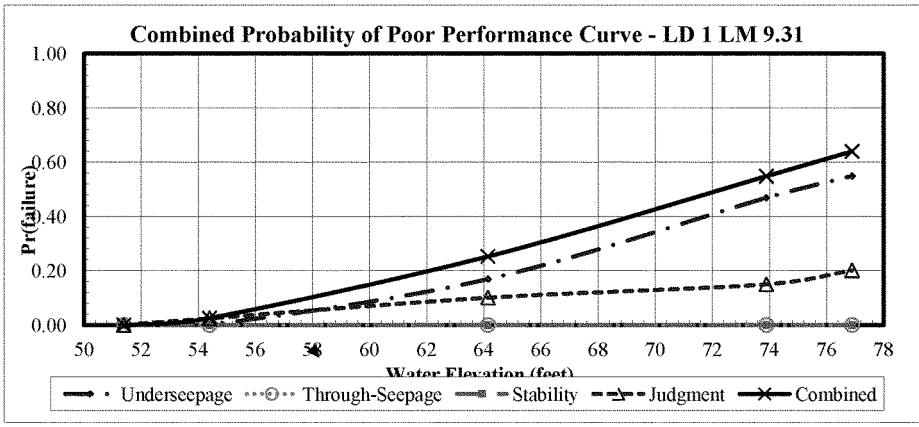

Figure 7-6 Combined R&U, Feather River South (Shanghai)

7.8 Feather River North – LD9 Reach

The section describes the reach selection and modeling criteria for the Feather River North – LD9 Reach.

Reach Selection:

This reach was selected to model the reach north of Yuba City that has experienced distress during flood events but has not had previous seepage or stability improvements, and is not adjacent to the Sutter Butte Canal. This reach is identified as PLM 5.6 downstream to PLM 0.0 of LD9, and is 5.6 miles long.

Selection of Cross-Section: The cross-section was selected to represent the portion of the reach most likely to breach based on previous screening analysis, and is located at PLM 0.52 of Levee District 9.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 7.5 and 20 feet and consists of clay, silt, and sandy clay overlaying a sand and silty sand aquifer 3.5-37 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-20.

Table 7-20 Permeabilities, Feather River North – LD9

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay Blanket (CL)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Silt/Clay Blanket (CL, ML)	1.9×10^{-4}	0.56	4.9×10^{-5}	0.14	4
Sandy Clay Blanket (SC)	1.9×10^{-3}	5.6	4.9×10^{-4}	1.4	4
Silty Sand Aquifer (SW-SM)	4.9×10^{-3}	14	4.9×10^{-4}	1.4	10
Sand Aquifer (SW)	9.8×10^{-3}	28	9.8×10^{-4}	2.8	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-21 as follows.

Table 7-21 Random Variables, Feather River North – LD9

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	13	5	38
Permeability Ratio (k_f/k_b)	1730	1217	70
Foundation Sand thickness (d)	28	17	61

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-22.

Table 7-22 Stability Random Variables, Feather River North – LD9

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	29	4	13
Levee Unit Weight γ (pcf)	120	48	40
Blanket Layer Cohesion c (psf)	150	11	7
Blanket Layer Unit Weight γ(pcf))	120	16	13
Blanket Layer Φ(degrees)	31	12	40

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-7. The underseepage performance mode accounts for much of the risk of failure for this reach. This is consistent with the performance history of excessive seepage, and boils during flood events.

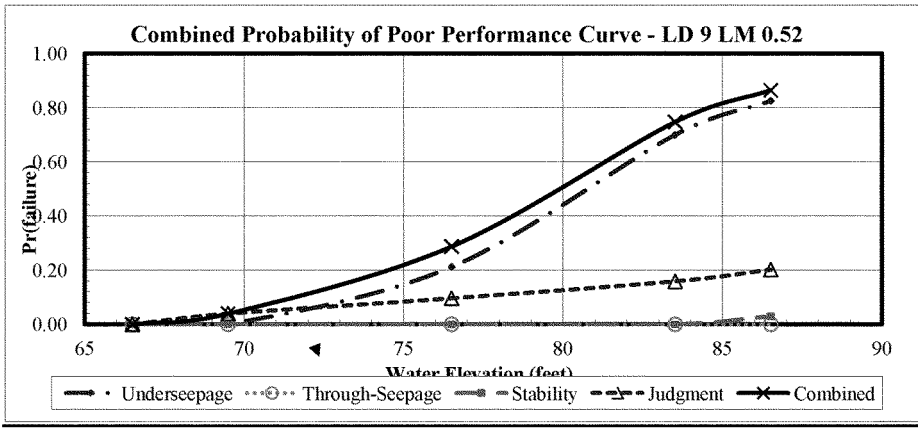

Figure 7-7 Combined R&U, Feather River North – LD9

7.9 Feather River North – Middle Reach

The section describes the reach selection and modeling criteria for the Feather River North – Middle Reach.

Reach Selection:

This reach was selected to model the reach within the agricultural area north of Yuba City that has not experienced any distress during flood events and is not adjacent to the Sutter Butte Canal. This reach is identified as PLM 2.8 downstream to PLM 0.0 of MA 16 and PLM 6.24 downstream to PLM 5.6 of LD9, and is approximately 3.44 miles long.

Selection of Cross-Section: The cross-section at PLM 0.09 of MA 16 was selected to represent this reach.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 3 and 15 feet and consists of silty clay and clay overlaying a sand and silty sand aquifer 1.5-30 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-23.

Table 7-23 Permeabilities, Feather River North - Middle

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay/Silt Blanket (CL, ML)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Thin Clay/Silt Blanket (CL, ML)	4×10^{-5}	0.114	1.1×10^{-5}	0.0284	4
Silty Sand Aquifer (SM)	4.9×10^{-3}	14	4.9×10^{-4}	1.4	10
Sand Aquifer (SP-SM)	9.8×10^{-3}	28	9.8×10^{-4}	2.8	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-24 as follows.

Table 7-24 Random Variables, Feather River North - Middle

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	6	5	76
Permeability Ratio (k_f/k_b)	2633	1742	56
Foundation Sand thickness (d)	16	8	53

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-25.

Table 7-25 Stability Random Variables, Feather River North - Middle

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	31	4	12
Levee Unit Weight γ (pcf)	125	6	5
Blanket Layer Cohesion c (psf)	150	50	33
Blanket Layer Unit Weight γ(pcf))	115	6	5
Blanket Layer Φ(degrees)	28	3	12

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-8. The underseepage performance mode accounts for much of the risk of failure for this levee reach.

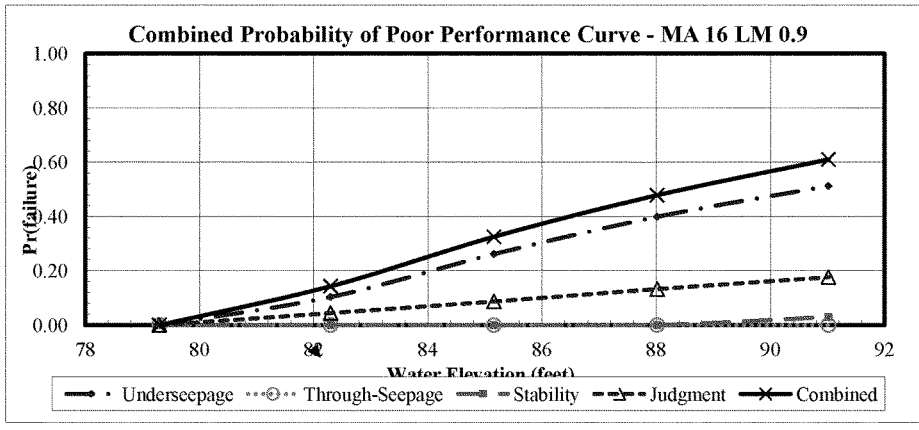

Figure 7-8 Combined R&U, Feather River North - Middle

7.10 Feather River North – Canal Reach

The section describes the reach selection and modeling criteria for the Feather River North-Canal Reach.

Reach Selection:

This reach represents the portion of the North Feather River levee that is abutted by the Sutter Butte Canal from PLM 2.65 downstream to PLM 0 of MA7, and PLM 4.09 downstream to PLM 2.8 of MA16. This reach is approximately 3.94 miles long.

Selection of Cross-Section: The cross-section selected to represent the levee with the irrigation canal is at PLM 2.9 of MA 16.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 8 and 20 feet and consists of silt, clay, sandy silt, and sandy clay overlaying a sand and silty sand aquifer 3-18 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-26.

Table 7-26 Permeabilities, Feather River North - Canal

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Thin Clay/Silt Blanket (CL, ML)	3.9×10^{-4}	1.12	9.8×10^{-5}	0.28	4
Clay/Silt Blanket (CL, ML)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Silty Sand/Clayey Sand Blanket (SC, SM)	1.9×10^{-4}	0.56	4.9×10^{-5}	0.14	4
Silty Sand Aquifer (SM)	4.9×10^{-3}	14	4.9×10^{-4}	1.4	10
Sand Aquifer (SP-SM)	9.8×10^{-3}	28	9.8×10^{-4}	2.8	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-27 as follows.

Table 7-27 Random Variables – Feather River North - Canal

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	13	5	41
Permeability Ratio (k_f/k_b)	1053	1032	98
Foundation Sand thickness (d)	12	5	45

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-28.

Table 7-28 Stability Random Variables – Feather River North Canal

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	29	1	5
Levee Unit Weight γ (pcf)	120	6	5
Blanket Layer Cohesion c (psf)	150	17	11.5
Blanket Layer Unit Weight γ(pcf))	120	6	5
Blanket Layer Φ(degrees)	31	4	11.5

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-8. The underseepage and judgment performance modes account almost equally for the risk for this levee reach. In addition to the canal adjacent to the landside toe, there are numerous culverts through this levee, many of which were installed in the 1940's.

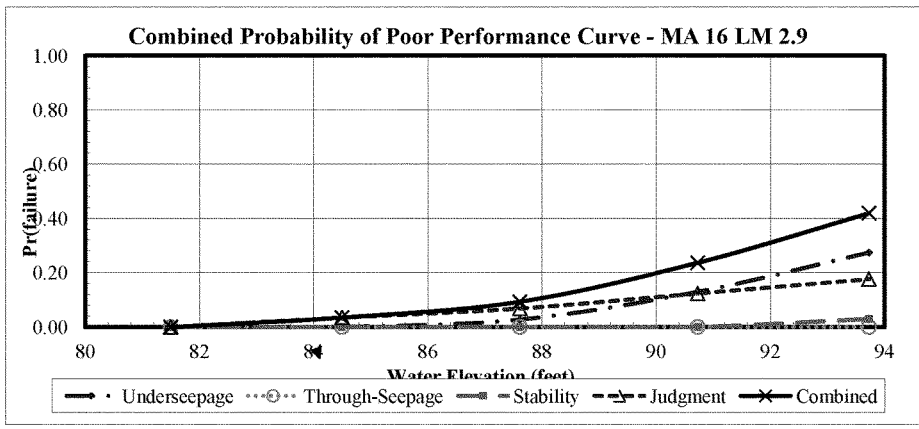

Figure 7-9 Combined R&U, Feather River North - Canal

7.11 Feather River North – Hamilton Bend Reach

The section describes the reach selection and modeling criteria for the Feather River North-Hamilton Bend Reach.

Reach Selection:

This reach is characterized by deposits of dredge tailings (silty and clayey gravel to small cobble size) beneath the levee from roughly PLM 1.20 downstream to PLM 0 (MA 7/Hamilton Bend Unit) and PLM 12.07 downstream to 2.65 (MA 7) for a total of roughly 8.8 miles. The MA 7/Hamilton Bend Unit levee was mostly constructed from the dredge tailings.

Selection of Cross-Section: The cross-section selected to represent the portion of the segment most likely to breach is where the levee is relatively tall at MA 7/Hamilton Bend Unit PLM 0.51.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 8.5 and 12 feet and consists of clay, sandy silt, sandy clay, and clayey sand overlaying a silty sand and gravel aquifer 10-60.5 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-29.

Table 7-29 Permeabilities, Feather River North – Hamilton Bend

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay Blanket (CL)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Sandy Silt/Sandy Clay Blanket (CL, ML)	1.4×10^{-5}	0.04	3.5×10^{-6}	0.01	4
Clayey Sand Blanket (SC)	1.9×10^{-4}	0.56	4.9×10^{-5}	0.14	4
Silty Sand and Gravel Aquifer (SM, GM)	4.9×10^{-3}	14	4.9×10^{-4}	1.4	10
Sand/Gravel Aquifer (SP-SM, SP, GM, GP)	2.5×10^{-2}	70	2.5×10^{-3}	7	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-30 as follows.

Table 7-30 Random Variables – Feather River North – Hamilton Bend

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	12	13	26
Permeability Ratio (k_f/k_b)	11742	11507	98
Foundation Sand thickness (d)	30	21	70

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-31.

Table 7-31 Stability Random Variables – Feather River North – Hamilton Bend

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	29	1	5
Levee Unit Weight γ (pcf)	120	6	5
Blanket Layer Cohesion c (psf)	150	17	11.5
Blanket Layer Unit Weight γ(pcf))	120	6	5
Blanket Layer Φ(degrees)	31	4	11.5

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-10. The underseepage performance mode accounts for almost all of the risk for this levee reach. This is

consistent with the foundation conditions of a thin blanket overlying a highly pervious sand and gravel layer.

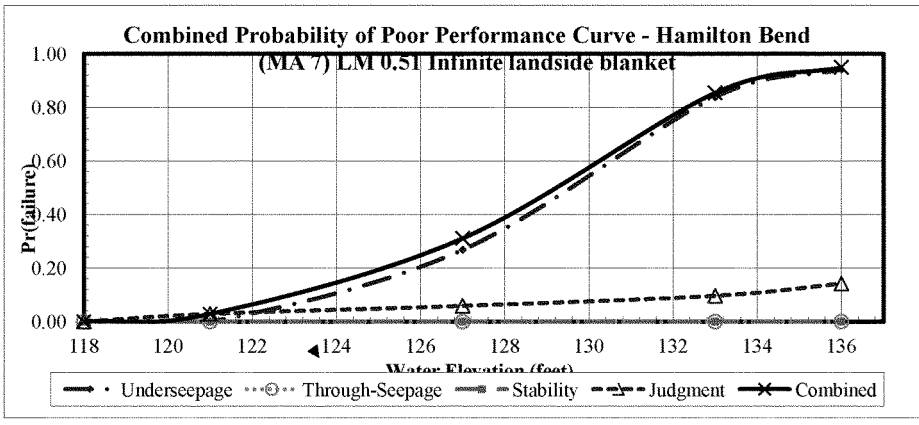

Figure 7-10 Combined R&U, Feather River North – Hamilton Bend

7.12 Cherokee Canal

The section describes the reach selection and modeling criteria for the Cherokee Canal left levee from PLM 9.9 upstream to PLM 6.10.

Reach Selection:

This reach consists of the entire portion of the levee that is within the SBFS. Boring logs on this levee from the Corps' Feasibility Study are in Enclosure D.

Selection of Cross-Section: The cross-section at PLM 9.50 was selected to represent the reach. It is the location of the boring most downstream, and at the location of the tallest portion of the levee. This location overtopped in 1986 due to flooding induced by debris build-up at the railroad bridge immediately downstream.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. The thickness of the blanket varies between 3 and 19 feet and consists mostly of silt and sandy silt with some low-plasticity clay overlaying a sand, silty sand, and clayey sand aquifer 1.5-14.5 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-32.

Table 7-32 Permeabilities, Cherokee Canal

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay Blanket (CL)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Silt Blanket (ML)	1.4×10^{-5}	0.04	3.5×10^{-6}	0.01	4
Sandy Silt/Clayey Sand Blanket (ML, SC)	1.9×10^{-4}	0.56	4.9×10^{-5}	0.14	4
Silty Sand/Clayey Sand Aquifer (SM, SC)	3.5×10^{-4}	1	3.5×10^{-5}	0.1	10
Sand Aquifer (SP, SW)	3.5×10^{-3}	10	3.5×10^{-4}	1	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-33 as follows.

Table 7-33 Random Variables – Cherokee Canal

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	8	5	63
Permeability Ratio (k_f/k_b)	417	409	98
Foundation Sand thickness (d)	9	5	56

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-34. For this reach, the levee cohesion was varied instead of the foundation cohesion. The foundation consists mostly of silt and sandy silt soils with low to no cohesion.

Table 7-34 Stability Random Variables – Cherokee Canal

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	28	1	5
Levee Unit Weight γ (pcf)	120	6	5
Levee Cohesion c (psf)	150	17	11.5
Blanket Layer Unit Weight γ(pcf))	115	6	5
Blanket Layer Φ(degrees)	29	3	11.5

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-11. The underseepage performance mode accounts for almost all of the risk for this levee reach, although the risk is lower than other reaches in the study. This is consistent with the low levee height and the lack of poor underseepage performance history with this portion of levee.

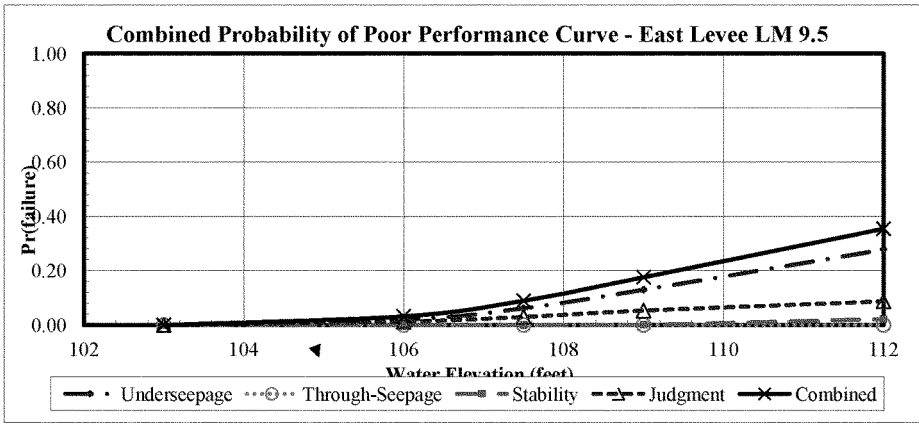

Figure 7-11 Combined R&U, Cherokee Canal

7.13 Wadsworth Canal (right)

There are no existing soil borings along the right levee of the Wadsworth Canal. This levee was added to the Feasibility Study recently at the request of the local sponsor, and this levee is included in the NULE program, which has not had explorations conducted. This levee only protects agricultural land – the small town of Sutter is located on high ground at the base of the Sutter Buttes – so economic damages from a breach would be insufficient to justify Federal interest in modifying or strengthening the levee. Due to the lack of potential economic damages and the time/funding restraints of the 3-3-3 Pilot Study, we decided to base the fragility curve on existing borings on the left levee of the Wadsworth Canal. The canal is about 300 feet wide (levee crest centerline to levee crest centerline).

Reach Selection: One reach, from PLM 0.00 to 4.66, was used for this levee, due to the lack of subsurface data.

Selection of Cross-Section: The cross section at PLM 0.50 was selected to represent this reach. This levee increases in height from about 5 feet at the upstream end to 20 feet at the downstream end, and the left bank levee has experienced seepage and boils during floods at the downstream end.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. Since this index point is located downstream of the index point on the left side of the canal, the underseepage statistical parameters for this reach were determined using more borings within the cutoff wall extent on the left side. The thickness of the blanket varies between 4 and 10 feet and consists of clay, silt, sandy clay, and sandy silt, overlaying a sand, silty sand, and clayey sand aquifer 3-28 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet and the permeabilities are summarized in Table 7-35.

Table 7-35 Permeabilities, Wadsworth Canal (Right)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay Blanket (CL)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Silt Blanket (ML)	4.9×10^{-5}	0.14	1.2×10^{-5}	0.035	4
Silty Sand Blanket (ML)	4.9×10^{-4}	1.4	1.2×10^{-4}	0.35	4

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Silty Sand Aquifer (SM)	$4.9x10^{-4}$	1.4	$4.9x10^{-5}$	0.14	10
Sand with Silt/Clay Aquifer (SP-SC, SP-SC)	$4.9x10^{-3}$	14	$4.9x10^{-4}$	1.4	10
Sand Aquifer (SP)	$9.8x10^{-3}$	28	$9.8x10^{-4}$	2.8	10

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 7-36 as follows.

Table 7-36 Random Variables – Wadsworth Canal (Right)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	7	2	29
Permeability Ratio (k_f/k_b)	1244	1219	98
Foundation Sand thickness (d)	13	11	85

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-37.

Table 7-37 Stability Random Variables – Wadsworth Canal (Right)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	32	4	13

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Cohesion c (psf)	10	4	40
Levee Unit Weight γ (pcf)	125	9	7
Blanket Layer Φ(degrees)	28	4	13
Blanket Layer Cohesion c (psf)	100	40	40

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-12. The underseepage performance mode accounts for almost all of the risk for this levee reach. This is consistent with the thin blanket layer compared to the levee height near the index point and the history of excessive seepage and boils in the downstream part of this reach.

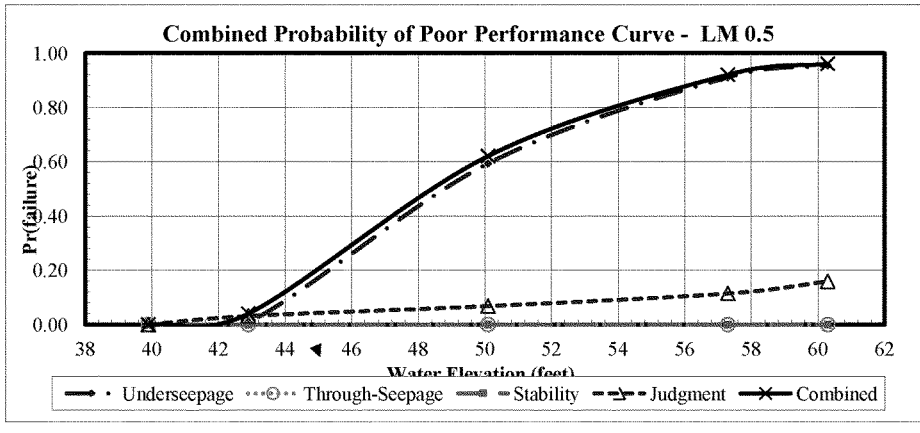

Figure 7-12 Combined R&U, Wadsworth Canal (Right)

7.14 Sutter Bypass (upstream)

There are no existing soil borings along the left levee of the Sutter Bypass upstream of Wadsworth Canal. This levee was added to the Feasibility Study recently at the request of the local sponsor, and this levee is included in the NULE program, which has not had explorations

conducted. This levee only protects agricultural land – the small town of Sutter is located on high ground at the base of the Sutter Buttes – so any economic damages from a breach would be insufficient to justify Federal interest in modifying or strengthening the levee. Due to the lack of potential economic damages and the time/funding restraints of the Pilot Study, we decided to base the fragility curve on existing borings on the Sutter Bypass downstream of the Wadsworth Canal.

Reach Selection: One reach, from PLM 0.00 to 4.31, was used for this levee, due to the lack of subsurface data.

Selection of Cross-Section: The cross section at PLM 4.0 was selected to represent this reach. The levee height and levee geometry do not vary significantly over this reach, and this cross section is just upstream of the Wadsworth Canal, not far from the closest soil boring on the Sutter Bypass downstream of the Wadsworth Canal.

Underseepage Reliability Analysis: The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point. Since there are no soil borings in this levee reach, the same borings, permeabilities, and statistical parameters were used for this reach as for the Sutter Bypass (Upper) Reach. The permeabilities are summarized in Table 7-38 and the random variables are shown on Table 7-39 (identical to Tables 7-5 and 7-6 respectively).

Table 7-38 Permeabilities, Sutter Bypass (Upstream)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio K_h/K_v
	cm/sec	ft/day	cm/sec	ft/day	
Clay/Sandy Clay Blanket (CL)	9.8×10^{-6}	0.028	2.5×10^{-6}	0.007	4
Silty Sand Blanket (SM)	4.2×10^{-4}	1.2	1×10^{-4}	0.3	4
Silty Sand Aquifer(SM)	1×10^{-3}	3	1×10^{-4}	0.3	10
Sand with Silt Aquifer (SP-SM)	3.5×10^{-3}	10	3.5×10^{-4}	1	10

Table76-39 Random Variables – Sutter Bypass (Upstream)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	10	4	40
Permeability Ratio (k_f/k_b)	725	650	90
Foundation Sand thickness (d)	10	6	60

Stability Reliability Analysis: The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 7-40. The stability parameters used for this reach were based solely on the closest boring to the index point, whereas the stability parameters used for the Sutter Bypass (Upper) Reach were based on borings further downstream, closer to that index point.

Table 7-40 Stability Random Variables – Sutter Bypass (Upstream)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Φ(degrees)	28	3	12
Levee Unit Weight γ (pcf)	115	6	5
Blanket Layer Cohesion c (psf)	200	66	33
Blanket Layer Unit Weight γ (pcf)	115	6	5
Blanket Layer Φ(degrees)	28	3	12

Probability of Failure Curve: The combined fragility curve is shown in Figure 7-13. The underseepage performance mode accounts for almost all of the risk for this levee reach at low water surface elevations; underseepage and stability both contribute to the risk at high water elevations. Even though the same random variables were used for this reach as for the Sutter Bypass (Upper) Reach, the underseepage curve is slightly different because the levee at this

index point is about 6 feet shorter than the levee at the Sutter Bypass (Upper) index point. This is consistent with the thin blanket layer compared to the levee height near the index point.

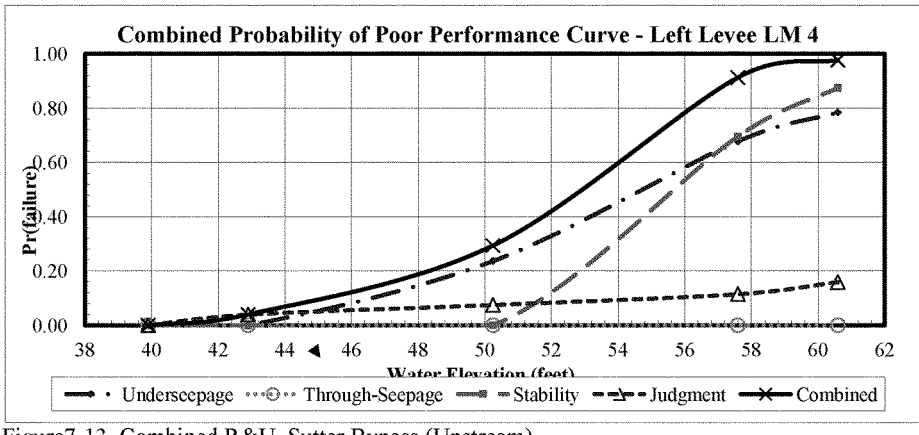

Figure7-13 Combined R&U, Sutter Bypass (Upstream)

8 GEOTECHNICAL ASPECTS OF FEASIBILITY STUDY ALTERNATIVES

8.1 General

Eight draft alternatives for reducing the flood risk within the SBFS system levees were developed as part of the Feasibility Study. The plan formulation process, including description of the draft array of alternatives, screening of alternatives, and the recommended Tentatively Selected Plan (TSP), is covered in detail in Chapter 3 of the main Feasibility Study report. During the screening of the draft array of alternatives, geotechnical recommendations for seepage and stability remediation for fix-in-place alternatives and seepage controls for non-fix in place alternatives (e.g. new ring levees, setback levees, etc.) were developed based in large part using engineering judgment. This Class 4 (reconnaissance level) approach was used to equalize the potential differences between seepage controls recommended for segments with existing geotechnical data, and those that had no subsurface data (non-fix-in-place measures). The approach assumed that cutoff walls were the primary method for seepage control, and the design of the measures (e.g. length, depth, percentage of reach, etc) was selected using judgment and the principal of most likely minimum and maximum for each value. After identifying a range, a expected mean value was selected again using judgment based on experience. This approach was used for evaluation of the draft array of alternatives only, and a memorandum documenting this action is in Enclosure H of this report. The design of the final array of alternatives was based on a Class 3 (feasibility level) conventional approach using existing subsurface explorations and deterministic seepage and stability analyses.

The remainder of this chapter in the Geotechnical Appendix to the Feasibility Study discusses the geotechnical aspects of the final array of alternatives. The final array of alternatives is:

- Alternative SB-1: No action
- Alternative SB-7: Fix-in-Place Feather River Levees: Sunset Weir to Laurel Avenue
- Alternative SB-8: Fix-in-Place Feather River Levees: Thermalito Afterbay to Laurel Avenue

8.2 Minimum Levee Design Criteria

Minimum levee design criteria from four sources (EM 1110-2-1913, Sacramento District Geotechnical Levee Practice, DWR Urban Levee Design Criteria, and the Code of California Regulations (CCR) Title 23 Division 1) is shown on Plate 10. The criteria are slightly different between the sources; in summary, the requirements are for a crest width of 10-20 feet, sideslopes of 2H:1V to 3H:1V, a landside easement of 10-20 feet, and a waterside easement of 15 feet. The Sacramento District Geotechnical Levee Practice and DWR Urban Levee criteria are for newly-

constructed levees; exceptions may be allowed on a case-by-case basis for the reconstruction/improvement of existing levees. The Sacramento District allows a narrower crest width for existing levees that have improvements constructed to address seepage and stability concerns, although we generally will not go narrower than 15 feet to allow for 2-way pickup truck traffic on the levee crest. The Sacramento District also will accept whatever landside or waterside easement the local sponsor has. In cases where there is no existing landside easement, we require a minimum easement of 10 feet in urban areas. In conjunction with the Sacramento District Levee Safety Program Manager, the following minimum levee template criteria were adopted for this Feasibility Study:

- Crest width: 15 feet
- Landside slope: 2H:1V
- Waterside slope: 3H:1V where levee is being reshaped or relocated; existing slope at other locations
- Landside easement: 15 feet or the existing easement
- Waterside easement: 15 feet

The existing landside and waterside easements along the FRWL are not known at this time. Sponsors/LMAs frequently do not have records of their easements, and experience on other projects shows the work to determine the existing easements can take up to a year to complete. The Feasibility Study Real Estate maps were produced assuming a 15-foot waterside easement over the entire FRWL, a 15-foot landside easement in the urban area of Yuba City (between SBFCA stations 821+00 to 1135+00), and a 20-foot landside easement outside of Yuba City, except at one location where there is an existing 10-foot bench between the landside levee toe and the Sutter Butte Canal. At that location, a 10-foot landside easement is shown on the Real Estate Maps. The existing easements will be researched during the Planning and Engineering Design (PED) phase to develop a record of the existing easements and determine what easements need to be purchased.

8.3 Alternative SB-1: No Action

Under the No Action alternative, the existing condition of the levees as described in Chapters 1 and 7 of this report will continue into the future. The FRWL will continue to experience seepage-related distress during future flood events. Floodfighting will continue to be an expense for the LMAs and PL 84-99 rehabilitation assistance will continue to be an expense for the Federal Government (as long as the levees are active in the program). Individuals and critical infrastructure within the SBLS will remain at high risk from future flood events.

8.4 Alternatives SB-7 and SB-8 (in Relation to the SBFCA FRWL Improvement Project)

8.4.1 General

Due to the time and funding constraints of the Pilot Study process, the Feasibility Study Project Delivery Team (PDT) relied heavily on the SBFCA FRWL Improvement Project design reports for the proposed improvements, plans, quantity take-offs, and cost estimates for developing the Feasibility level design and cost estimate for Alternatives SB-7 and SB-8. Currently the SBFCA FRWL Improvement Project is at the 100% design level for the Contract C area between Shanghai Bend and Live Oak (LD 1 PLM 11.08 to MA16 PLM 2.87, SBFCA station 844+00 to 1625+00). The areas between Laurel Avenue and Shanghai Bend (MA3 PLM 3.64 to LD 1 PLM 10.66, SBFCA station 180+00 to 832+00), and Live Oak to Thermalito Afterbay outlet channel (MA 7 PLM 0.00 to Hamilton Bend PLM 1.20, SBFCA station 1625+00 to 2367+00) are at the 65% design level. The Feasibility Study design and cost estimate are based on the SBFCA 65% design submittal; the 90% design for the Contract C area was submitted in October 2012, and the Feasibility Study effort needed to get underway in July 2012 to stay on schedule. While design modifications between 65% and 90% submittals can and do occur, a 65% design submittal is more detailed than the usual Feasibility-level design, and the contingency added to the Feasibility Study cost estimate is expected to account for changes between the 65% design and the final design.

8.4.2 Remediation Measures

Where the existing levee meets the geotechnical seepage and stability criteria, due to either an existing cutoff wall or levee geometry/subsurface conditions, no remediation is needed. Where remediation is needed, cutoff walls are the primary feature of the SBFCA project for remediating geotechnical deficiencies of the existing FRWL for the following reasons:

- Cutoff walls are highly effective when constructed properly
- Cutoff walls do not require the acquisition of additional permanent real estate
- Cutoff walls do not require maintenance once constructed
- Cutoff walls constructed by the conventional open-trench method are cost comparable to landside seepage berms when the costs of additional permanent real estate and environmental mitigation associated with seepage berms are included
- Cutoff walls have minimal long-term environmental impact primarily due to their location within the existing levee footprint.

Early in their design process, the SBFCA design team evaluated two primary measures for remediation of the FRWL. In general, the measures were a fully-penetrating soil-bentonite (SB) cutoff wall and a shallow SB cutoff wall combined with a seepage berm or relief wells (both alternatives include a partial levee degrade to obtain the needed working platform width). A reach-by-reach cost comparison between the two measures showed a fully-penetrating SB cutoff wall was the least cost measure for most reaches (see Chapters 8 and 9 and Table 9-1 of the main Pre-Design Formulation Report for more information on the SBFCA cost analysis). However, site conditions dictated selection of a different measure for some reaches or portions of reaches. Those conditions are summarized in the following bullets.

- A cutoff wall with a full levee degrade is proposed where the levee has a severe burrowing rodent infestation just north of Yuba City and to prevent having to use the

more expensive Deep Mixing Method (DMM) for cutoff wall construction due to depth just north of Shanghai Bend.

- Jet grout cutoff walls are proposed at locations where it is not practical to construct a conventional SB cutoff wall (i.e. bridges, railroad crossings, and the Yuba City Water Treatment Plant).
- Seepage berms by themselves are used in the northernmost end of the FRWL because a conventional SB cutoff wall may not be constructible through the cobble levee.
- Partially penetrating cutoff walls combined with seepage berms or relief wells are used in the southern end of the FRWL because fully-penetrating cutoff walls would need to be too deep to be cost-effective.

The Feasibility Study PDT modified the SBFCA 65% plans to address some minor differences between the SBFCA 408 project and the recommended Feasibility project (see section 8.5 of this report for details of the modifications). The modified SBFCA 65% plans are given in Appendix M of this report, but are provided as a separate file. Table 8-1 lists the proposed remedial measures from the SBFCA 65% plans from downstream to upstream. There are overlaps at the transitions between remedial measures (for example, an SB cutoff wall to a jet grout cutoff wall).

Table 8-1 Proposed Remedial Measures, SBFCA FRWL Improvement Project, 65% Plans

Location (PLM)	Location (SBFCA Stationing)	Remedial Measures
MA3 PLM 3.26 to MA3 PLM 4.19	180+00 to 230+00	Degrade levee to approximately half-height, SB cutoff wall (depth 27 ft), reconstruct levee, seepage berm, culvert replacement
MA3 PLM 4.19 to LD1 PLM 3.24	230+00 to 451+00	Degrade levee to approximately half-height, SB cutoff wall (depth 33 to 88 ft), reconstruct levee, culvert removal, culvert replacement
LD PLM 3.24 to LD1 PLM 3.71	451+00 to 476+00	Degrade levee to approximately half-height, SB cutoff wall (depth 41.5 ft), reconstruct levee, seepage berm, culvert removal
LD1 PLM 3.71 to LD1 PLM 4.61	476+00 to 513+50	No work (Star Bend setback levee/cutoff wall) *(Note: See paragraph 8.4.3 for additional information on the Star Bend area)*
LD1 PLM 4.61 to LD1 PLM 10.66	513+50 to 832+00	Degrade levee to approximately half-height, SB cutoff wall (depth 40 to 73 ft), reconstruct levee, new relief wells (sta 545+00 to 570+00 only), culvert removal, culvert replacement
LD1 PLM 10.66 to LD1 PLM 11.08	832+00 to 844+00	No work (Shanghai Bend setback levee/cutoff wall)
LD1 PLM 11.08 to LD1 PLM 12.21	844+00 to 898+00	Degrade entire levee, SB cutoff wall (depth 85 ft), reconstruct levee, rehabilitation or replacement of existing relief wells, culvert replacement

Location (PLM)	Location (SBFCA Stationing)	Remedial Measures
LD1 PLM 12.21 to LD1 PLM 12.70	898+00 to 923+75	Degrade levee to approximately half-height, SB cutoff wall (depth 44'), reconstruct levee, culvert replacement
LD1 PLM 12.70 to LD1 PLM 14.34	923+75 to 1006+04	Encroaching structure demolition (existing Yuba City cutoff wall)
LD1 PLM 14.34 to LD1 PLM 14.38	1006+04 to 1007+90	Jet grout cutoff wall (depth 41') at railroad and Fifth St. bridges
LD1 PLM 14.38 to LD1 PLM 14.61	1007+90 to 1023+70	Culvert removal (existing Yuba City cutoff wall)
LD1 PLM 14.61 to LD1 PLM 14.70	1023+70 to 1028+30	Stability berm, fill in unused tunnel at 10th Street bridge
LD1 PLM 14.70 to LD1 PLM 15.64	1028+30 to 1077+85	Culvert replacement (existing Yuba City cutoff wall)
LD1 PLM 15.64 to LD1 PLM 15.98	1077+85 to 1096+00	Degrade levee to approximately half-height, SB cutoff wall (depth 40 ft), reconstruct levee, culvert replacement
LD1 PLM 15.98 to LD1 PLM 16.03	1095+80 to 1098+30	Jet grout cutoff wall (depth 40 ft) at water treatment plant, culvert replacement
LD1 PLM 16.03 to LD1 PLM 16.63	1098+10 to 1129+98	Degrade levee to approximately half-height, SB cutoff wall (depth 40 to 77 ft), reconstruct levee, culvert replacement
LD1 PLM 16.62 to LD1 PLM 16.64	1129+49 to 1130+67	Jet grout cutoff wall (depth 77 ft), stoplog structure installation at railroad track crossing
LD1 PLM 16.64 to LD9 PLM 6.14	1130+20 to 1455+00	Degrade levee to approximately half-height, SB and DMM cutoff wall (depth 29 to 120 ft), reconstruct levee, culvert removal, culvert replacement *(Note: Alternative SB-7 ends at station 1433+83)*
LD9 POM 6.14 to MA 16 PLM 0.01	1455+00 to 1461+00	Degrade entire levee, SB cutoff wall (depth 35 ft), reconstruct levee
MA16 PLM 0.01 to MA16 PLM 3.15	1461+00 to 1625+00	Degrade levee to approximately half-height, SB cutoff wall (depth 26 to 62 ft) , reconstruct levee, culvert removal, culvert replacement
MA16 PLM 3.15 to MA16 PLM 4.06	1625+00 to 1673+00	Culvert replacement (short levee, no adjacent canal)
MA 16 PLM 4.06 to MA7 PLM 1.83	1673+00 to 1769+31	Degrade levee to approximately 20 to 50% of height, SB cutoff wall (depth 26 to 48 ft), reconstruct levee with shallower sideslopes, culvert replacement

Location (PLM)	Location (SBFCA Stationing)	Remedial Measures
MA7 PLM 1.83 to MA7 PLM 2.66	1769+31 to 1813+33	Culvert replacement (short levee, no adjacent canal)
MA7 PLM 2.66 to MA7 PLM 4.34	1813+33 to1900+50	Degrade levee to approximately 20 to 50% of height, SB cutoff wall (depth 18 to 73 ft), reconstruct levee, culvert removal, culvert replacement
MA7 PLM 4.33 to MA7 PLM 4.40	1900+00 to 1904+00	Jet grout cutoff wall (depth 78 ft) at Gridley bridge
MA7 PLM 4.39 to MA7 PLM 11.85	1903+50 to 2292+00	Degrade levee to approximately half-height, SB and DMM cutoff wall (depth 17 to 90 ft), reconstruct levee, culvert removal, culvert replacement
MA7 PLM 11.81 to MA7 PLM 12.06	2290+00 to 2303+00	Seepage berm (170 ft wide)
MA7 PLM 12.06 to Hamilton Bend PLM 0.51	2303+00 to 2330+75	Culvert removal (short, wide levee)
Hamilton Bend PLM 0.51 to Hamilton Bend PLM 1.20	2330+75 to 2367+00	Seepage berm (100-120 ft wide), culvert removal

The remainder of this section of this report gives locations only in SBFCA stationing, since PLMs are not shown in the SBFCA project geotechnical reports and the 65% design plans.

8.4.3 Star Bend

Star Bend is a 90-degree bend in the Feather River and the FRWL located approximately 8.7 miles south (downstream) of downtown Yuba City (SBFCA stations 478+50 to 512+00). As stated in paragraph 1.2.4.3 of this report, a setback levee with a 40 to 65-foot deep SB cutoff wall through the foundation was constructed at Star Bend by the LMA in 2008. The project sponsor would like to obtain reimbursement credit for the setback levee/cutoff wall under the Feasibility Study. Since the construction of setback levees with cutoff walls in the foundation is more expensive than fixing existing levees in place, the SBFS did not include a setback levee at Star Bend in any of the Study alternatives. The sponsor will only get reimbursement credit based on the cost of fixing the Star Bend levee in place by degrading the levee to approximately half it's height and constructing an SB cutoff wall with a depth of 65 feet.

8.5 Feasibility Study Modifications to SBFCA FRWL Improvement Project 65% Design Submittal

The SBFCA FRWL project design is being thoroughly reviewed at every phase for the 408 modification process. The design A/E firms (Wood Rodgers, HDR, MHM, Blackburn Consulting, and URS) do internal quality control review, and additional review is conducted by SBFCA, DWR, the Central Valley Flood Protection Board, and the Sacramento District. An Independent Panel of Experts (IPE) provides external and Safety Assurance Review (SAR). For the Feasibility Study, the PDT reviewed the 65% submittal to determine if it includes any improvements that are beyond Federal interest (and would be 100% sponsor cost) and if any improvements do not meet minimum study criteria. For the geotechnical discipline , nothing in the submittal was determined to be beyond Federal interest. However, three items, not directly geotechnical but related to levee safety, do not meet minimum Corps requirements. Those three items are discussed below.

8.5.1 Vegetation Removal

The Corps conditions for acceptance of a major/minor modification under the 408 process do not require all Corps requirements to be met. The Corps will approve proposed modifications under 408 as long as the levee integrity will not be reduced and any levee improvements may be credited to the Sponsor as long as the improvements are in agreement with the Feasibility Study approved improvement plan. The FRWL currently has mature trees on the both the levee slopes and within 15 feet of both the landside and waterside levee toes, with the majority of the trees being within 15 feet of the toes. The SBFCA plans include removal only of trees required to do the project construction. The Feasibility Study proposed plan for ETL 1110-2-571 compliance is for complete removal of all vegetation from the vegetation free zone as shown in the ETL. The PDT developed a cost estimate for removal of the woody vegetation from the levee vegetation free zone. Tree removal (and associated mitigation) costs were based on an estimate done by SBFCA. The estimated cost of ETL 1110-2-571 compliance by removal of woody vegetation is within the overall Feasibility Study cost contingency. A memorandum documenting this action is in Enclosure I of this report.

8.5.2 Landside Easement at the Sutter Butte Canal

At four locations (about 3.3 miles total length), the Sutter Butte Canal is adjacent to the landside levee toe, without a landside access easement. These locations are, from downstream to upstream:

- Station 1430+00 to 1449+00
- Station 1610+50 to 1623+00
- Station 1675+00 to 1765+80
- Station 1904+00 to 1957+00

The upstream location has a small landside bench, approximately 10 feet wide, between the levee toe and the canal. This bench can provide a 10-foot minimum required landside easement with some minor regrading. The PDT evaluated four options to obtain a landside easement at the other three locations. The options are:

1. Cut a horizontal bench into the landside levee toe at the cutoff wall degrade elevation and construct a retaining wall to replace the lower levee slope
2. Replace the levee with a floodwall
3. Realign the levee 15 feet to the waterside
4. Relocate the canal away from the levee toe

Option 3 was selected for the two downstream locations. At the third location (station 1675+00 to 1765+80), the levee is adjacent to the river at the upstream end of the location (station 1753+00 to 1765+80). Option 3 was selected for the downstream portion of this location (station 1675+00 to 1753+00) and option 4 was selected for the upstream portion of this location (station 1753+00 to 1765+80). Typical cross sections were prepared for all four locations and cost estimates were prepared for the selected option at each location. The Civil Design Appendix contains additional discussion of this issue.

8.5.3 Landside Slope Protection for Levee Superiority

The definition of levee superiority per EC 1110-2-6066 (Design of I-Walls, 31 October 2010) is the increment of additional height added to a flood risk management system to increase the likelihood that when the design event is exceeded, controlled flooding will occur at the design overtopping section. Since alternatives SB-7 and SB-8 are based on an existing levee profile, the design top of levee was reviewed relative to the modeled mean water surface profiles to determine the likely initial overtopping location. The initial overtopping in the alternative SB-7 footprint will likely occur between SBFCA stations 547+00 to 604+60. The initial overtopping in the footprint only covered by alternative SB-8 will likely occur between SBFCA stations 1582+00 to 1601+00. These locations are in non-urbanized areas and initial overtopping is estimated to occur between the mean 0.5% (1/200) ACE and 0.2% (1/500) ACE events. Within these 1-mile sections, the landside levee slope will be covered with an anchored High Performance Turf Reinforcement Mat (HPTRM). This design will increase the erosion resistance of the landside levee slope at the initial overtopping locations.

8.6 Overview of SBFCA Geotechnical Analysis

8.6.1 Existing Conditions

The Geotechnical Analyses for Pre-Design Formulation Report (PFR) (Appendix D of the PFR, dated August 2011), includes seepage and slope stability analyses for the existing condition of the FRWL. The PFR divided the levee into 41 reaches. One cross section was analyzed per reach. The analyses were conducted to determine which portions of the levee require remediation and to evaluate the effectiveness of various remedial measures. Analyses were

conducted at two water surfaces; the design water surface (DWS) and the hydraulic top of levee (HTOL). The DWS is defined as the 0.5% (1/200) Annual Chance of Exceedance (ACE) upstream of station 461+00 (located just downstream of the Star Bend setback levee) and the 1% (1/100) ACE downstream of station 461+00. (California state law, enacted in 2007 (SB 5), requires urban levees (defined as levees in areas of 10,000 people or more) to be designed to the 0.5% (1/200) ACE). Note that the DWS used in the SBFCA geotechnical design is not the project authorized water surface as described in the Hydraulic Appendix. The hydraulic top of levee (HTOL) is defined as the lowest of:

- The 0.5% (1/200) ACE plus 3 feet water surface upstream of station 461+00 and the 1% (1/100) ACE plus 3 feet water surface downstream of station 461+00
- The 0.2% (1/500) ACE water surface
- The levee crest elevation

One foot was added to the appropriate water surface elevations to evaluate remediation measures. The DWS+1 foot elevation was compared with the project authorized water surface at selected locations along the Feather River and the elevations agree within a foot.

For each cross section, analyses were conducted in the following order:

- Seepage at the DWS
- Seepage at the HTOL
- Landside slope stability at the DWS
- Landside slope stability at the HTOL
- Rapid Drawdown slope stability

The seepage analyses were done first due to the performance history of the FRWL, which has experienced extensive seepage-related distress but little stability-related distress during floods. If a section did not meet criteria for any analysis, it was determined to be in need of remediation, and the remaining existing conditions analyses were not conducted. Each section found to be in need of remediation was then re-analyzed with two remediation measures in place, generally a cutoff wall and a seepage berm.

Section 4.0 of the Geotechnical Analysis for the PFR describes the methodology used to select sections and parameters for seepage and stability analyses. Table 4-4 of the Geotechnical Analysis for the PFR gives seepage exit gradient criteria for the SBFCA design. Section 5.0 of the Geotechnical Analysis for the PFR discusses analysis results. Tables 5-1A through 5-41B of the Geotechnical Analysis for the PFR summarize the levee/foundation characterization and the seepage/stability analysis results for each reach. Those tables are included in Enclosure J of this report. Stick log profiles of the FRWL are given in Appendix A of the Geotechnical Analysis for the PFR. Analysis cross sections are shown in Appendix B of the Geotechnical Analysis for the PFR. The Geotechnical Analysis for the PFR is in Enclosure M of this report, but is provided as a separate file for ease of review. Most cross sections analyzed did not meet the project seepage criteria. This agrees with the deterministic and probabilistic analyses done for this study and the deterministic analyses done for the DWR ULE study, which show underseepage to

be the primary contributor to poor performance of the FRWL. This also agrees with the performance history of extensive seepage-related distress on the FRWL.

8.6.2 With-Project Conditions

Two final geotechnical reports were submitted in October 2012; the Geotechnical Design Recommendations Report (GDRR) (2 volumes) and the Geotechnical Data Report (GDR). These reports cover the entire Feather River West Levee from the Sutter Bypass confluence upstream to the Thermalito Afterbay outlet channel. These reports are included in Enclosure M of this report, but provided as separate files. The final GDR includes results of all geotechnical explorations done under the SBFCA FRWL Improvement Project. The final GDRR includes a general description of the levees; past performance history; remedial measures constructed to date; seismic vulnerability analysis; and with-project seepage and slope stability analyses conducted to support the levee improvements as shown on the 65% project plans. Stick log profiles of the FRWL are given in Appendix A of the final GDRR. The stick log profiles with the final GDRR contain explorations conducted by the FRWL Improvement Project and the DWR ULE project subsequent to the submittal of the Geotechnical Analysis for the PFF. With-project seepage and slope stability analyses were conducted on one to six cross sections per SBFCA reach. Sections 6.0 and 7.0 of the final GDRR describe the methodology for the with-project seepage and slope stability analyses. Section 8.0 of the final GDRR describes the analysis results. Table 8-1 of the final GDRR summarizes results of those analyses, including sensitivity analyses conducted on several cross sections to evaluate the effects of different parameters (including blanket layer thickness, soil type, soil permeability, soil shear strength, seepage analysis boundary conditions, and cutoff wall tip elevation). This table is included as Enclosure K of this report. Appendix C of the final GDRR contains with-project seepage and slope stability analysis sections. The with-project seepage and slope stability analyses were conducted at the same water surface elevations used to evaluate remediation alternatives in the Geotechnical Analysis for the PFR (DWS+1 foot and HTOL+1 foot). All proposed alternatives for all design analysis sections meet Corps design criteria. The SBFCA project as designed meets all required Corps geotechnical design criteria.

Settlement analysis was not conducted for the FRWL Improvement Project. The FRWL is several decades old and will be rebuilt to the same height after degrade and cutoff wall installation.

8.6.3 Seismic Vulnerability Analysis

As stated in section 6.3 of this Geotechnical Appendix, the Sacramento District draft manual for seismic deformation evaluation of levees, which is currently under review for nationwide implementation, recommends designing for seismic loading only those levees loaded permanently by high water levels. Levees subject to intermittent loading (which includes all the levees in the SBLS) will only be evaluated for liquefaction potential and seismic deformation to

inform sponsors of the risk level so they can identify and evaluate borrow sites for levee rebuilding after an earthquake, if necessary. Designing intermittently-loaded levees for seismic deformation is cost-prohibitive.

Seismic vulnerability analysis was conducted under both the DWR ULE and the SBFCA 408 projects. The ULE analysis covered all the levees within the SBLS, while the SBFCA analysis only covers the FRWL from Star Bend upstream to the Thermalito Afterbay outlet channel. The SBFCA 408 project analyzed more sections than the ULE project (44 versus 13, respectively) on the FRWL upstream of Star Bend because the SBFCA project is in design, while the ULE project is in the study phase. Both projects used a similar methodology for their analysis:

- A liquefaction triggering analysis was conducted using the higher of the average winter and average summer water surface elevations of the appropriate waterway. The ULE evaluation used peak ground accelerations (PGA) for the 100, 200, and 500-year earthquakes obtained from the ULE project guidance document, while the SBFCA analysis only used the 200-year earthquake PGA from the ULE guidance document.
- Post-earthquake slope stability analysis was then conducted, using undrained shear strengths for fine-grained soils and post-liquefaction undrained shear strengths for coarse-grained soils that were expected to liquefy. If the post-earthquake slope stability Factor of Safety was less than 1.0, the section was considered compromised and no additional analysis was done.
- Otherwise, a pseudo-static earthquake slope stability analysis was conducted using a seismic coefficient. If the pseudo-static slope stability Factor of Safety was greater than 1.0, then the section was considered probably uncompromised and no additional analysis was done.
- Otherwise, a Newmark-type deformation analysis was done to estimate horizontal displacement, from which vertical displacement and freeboard loss were estimated.

Based on the estimated vertical displacement, a seismic vulnerability classification (probably uncompromised, possibly compromised, probably compromised, or compromised) was determined. The ULE and SBFCA projects used slightly different criteria to determine the vulnerability classification. The ULE criteria is based on the amount of vertical deformation in feet and the remaining freeboard above a 50% (1/2) ACE water surface elevation and the SBFCA criteria is based on the amount of vertical deformation in percent of levee height and the remaining freeboard above a 10% (1/10) ACE water surface elevation. Table 8-2 compares the ULE and SBFCA seismic vulnerability classification criteria.

Table 8-2 Seismic Vulnerability Classification Criteria

Vertical Deformation		Significant Damage to internal structures (i.e. cutoff walls)	Remaining Freeboard for Post-Seismic Evaluation		Seismic Vulnerability Class
ULE (ft)	SBFCA (percent of landside levee height)		ULE (50% (1/2) ACE water surface) (ft)	SBFCA (10% (1/10) ACE water surface) (ft)	
<1	<5	No	>1	>1	Probably Uncompromised
1-3	<10	Possibly	>1	>1	Possibly Compromised
3-10	<20	Likely if existing	None	None	Probably Compromised
Unlimited (flow slide condition)	Unlimited, >10' (flow slide condition)	Yes	None	None	Compromised

Seismic vulnerability evaluation results from the SBFCA project are in Table 8-4 of the final GDRR and results from the ULE are in Tables 5-16 and 5-17 of the P1GER. SBFCA results are tabulated by reach while the ULE results are tabulated by a single station. The Sacramento District's geotechnical earthquake engineering expert reviewed the seismic vulnerability analyses performed for the ULE and SBFCA projects. His review is documented in a memorandum given in Enclosure L of this report. While there are minor differences between the ULE and SBFCA evaluations and the draft Corps of Engineers evaluation recommendations, the ULE and SBFCA evaluations are considered to be satisfactory. Table 8-3 of this report gives a comparison of the SBFCA and ULE seismic analysis results for reaches where both projects did an evaluation. The seismic vulnerability classifications are mostly the same between the two evaluations; the 3 differences are attributed to different soil borings being used for the two evaluations. As can be seen in Table 8-3 below and Table 8-4 of the final GDRR, some portions of the FRWL downstream of SBFCA station 1243+00 (located about 3 miles north of Yuba City) are predicted to experience significant deformation during a 200-year earthquake. The Sponsor is encouraged to identify emergency borrow area(s) to reconstruct the levee to a limited level of protection (10% (1/10) ACE) within 3 months after a significant earthquake.

Table 8-3 Comparison of SBFCA and ULE Seismic Vulnerability Class

SBFCA Reach	SBFCA Station Range	ULE Boring Location (SBFCA Station)	Seismic Vulnerability Class
8	598+87 to 654+75	626+31	Compromised (SBFCA)
			Possibly Compromised (ULE)
9	674+00 to 695+00	674+30	Probably Uncompromised (SBFCA and ULE)
13	845+00 to 927+00	861+17	Compromised (SBFCA and ULE)
15	954+00 to 968+00	959+03	Compromised (SBFCA and ULE)
18	1130+86 to 1136+00	1135+58	Possibly Compromised (SBFCA and ULE)
19	1213+85 to 1243+00	1229+81	Likely Compromised (SBFCA)
			Probably Uncompromised (ULE)
19	1213+85 to 1243+00	1238+43	Likely Compromised (SBFCA)
			Probably Uncompromised (ULE)
23	1503+83 to 1609+37	1508+51	Probably Uncompromised (SBFCA and ULE)
24	1609+37 to 1623+86	1615+61	Probably Uncompromised (SBFCA and ULE)
31	1902+00 to 1958+00	1907+37	Probably Uncompromised (SBFCA and ULE)
33	1989+00 to 2122+00	2076+95	Probably Uncompromised (SBFCA and ULE)
35	2182+00 to 2224+00	2187+00	Probably Uncompromised (SBFCA and ULE)
35	2182+00 to 2224+00	2212+09	Probably Uncompromised (SBFCA and ULE)

8.6.4 Conclusion

The Sacramento District recommends the SBFCA 408 project as shown on their 65% submittal plans (except for the items discussed in Section 8.4 of this report). The SBFCA geotechnical

analysis is in conformance with Corps design requirements and procedures and we agree with their analysis and analysis results. The levee improvements shown on the SBFCA 65% submittal plans will perform as intended at the water surfaces used for the geotechnical analyses.

8.7 Borrow Sites

The SBFCA FRWL Improvement Project specifications include two primary material types: Type 1 levee fill, primarily used as a clay core for the reconstructed levee above the cutoff wall, and Type 2 levee fill, primarily used for shells for the reconstructed levee above the cutoff wall. Specifications for the two material types are as follows:

- Type 1 Levee Fill: USCS classification of CL, SC, or CH and; maximum particle size of 2 inches; minimum 35% by weight passing the #200 sieve; maximum liquid limit of 60; plasticity index between 12 and 40.
- Type 2 Levee Fill: Maximum particle size of 2 inches; minimum 12% by weight passing the #200 sieve; maximum liquid limit of 45.

Based on geotechnical investigations and standard practice, an approximately 20% increase should be applied to the total demand (to account for all material swell, loss and shrinkage during excavation, transportation and placement, respectively) when estimating the borrow amount needed. The SBFCA project team estimated the amount of levee degrade material that is suitable for reuse on a reach-by-reach basis. The approximate percentages of levee degrade material suitable for reuse as levee fill are shown in Table 8-4.

Table 8-4 Percentage of Levee Degrade Material Suitable for Levee Fill

SBFCA Reach	Percentage for Levee Core (Type 1)	Fraction	Percentage for Levee Shell (Type 2)	Fraction
2A-North	5	0.05	95	0.95
2B	5	0.05	95	0.95
3	5	0.05	95	0.95
4	5	0.05	95	0.95

SBFCA Reach	Percentage for Levee Core (Type 1)	Fraction	Percentage for Levee Shell (Type 2)	Fraction
5	5	0.05	95	0.95
6	5	0.05	95	0.95
7	40	0.4	60	0.6
8	0	0	85	0.85
9	0	0	55	0.55
10	0	0	70	0.7
11	0	0	100	1
12	NA	NA	NA	NA
13	0	0	95	0.95
14	NA	NA	NA	NA
15	NA	NA	NA	NA
16	NA	NA	NA	NA
17	0	0	100	1
18	15	0.15	85	0.85

SBFCA Reach	Percentage for Levee Core (Type 1)	Fraction	Percentage for Levee Shell (Type 2)	Fraction
19	30	0.3	70	0.7
20	0	0	100	1
21	0	0	100	1
22	15	0.15	85	0.85
23	0	0	90	0.9
24	0	0	100	1
25	0	0	100	1
26	0	0	100	1
27	80	0.8	20	0.2
28	15	0.15	85	0.85
29	NA	NA	NA	NA
30	0	0	95	0.95
31	30	0.3	70	0.7
32	0	0	100	1

SBFCA Reach	Percentage for Levee Core (Type 1)	Fraction	Percentage for Levee Shell (Type 2)	Fraction
33	0	0	100	1
34	0	0	100	1
35	0	0	100	1
36	0	0	100	1
37	0	0	100	1
38	0	0	100	1
39	NA	NA	NA	NA
40	60	0.6	0	0
41	60	0.6	0	0

While some of the levee soils removed during degrading will be re-used to reconstruct the levee, it is anticipated that borrow material will be needed to meet the levee fill material specifications. The SBFCA FRWL Improvement Project has identified potential borrow sites (Plate 11) and is currently in the process of sampling and testing the sites to ensure they meet material requirements.

8.8 Pipelines Crossing the Levee

There are numerous pipelines crossing the levee alignment, including electrical and telephone cables and various types of water lines (interior drainage gravity lines, interior drainage pump lines, water supply lines, and sewage disposal lines). Installation dates of the pipes vary between the 1930's and the early 2000's. Installation dates and details are not available for some of the

pipes. Some of the pipes have not been maintained and some of them do not have a means of positive closure. The SBFCA design team evaluated each pipe based on installation date (known or unknown) and adherence to Corps criteria for pipelines crossing levees in EM 1110-2-1913. All pipes that are not currently being used will be removed. All active pipes known or suspected of being beyond their estimated service life will be removed and replaced to comply with Corps criteria, including routing above the design water surface for pressurized pipes and installing positive closure for all pipes. Pipes that are known to be recent installations will remain, although there may be minor modifications made to comply with Corps criteria. The Civil Design Appendix contains additional information on this issue.

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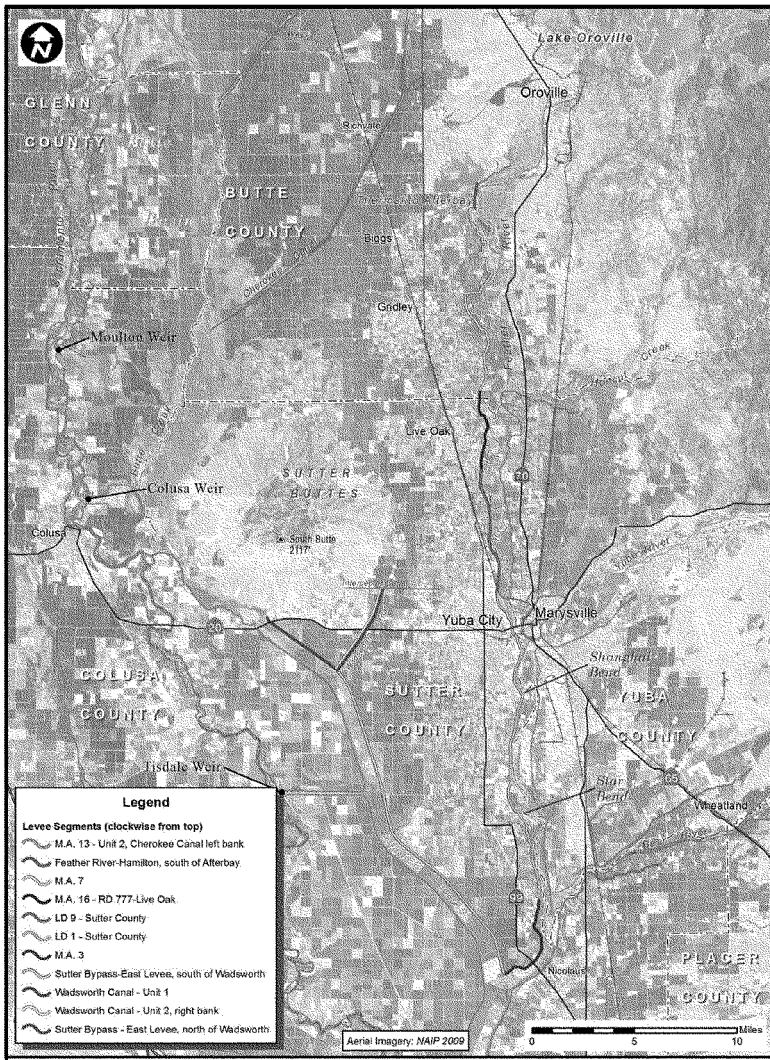
PLATES



DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

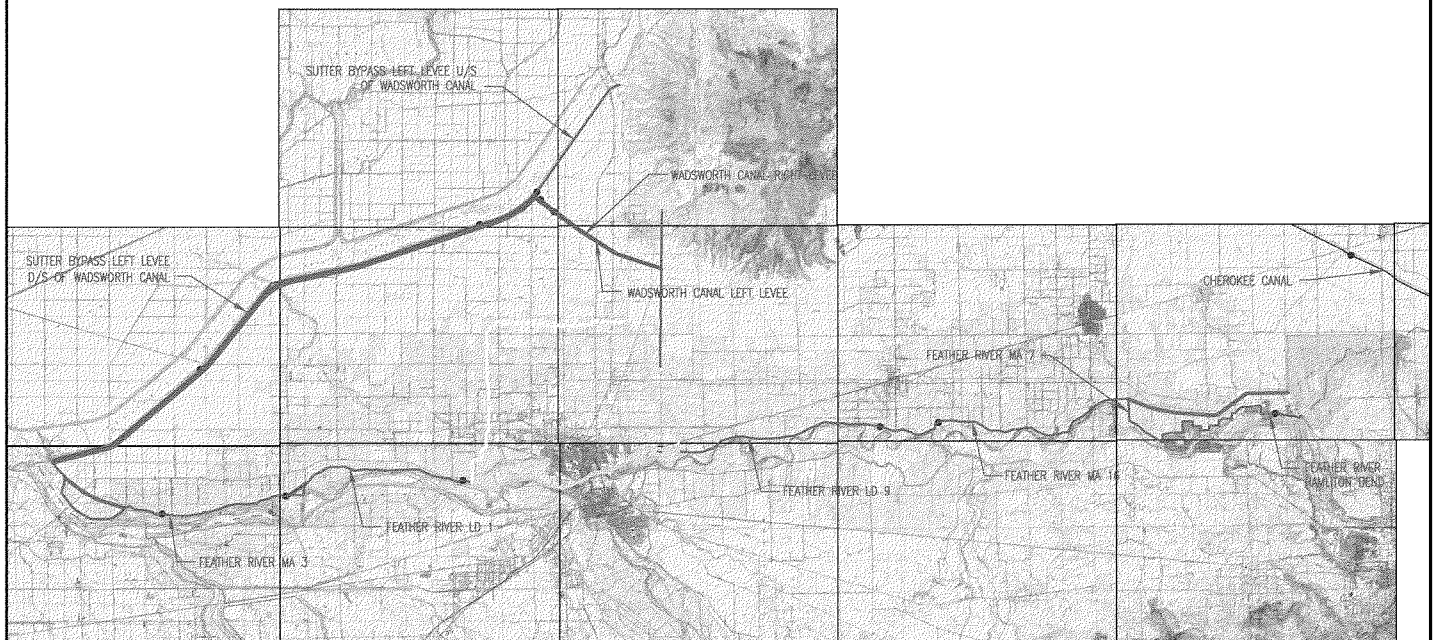
SUTTER & BUTE COUNTIES — CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

SEGMENT MAP

DATE: 8/20/2012 | SCALE: 1"=2500' | PLATE-1

DWG-INFO



SCALE IN FEET

0 7500 15000 30000

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

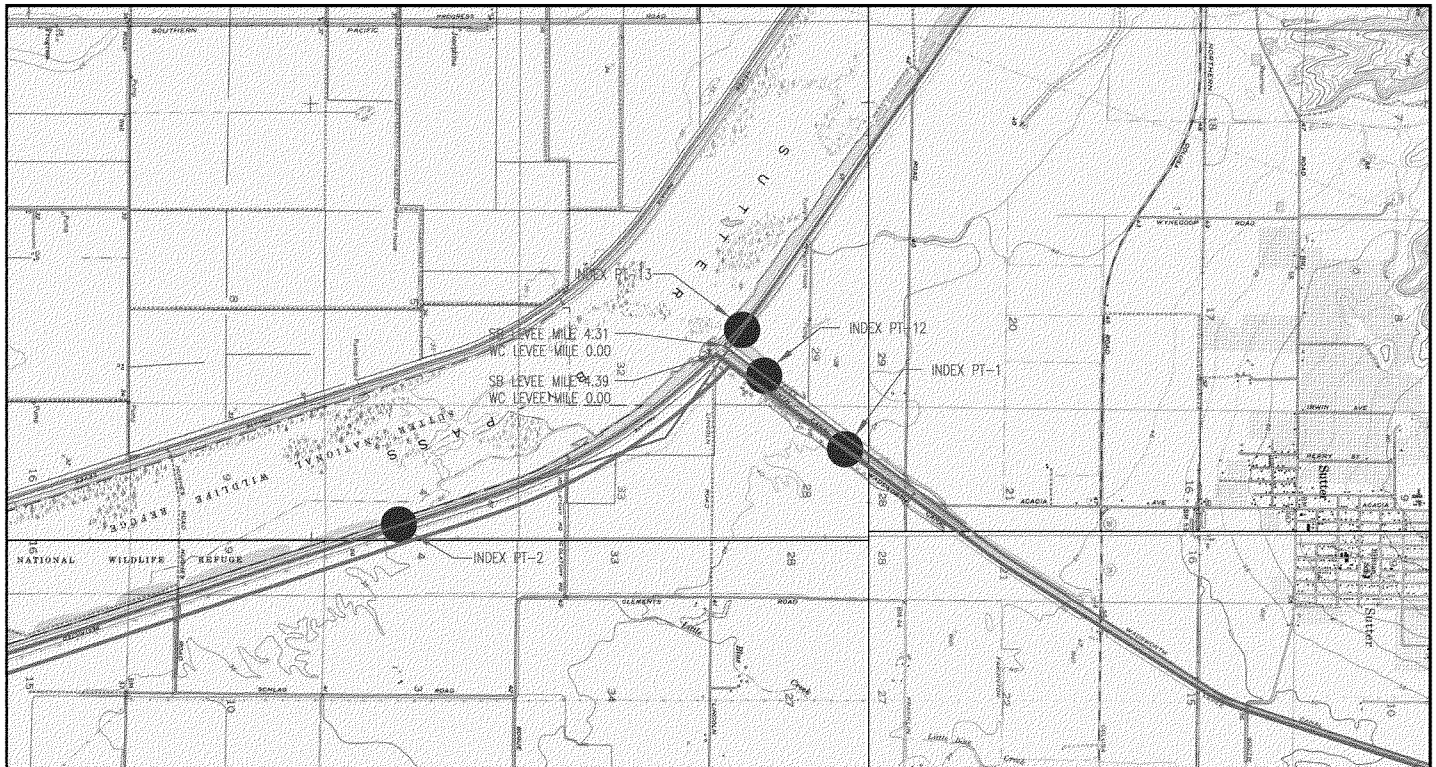
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

OVERALL STUDY MAP

DATE	SCALE	
8/20/2012	1"=15000'	PLATE-2

DWG-INFO



SCALE IN FEET

0 1250 2500 5000

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

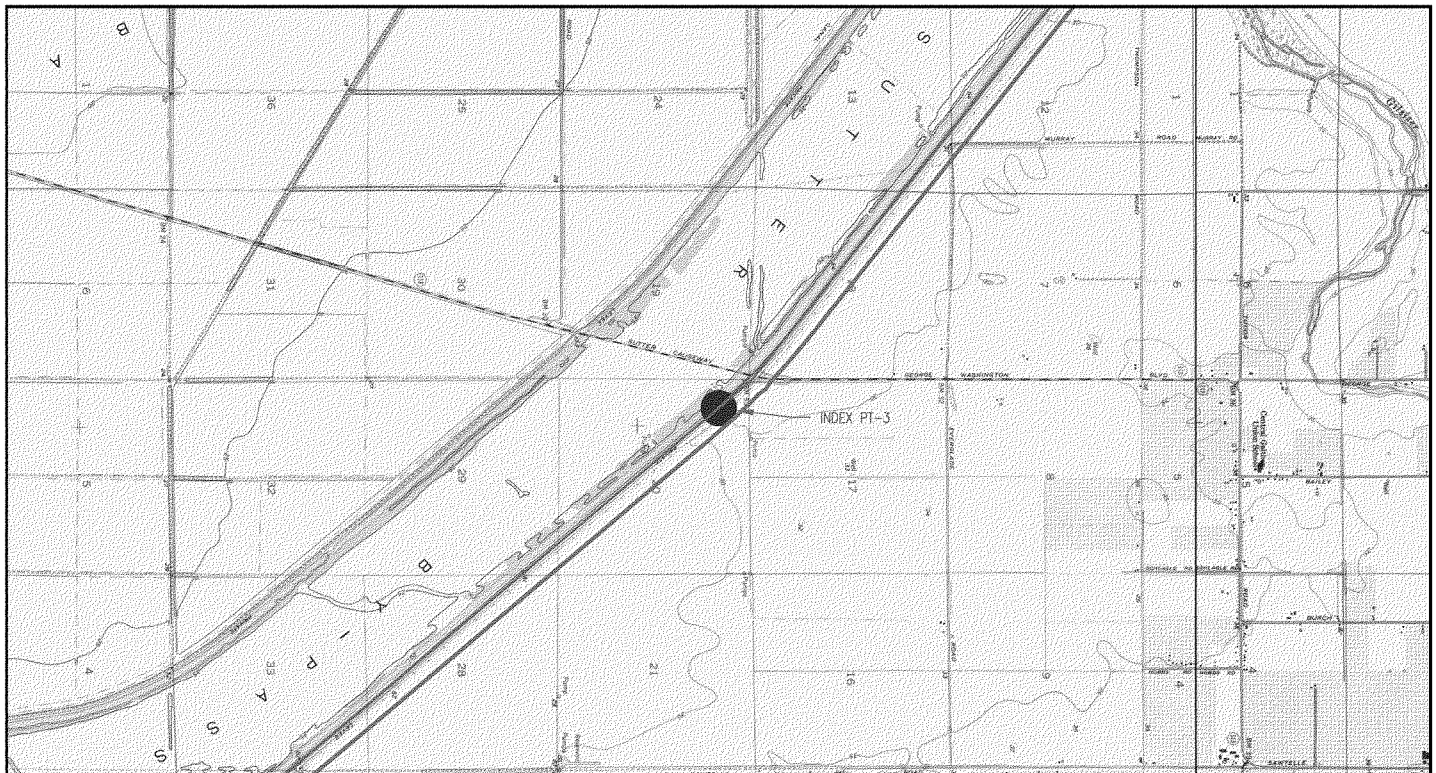
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINTS 1,2,12,13

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-3

CAN-NAD



DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

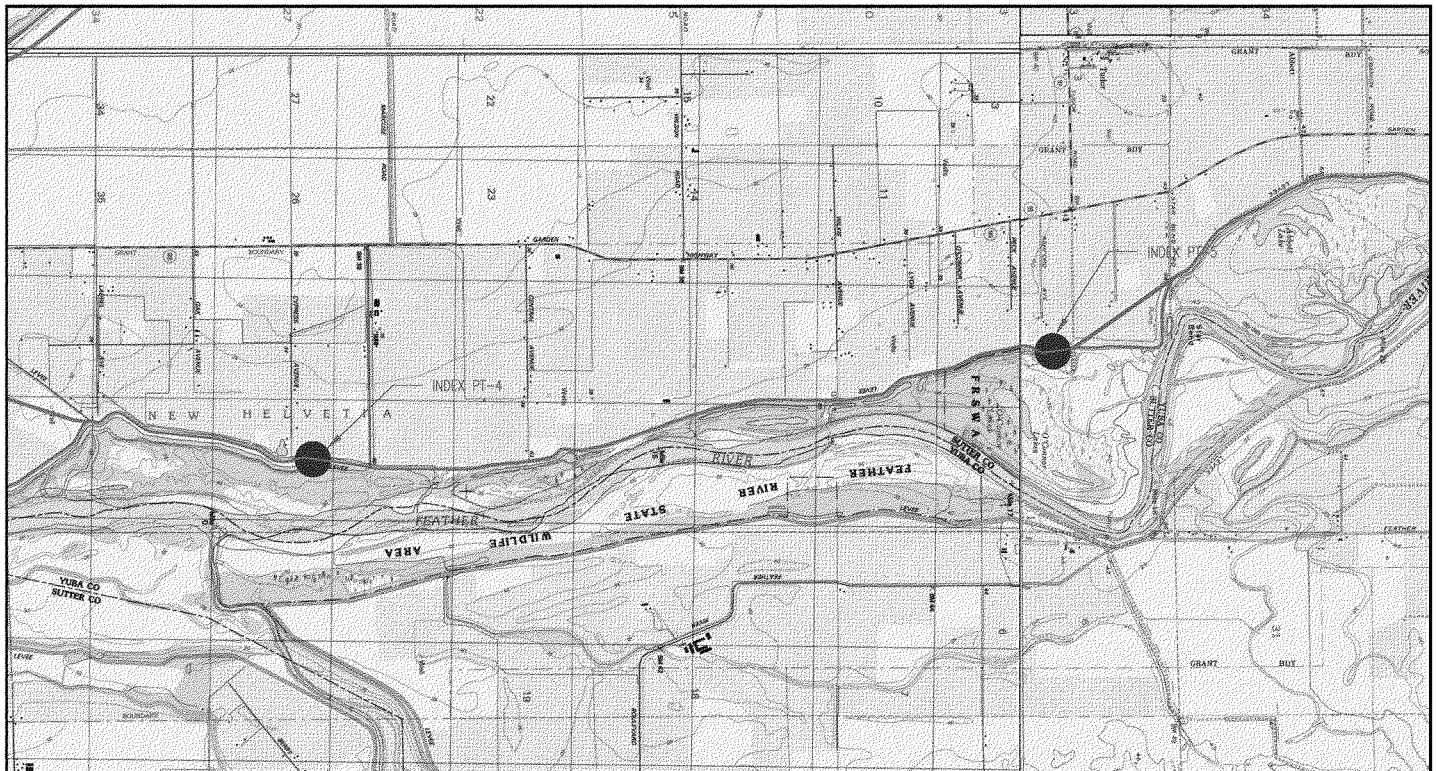
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINT 3

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-4

CAD-HM-DWG



SCALE IN FEET

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DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

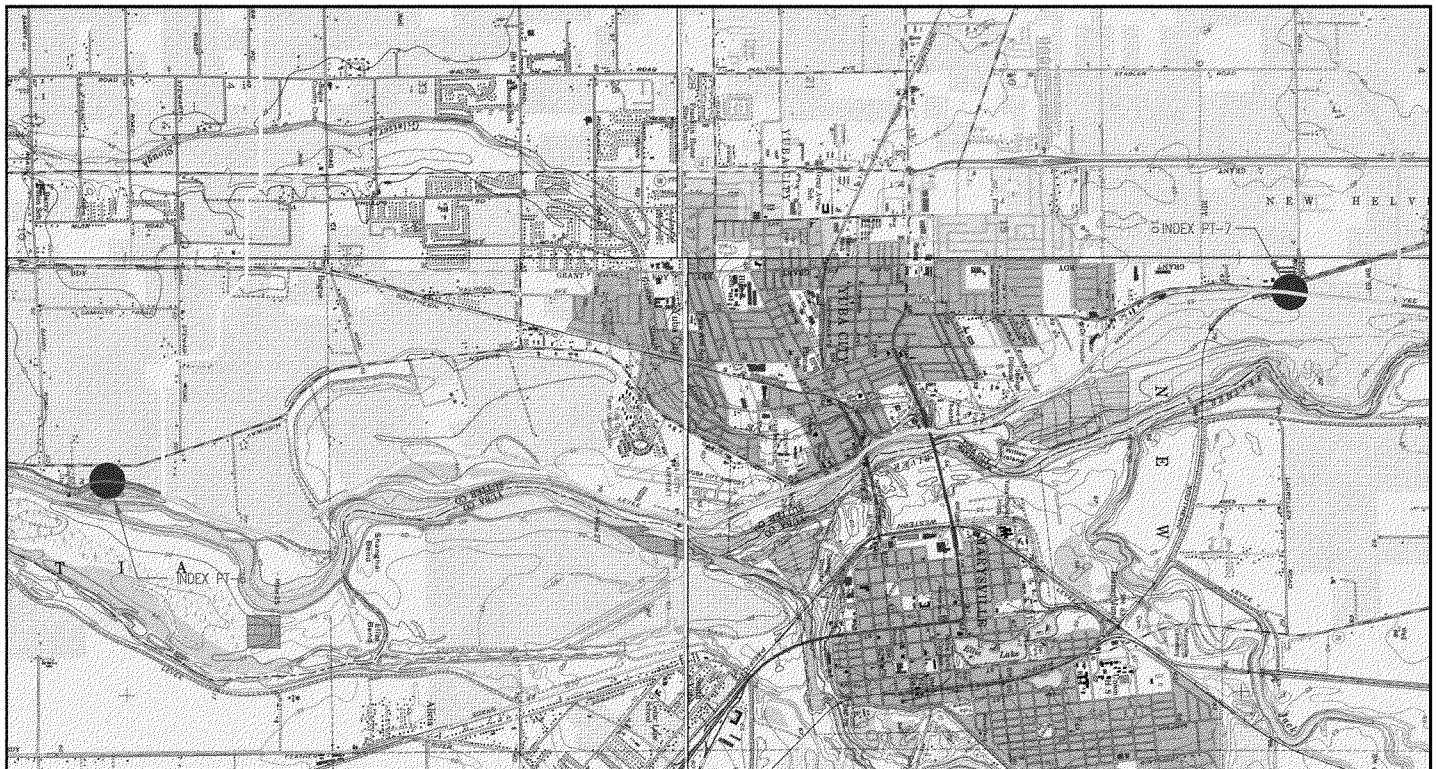
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINT 4, 5

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-5

DWG-INFO



SCALE IN FEET

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DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

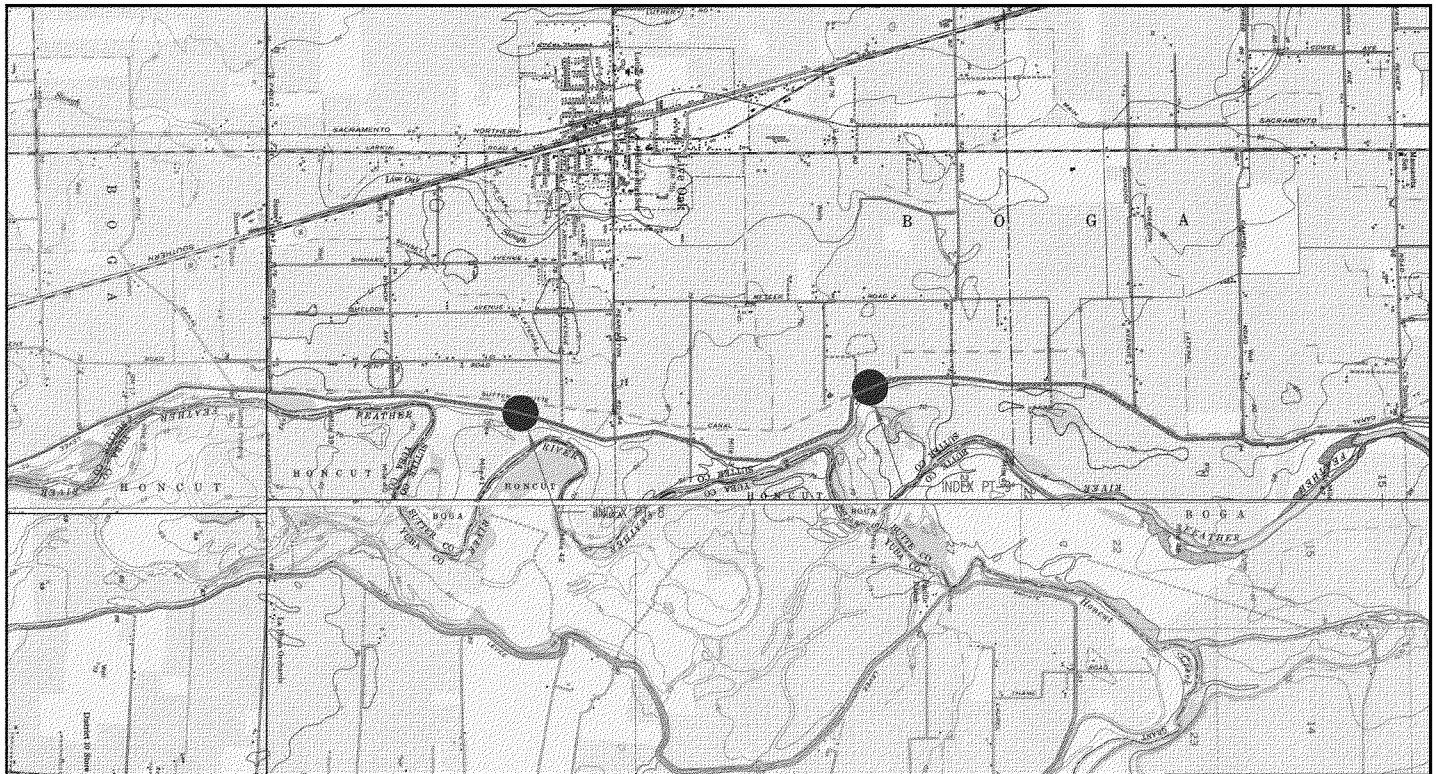
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINT 6, 7

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-6

CAD-JM-DWG



SCALE IN FEET

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DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

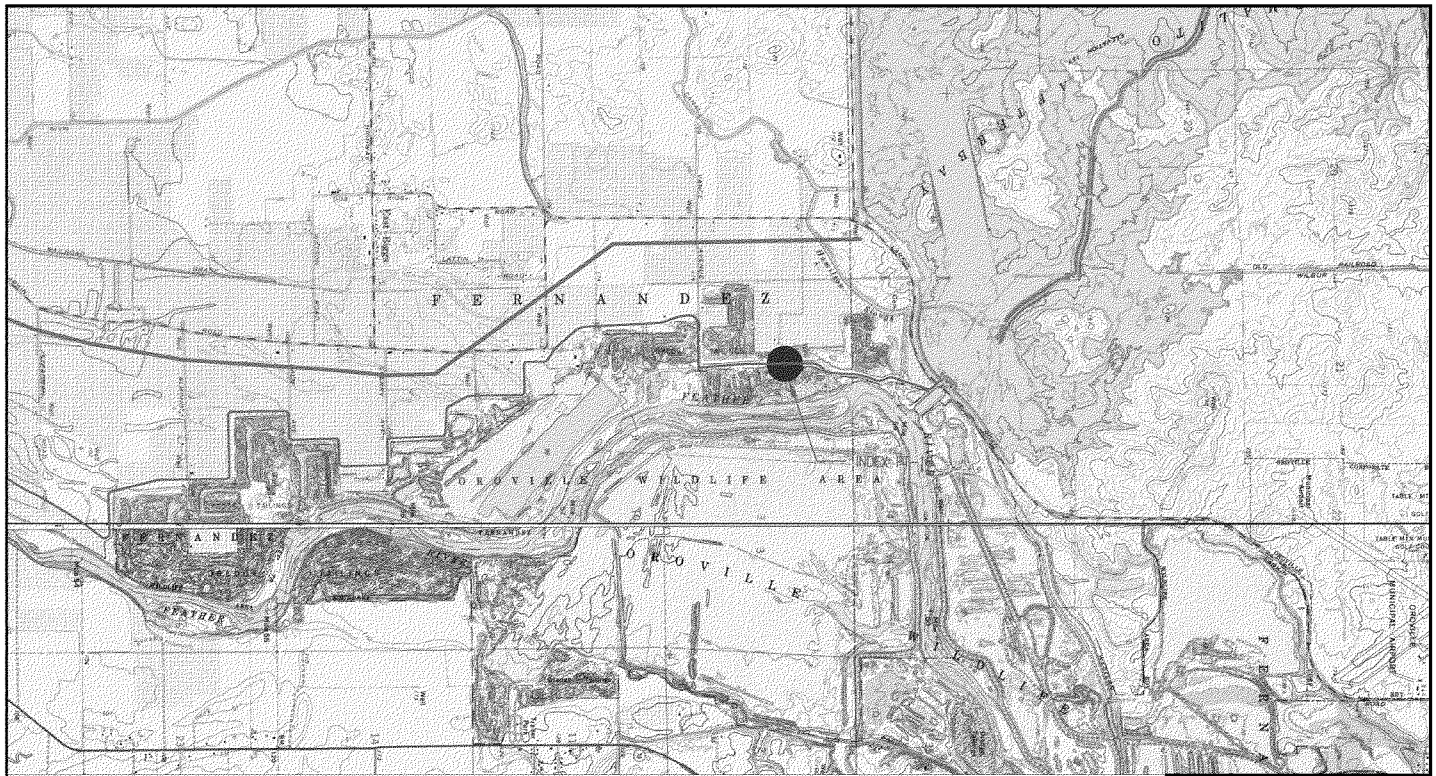
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINT 8, 9

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-7

DWG-INFO



SCALE IN FEET

0 1250 2500 5000

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

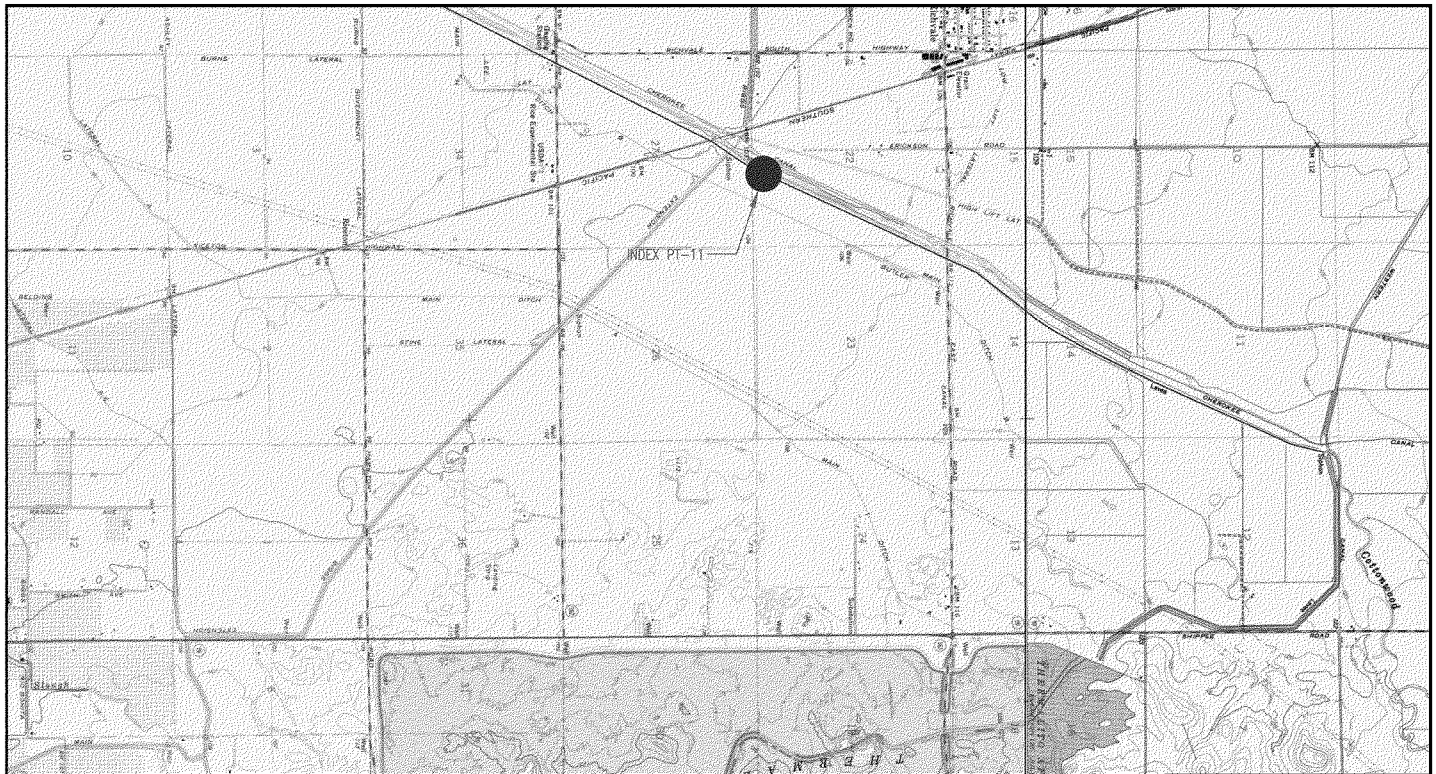
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINT 10

DATE	SCALE	
8/20/2012	1"=2500'	PLATE-8

DWG-INFO



SCALE IN FEET

0 1250 2500 5000

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

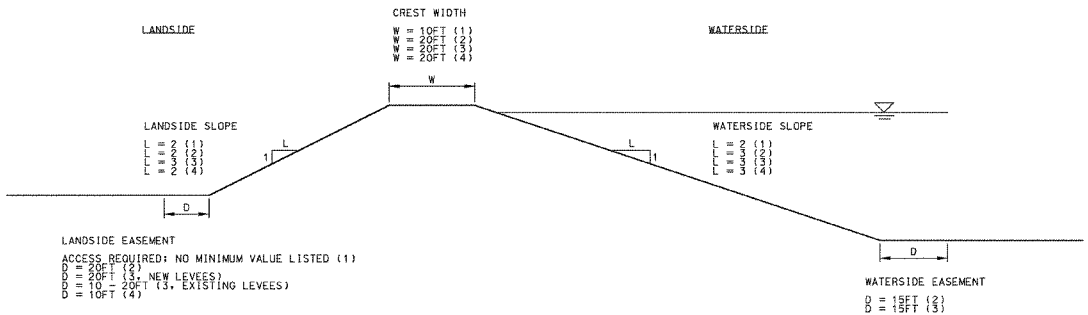
SUTTER & BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
UPDATED WITHOUT PROJECT CONDITIONS REPORT

INDEX POINT 11

DATE:	SCALE:	
8/20/2012	1"=2500'	PLATE-9

DWG-INFO



LANDSIDE EASEMENT

ACCESS REQUIRED: NO MINIMUM VALUE LISTED (1)
D = 20FT (2)
D = 20FT (3, NEW LEVEES)
D = 10 - 20FT (3, EXISTING LEVEES)
D = 10FT (4)

WATERSIDE EASEMENT

D = 15FT (2)
D = 15FT (3)

REFERENCES

(1) EM 1110-2-1913, DESIGN & CONSTRUCTION OF LEVEES, APRIL 2000
(2) SPK, GEOTECHNICAL LEVEE PRACTICE (REPP10LO OR SOP3), 11 APRIL 2008
(3) DWR, URBAN LEVEE DESIGN CRITERIA, MAY 2012 (NEW LEVEES, EXCEPTIONS MAY BE ALLOWED FOR RECONSTRUCTION OF EXISTING LEVEES
(4) CCR TITLE 23, WATERS DIVISION 1, CVFPB REGULATIONS, 22 JAN 2010

Plate 10

US Army Corps of Engineers®
Sacramento District

Date
Rev.
Designed by/
Date 1st Rev.
Drawn by/
Date 2nd Rev.
Checked by/
Date 3rd Rev.
Submitted by/
Date Approved by/
Design file no.
Drawing code
File name
File path

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

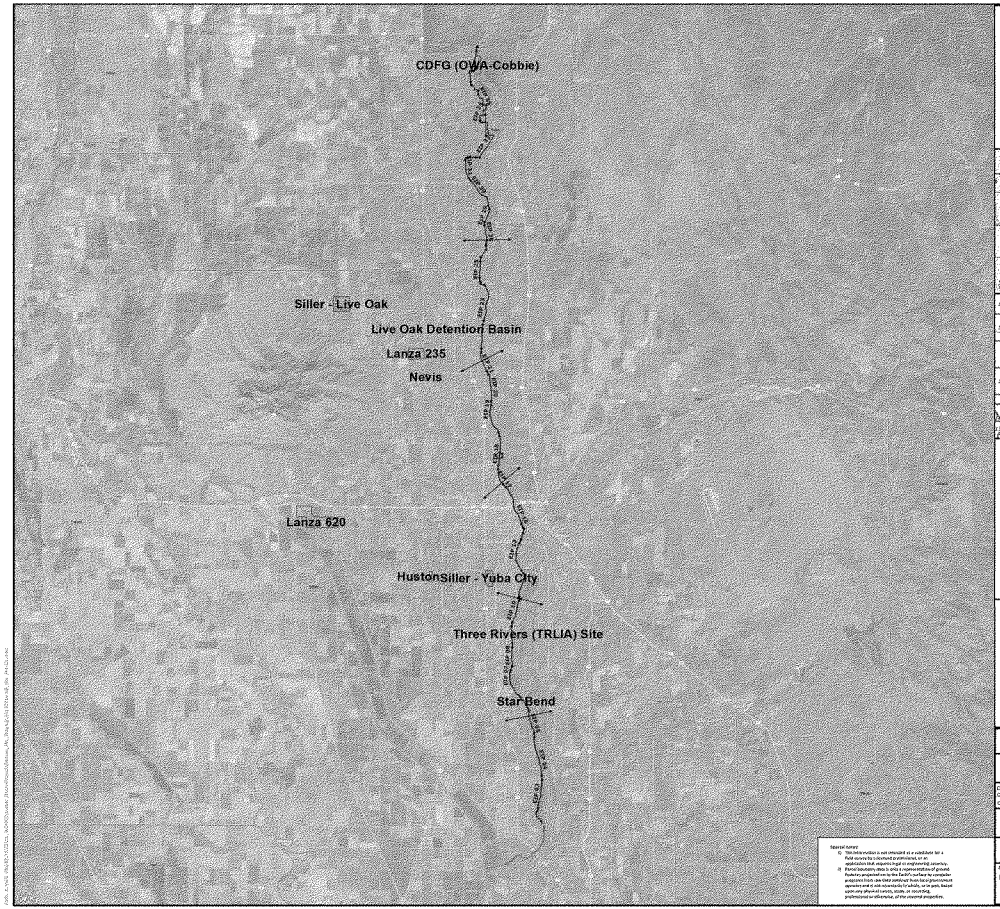
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

SUTTER BUTTE COUNTY
SUTTER BASIN FEASIBILITY STUDY
CVFB DESIGN APPENDIX

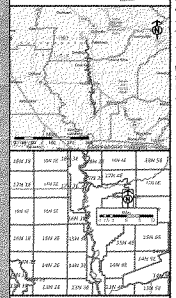
CALIFORNIA

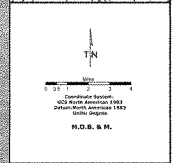
TYPICAL LEVEE GEOMETRIES
MINIMUM REQUIREMENTS

Sheet reference number:
–
Sheet – of –
AM-XX



Special survey:
1) This information is not intended as a substitute for a field survey by a licensed surveyor, or an application that requires legal or engineering service.
2) Parcel boundary data is only a representation of ground features and may not be exact. Parcel boundary data and acquisition line data derived from two dimensional aerial and orthorectified photos, or in part, based upon any physical survey, scale, or recording, professional or otherwise, of the covered properties.





ACQUISITION AUTHORIZATION

Preliminary Draft
As Applicable

PROJECT MAP

DEPARTMENT OF THE
USING SERVICE US ARMY CORPS OF ENGINEERS

LOCATION OF PROJECT

STATE CALIFORNIA
COUNTY SUTTER & BUTTE
DIVISION SOUTH PACIFIC DIVISION (SPD)
DISTRICT SOUTH PACIFIC DISTRICT (SPK)
ARMY AREA
OF
OF

TRANSPORTATION FACILITIES

RAILROADS
STATE ROADS
FEDERAL ROADS
AIRPORTS

ACQUISITION

TOTAL ACRES ACQUIRED
FEE
PUBLIC DOMAIN (WITHDRAWN / USE PERMIT)
USE PERMIT (Other than P.D.)
TRANSFER (WITHDRAWN / USE PERMIT)

LEASE
EASEMENT RESERVED IN FEE DISPOSAL
LESSER INTERESTS (EASEMENT / PERMIT / LICENSE)

DISPOSAL

TOTAL ACRES DISPOSED
SOLD
PUBLIC DOMAIN (WITHDRAWN / USE PERMIT)
USE PERMIT (Other than P.D.)
TRANSFERRED (FEE / USE PERMIT)
LEASES TERMINATED
LESSER INTERESTS TERM
REASSIGNED
ACRES TO

LEGEND

(EXCEPT FOR SPECIAL TOPICS) SHOWN MUST MAY VARIOUS ITEMS & PARCELS IN ACCORDANCE WITH ER 405-1-12, TOPOGRAPHIC DRAWING, ORC, 1994

Estates

- Borrow
- Mitigation
- FPLE_Levee
- OM_p
- Parcels
- CA_County_Boundary
- Reach ID

GENERAL PROJECT LOCATION

DEPARTMENT OF THE ARMY
OFFICE OF THE SACRAMENTO DISTRICT ENGINEER
SOUTH PACIFIC DIVISION

CARTOGRAPHER SSL
CARTO TECH.
CHECKED BY SSC
SUBMITTED BY
STEVE J. CAREY
CHIEF, FAGRAPTRAL SECTION
RECOMMENDED BY
CHIEF, GIS & MGMT. BRANCH

REAL ESTATE
SUTTER & BUTTE COUNTIES
CALIFORNIA

SUTTER BASIN GRR
BORROW AND MITITGATION SITES
(SB8)

APPROVED BY
DATE
CHIEF, REAL ESTATE DIVISION

OFFICE, CHIEF OF ENGINEERS, WASHINGTON 25, D.C.
REMIS CODE:
REMIS UNIQUE ID:
INSTALLATION OR PROJECT NO.
DRAWING NO.

Date Saved: 7/25/2013 8:32:35 AM ER 405-1-300 Eng. Form 1458A, Oct 85

Plate 11

ENCLOSURES

ENCLOSURE A

LEVEE PHOTOGRAPHS

WADSWORTH CANAL LEFT LEVEE

Photo 1. General view of the levee, looking upstream. Canal channel on the left.

Photo 2. General view of the levee, looking upstream.

Photo 3. Waterside levee slope and canal, looking north. High ground of Sutter Buttes in the background.

Photo 4. Landside levee slope, looking upstream.

Photo 5. Canal bank erosion, looking upstream.

SUTTER BYPASS LEFT LEVEE (DOWNSTREAM OF WADSWORTH CANAL)

Photo 1. General view of the levee, looking upstream. Bypass channel is on the left

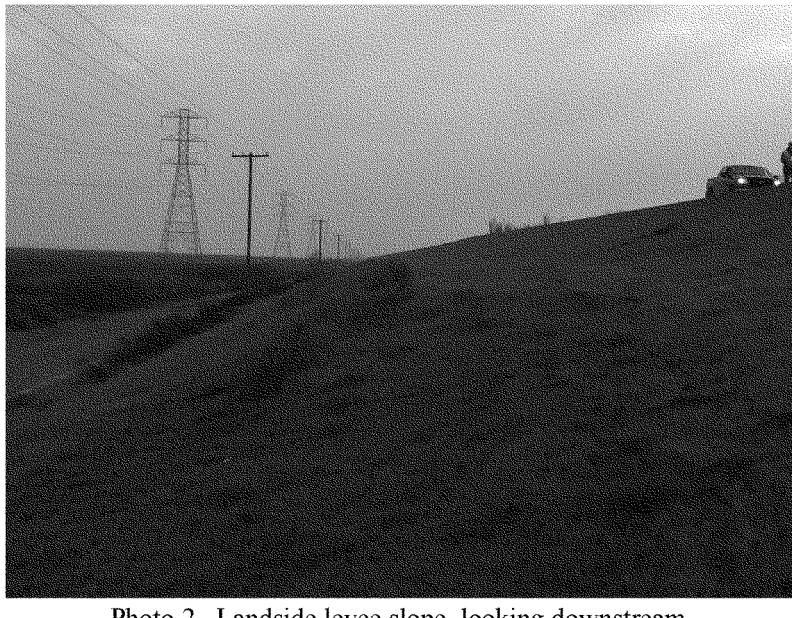


Photo 2. Landside levee slope, looking downstream.

Photo 3 Ditch about 50 feet from the landside toe.

Photo 4. Typical waterside levee slope, looking upstream

Photo 5. Stability berm at the landside toe, looking upstream

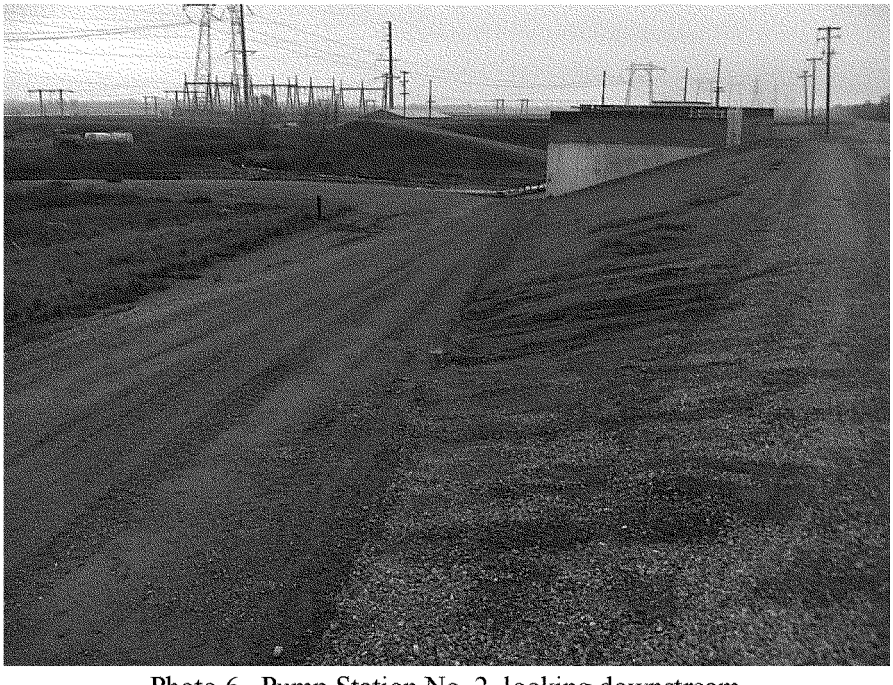


Photo 6. Pump Station No. 2, looking downstream

FEATHER RIVER SOUTH – MAINTENANCE AREA 3

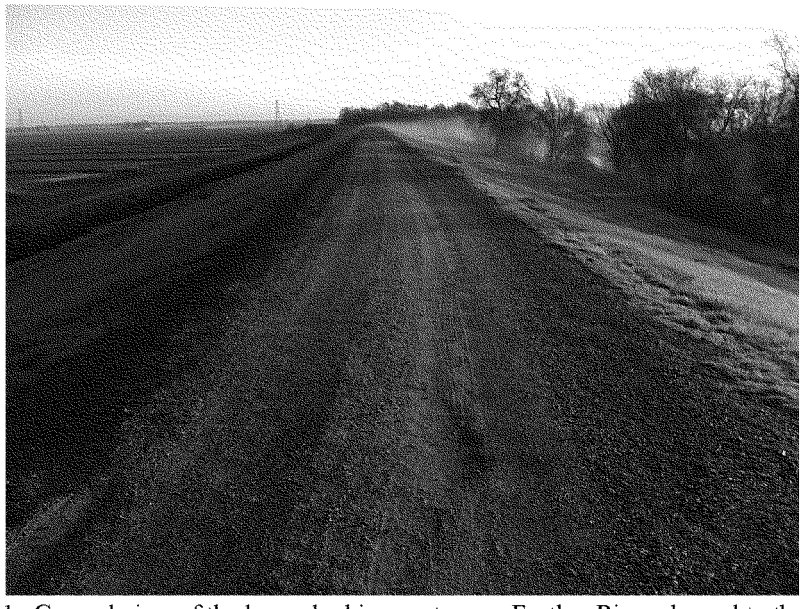


Photo 1. General view of the levee, looking upstream. Feather River channel to the right.

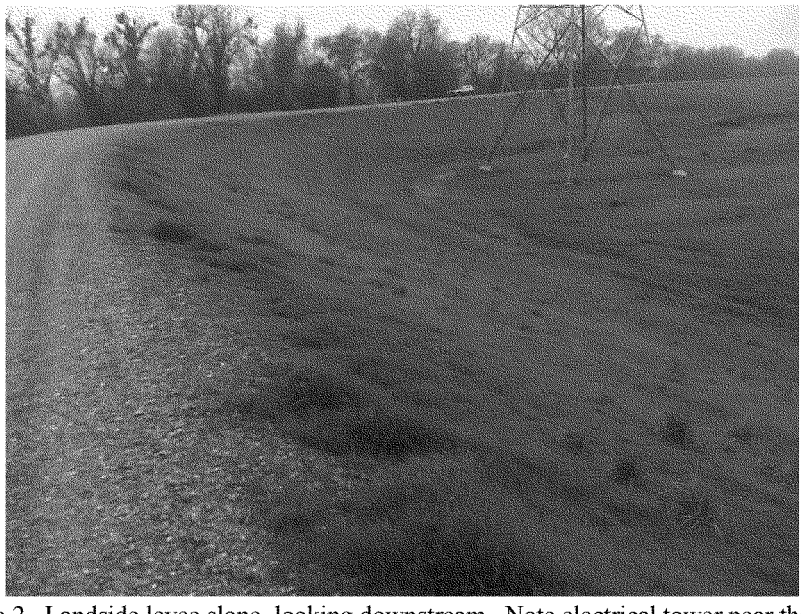


Photo 2. Landside levee slope, looking downstream. Note electrical tower near the toe.

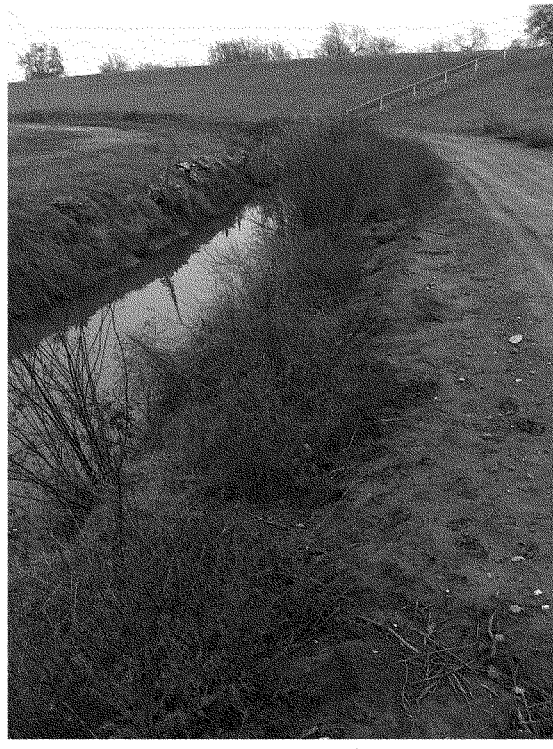


Photo 3. Ditch near the landside toe

Photo 4. Waterside levee slope, looking upstream.

FEATHER RIVER SOUTH – LEVEE DISTRICT 1

Photo 1. General view of the levee, looking upstream. Feather River channel on the right.

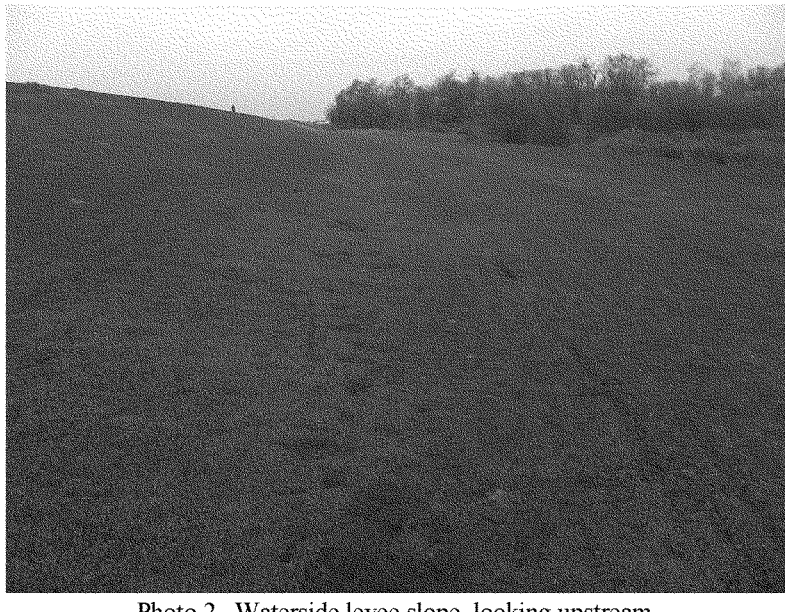


Photo 2. Waterside levee slope, looking upstream.

Photo 3. Landside levee slope, looking upstream.

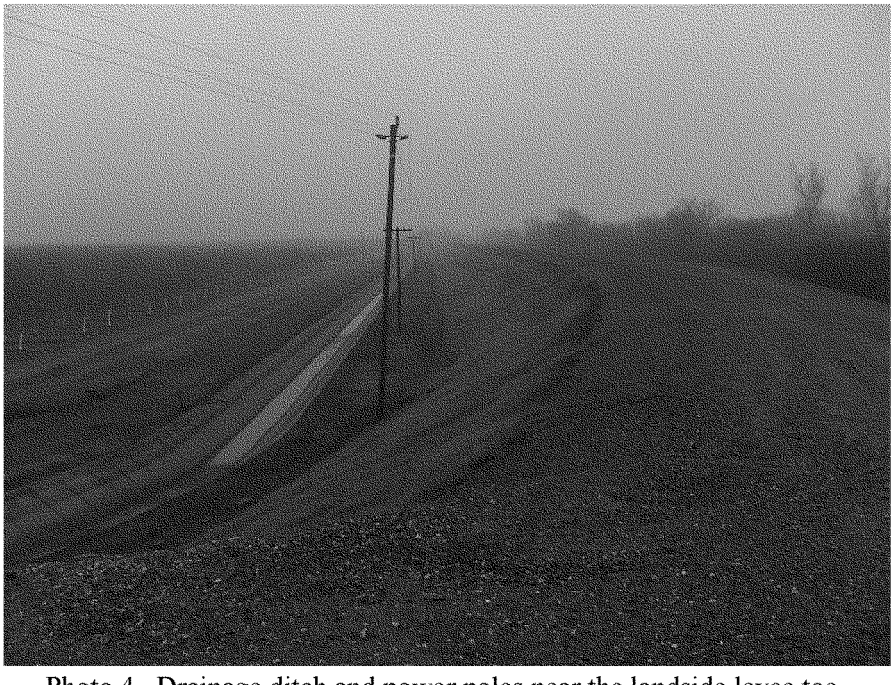


Photo 4. Drainage ditch and power poles near the landside levee toe.

Photo 5. Encroachment into the landside levee slope in Yuba City.

Photo 6. Star Bend relief wells and relief well drainage ditch.

FEATHER RIVER NORTH – LEVEE DISTRICT 9

Photo 1. General view of the levee.

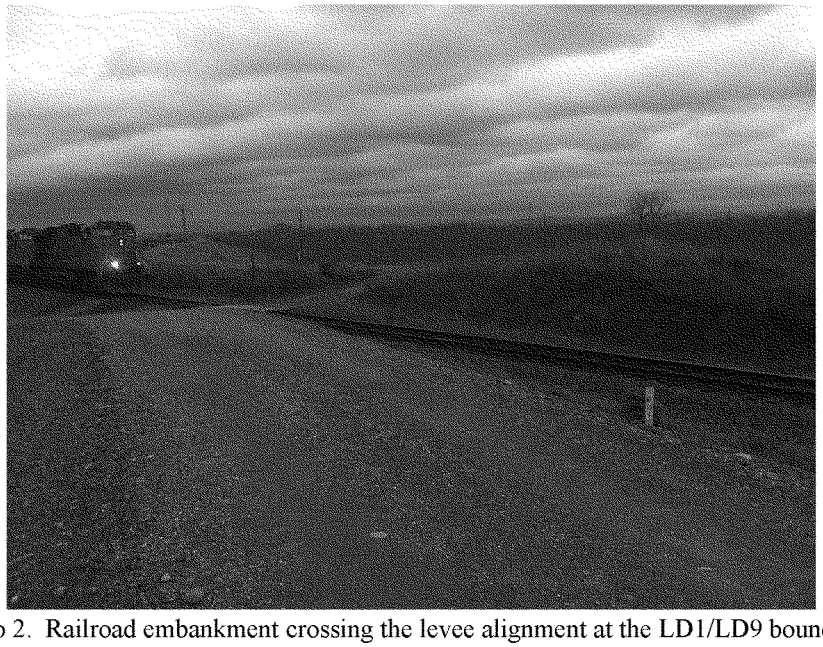


Photo 2. Railroad embankment crossing the levee alignment at the LD1/LD9 boundary.

Photo 3. Landside levee slope, looking downstream.

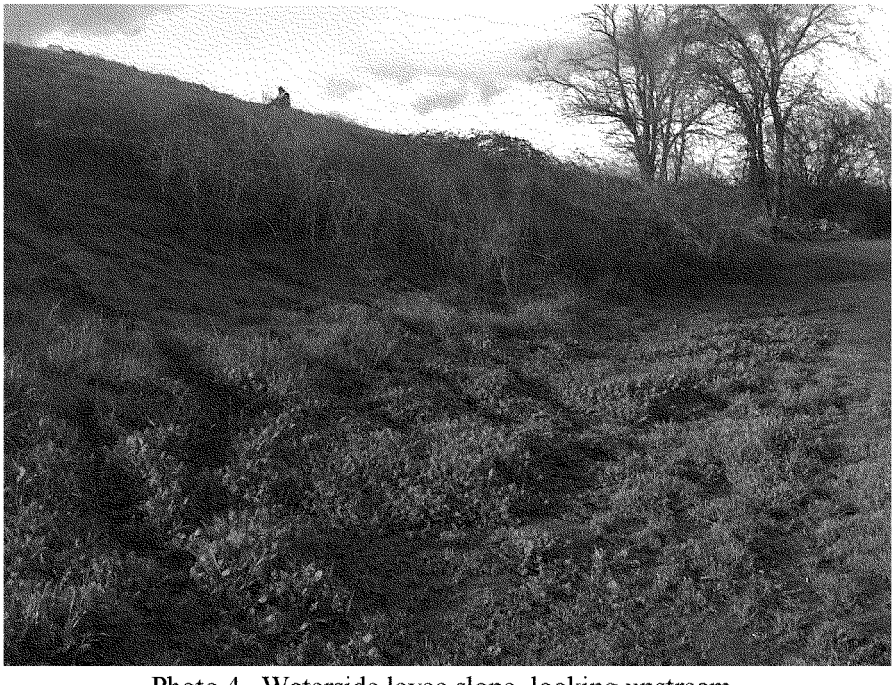


Photo 4. Waterside levee slope, looking upstream.

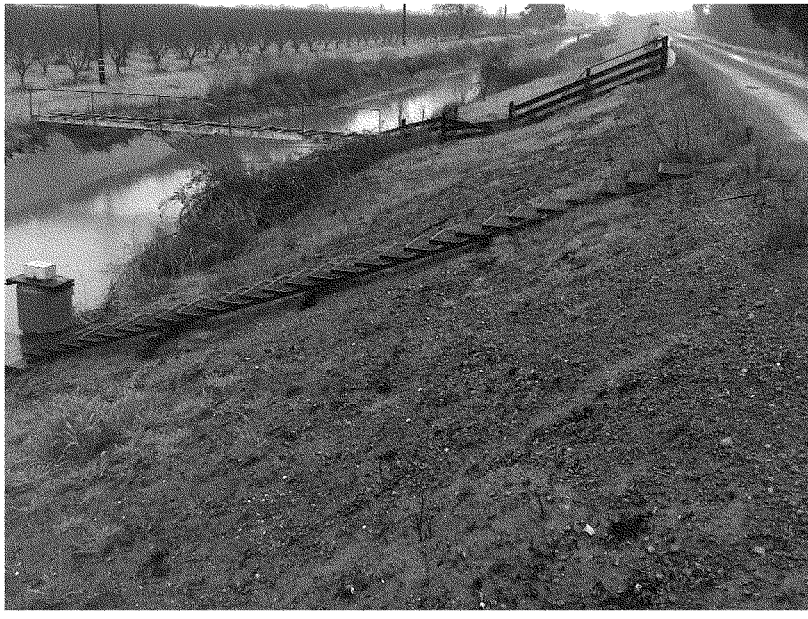


Photo 5. Sutter Butte Canal adjacent to the levee toe.

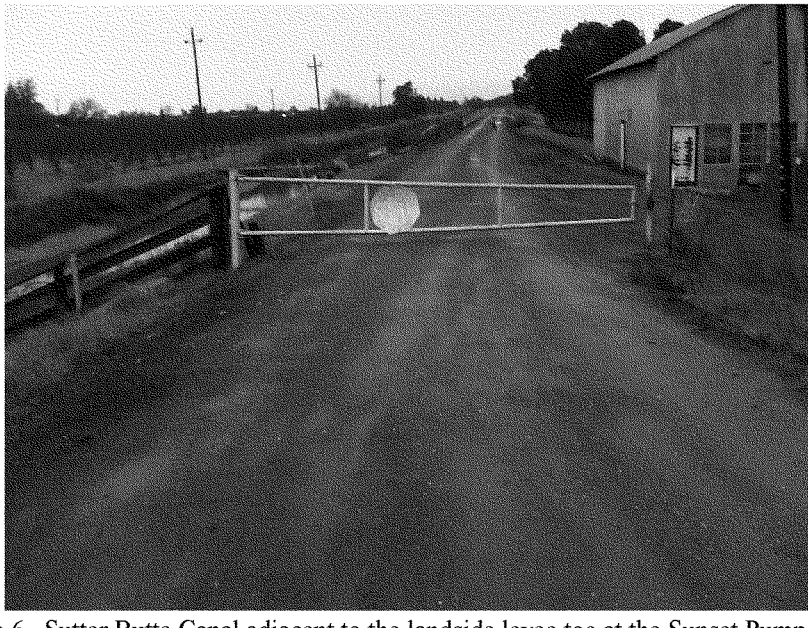


Photo 6. Sutter Butte Canal adjacent to the landside levee toe at the Sunset Pump Plant.

FEATHER RIVER NORTH – MAINTENANCE AREA 16

Photo 1. General view of the levee, looking upstream. Feather River channel to the right.

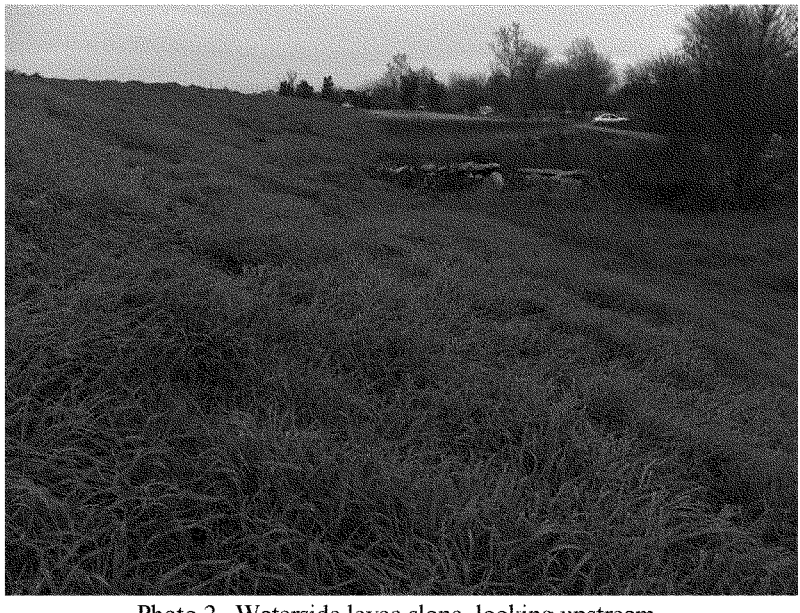


Photo 2. Waterside levee slope, looking upstream.

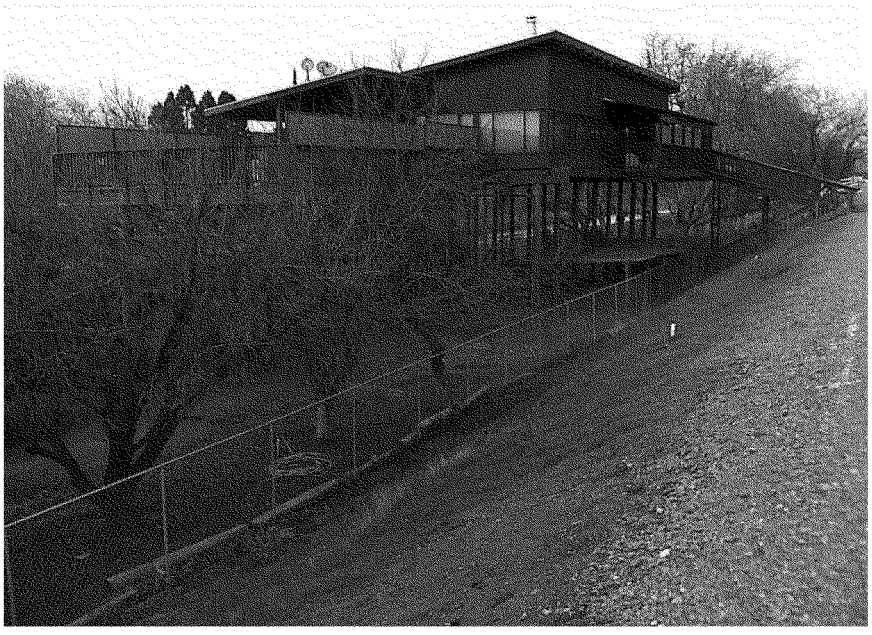


Photo 3. House at the landside levee toe.

Photo 4. Sutter Butte Canal adjacent to the landside levee toe.

Photo 5. Erosion/sloughing of the landside levee slope into the Sutter Butte Canal.

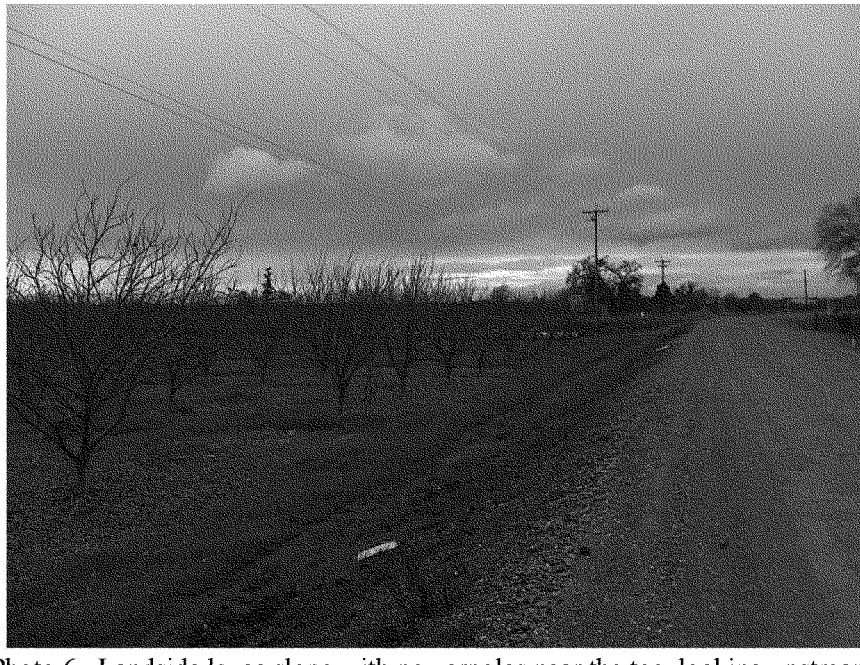


Photo 6. Landside levee slope with powerpoles near the toe, looking upstream.

FEATHER RIVER NORTH – MAINTENANCE AREA 7

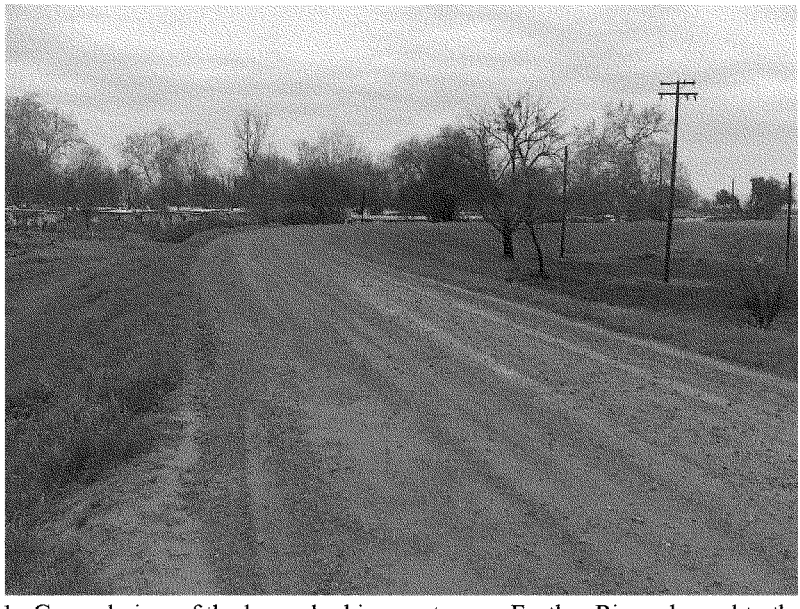


Photo 1. General view of the levee, looking upstream. Feather River channel to the right.

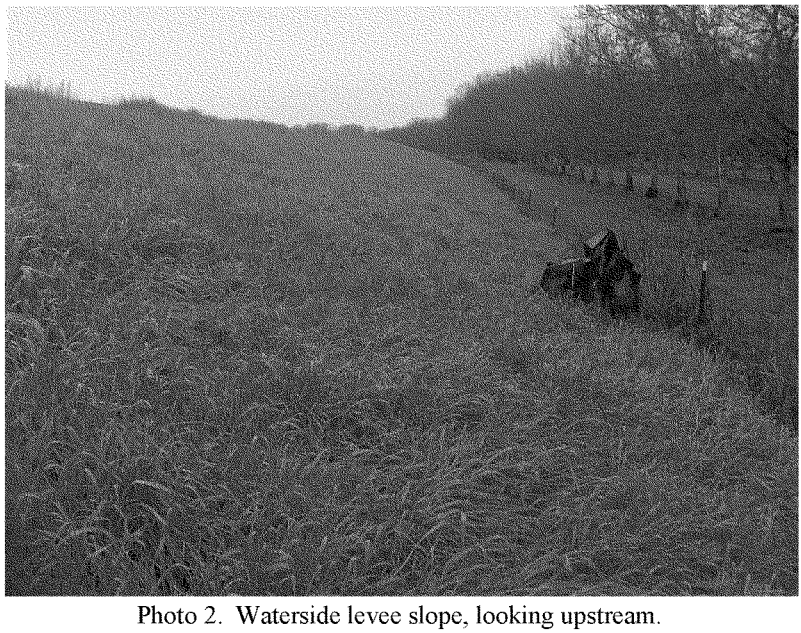


Photo 2. Waterside levee slope, looking upstream.

Photo 3. Landside slope erosion/sloughing into the adjacent Sutter Butte Canal; house on waterside of levee.

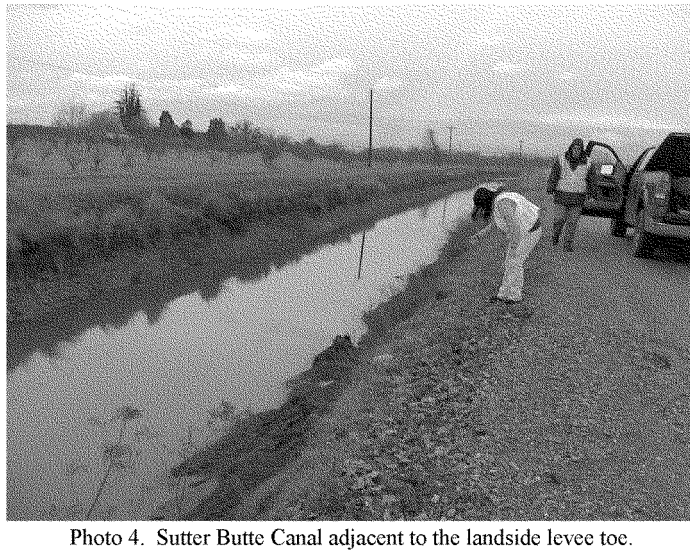


Photo 4. Sutter Butte Canal adjacent to the landside levee toe.

Photo 5. Waterside levee slope at the location of the former Gridley Bridge.

Photo 6. Weir structure in Sutter Butte Canal adjacent to the landside levee toe.

FEATHER RIVER NORTH – HAMILTON BEND

Photo 1. General view of the levee embankment, looking upstream. Feather River channel to the right.

Photo 2. Waterside levee slope, looking upstream.

Photo 3. Landside levee slope, looking downstream.

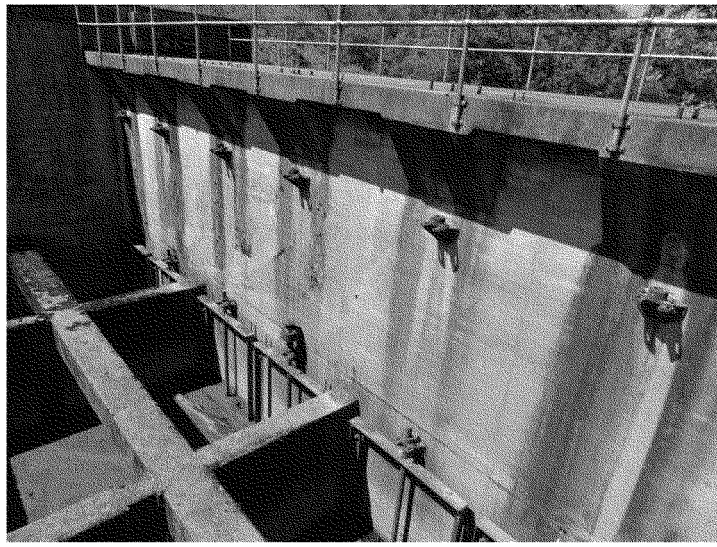


Photo 4. Sutter Butte Canal Headgate Structure. Note gate stems and hoist mechanisms have been removed, leaving the gates "stuck" in the closed position.

Photo 5. Dredge tailings on the waterside of the levee. Note tailings are higher than the levee crest in some locations.

ENCLOSURE B

SBLS PERFORMANCE HISTORY AND IMPROVEMENTS/MODIFICATIONS (FROM PERIODIC INSPECTION REPORT NO. 1)

Table M-1: Summary of Levee Performance Issues

Levee Mile or Location	Year	Problem/Issue	Document	Page
Hamilton West Levee - HAM1				
12.3	1955	Levee "broke in 4 places and potholes appeared"	P1GDR	2-42
Maintenance Area 07 - MA07				
0.1 to 0.9	N/A	Underseepage and high groundwater during irrigation season due to high water level in canal	P1GER	2-11
1 to 1.2	1999	Several large holes opened up during construction of slurry wall	P1GDR	2-40
2.7 to 2.9	1986	Seepage and boils	P1GER	2-12
9.8	1986	Seepage and boils	P1GER	2-12
N/A	N/A	Landside seepage and boils at various locations	P1GDR	2-41
Maintenance Area 16 - MA16				
N/A	N/A	Landside seepage and boils at various locations	P1GDR	2-41
Levee District 9 - LD9S				
0 to 1.6	1996	Seepage	P1GDR	2.56
0 to 1.6	1997	Seepage	MEM-97	3
0.1 to 0.42	1966	Seven sinkholes from old stumps left during levee construction	P1GER	2-9
2.17	1955	"Severe leaks"	P1GDR	2-42
2.3	N/A	Heavy saturation and levees turning to "mush"	P1GDR	2-42
2.5	N/A	Heavy saturation and levees turning to "mush"	P1GDR	2-42
2.56 to 2.65	1982	Erosion and raveling of rock revetments	P1GDR	2-44
2.8 to 3.1	1997	Seepage	P1GER	2-10
3 to 3.2	1997	Clear-water pinhole boils	P1GDR	2-42
3.5 to 3.6	N/A	Heavy saturation	P1GER	2-10
3.65	1955	"Severe leaks"	P1GDR	2-42
3.8	1986	Landside seepage and sand boils	P1GER	2-10
4.55-5.46	1997	900-feet of irrigation ditch slumping at levee toe	MEM-97	2
4.63	1957	Seepage at and beyond waterside toe during irrigation	P1GDR	2-42
4.93	1957	Seepage at and beyond waterside toe during irrigation	P1GDR	2-42
5.1	1986	Landside seepage and sand boils	P1GER	2-11
5.4 to 5.7	1997	Landside embankment distress	P1GER	2-11
N/A	N/A	Landside seepage and boils at various locations	P1GDR	2-41
Levee District 1 - LD1S				
1.5	1986	Crack formed in levee	P1GDR	2-25
2.75 to 5.25	1997	Boils at landside levee toe	LTR -97	Sheet 1
3.8	1986	2,600-ft stretch of boils, soft wet ground w/in 100 ft of toe	P1GDR	2-25
3.8	1997	Seepage	P1GDR	2-25
4.1 to 5	1995	Clear seepage at and beyond levee toe	P1GDR	2-25
4.1 to 5	1997	200-foot stretch of boils	P1GDR	2-25
6.1	1986	Erosion of small trees on waterside berm, holes on top of berm, berm slope eroded	P1GDR	2-25
6.3 to 7.01	1997	26 sink holes, probably rodent-related	MEM-97	2
7.3	N/A	Waterside bank erosion encroached on levee section	P1GDR	2-25

Table M-1: Summary of Levee Performance Issues

Levee Mile or Location	Year	Problem/Issue	Document	Page
Levee District 9 - LD9S (continued)				
8	1986	Waterside levee toe, portions of boat ramp parking lot and subgrade eroded	P1GDR	2-25
8.13	1997	Bank erosion at pump structure at waterside levee	LTR -97	Sheet 1
10.8	1986	Seepage	P1GDR	2-25
10.8	1995	High water, seepage, boil	P1GDR	2-25
11.0 to 12.4	1909	Levee broke	P1GDR	2-25
11.0 to 12.4	1911	Levee broke	P1GDR	2-25
11.0 to 12.4	1955	Levee broke	P1GDR	2-25
11.0 to 12.4	1986	Boils	P1GDR	2-26
11.0 to 12.8	1995	Sand boil noted, relief wells are damaged/not maintained	MEM-95	1
11.2	1997	Heavy seepage and boils	LTR -97	Sheet 1
12.1 to 12.3	1997	Heavy seepage and boils	LTR -97	Sheet 1
12.8 to 14.5	N/A	Seepage	P1GER	2-7
14 to 15.5	1955	Seepage	P1GDR	2-26
14 to 15.5	1986	Saturated, unstable, bulging landside slope, water pouring from parking lot pavement cracks & floor slab, waterside erosion at toe	P1GDR	2-26
14.27 to 14.57	1997	Bank and levee erosion	LTR -97	Sheet 1
14.74 to 14.81	1997	Bank erosion	LTR -97	Sheet 1
14.95 to 15.55	1997	Heavy seepage	LTR -97	Sheet 1
10th St Bridge to 1,000 ft north	1995	Seepage 100 ft landside of levee and Von Geldern Way	MEM-95	1
RM 19	1995	Seepage at toe of levee and beyond	MEM-95	2
Maintenance Area 03 - MA03				
2.3 to 3.3	N/A	Excessive seepage	P1GDR	2-24
3.7	1986	Boil in drainage ditch near levee toe	P1GDR	2-25
3.7	1997	Heavy seepage entering drainage ditch near levee toe, sloughing of the drainage ditch	P1GDR	2-25
Sutter Bypass, E Levee - SBP2				
4.4 to 5.4	1997	Heavy seepage, soil heaving	P1GDR	2-13
5.4 to 13 (McClatchy Road to Gilsizer Slough)	1958	Landside toe - ground heaving with mud flow, sand boils, berm movement and cracks	P1GDR	2-13
5.4 to 13 (Oswald Rd to Gilsizer Slough)	1958	Longitudinal cracks along landside slope	P1GDR	2-13
12.7 to 14.6	N/A	Seepage and boils	P1GER	2-4
16.6 to 16.78	N/A	Critical seepage area	P1GDR	2-14
17.6	1997	Seepage	P1GDR	2-14
20 to 22.37	1986	Waterside erosion at toe and lower slope	P1GDR	2-14
21.88 to 22.07	2001?	Seepage, boils, sinkhole on landside berm	P1GER	2-4

Table M-1: Summary of Levee Performance Issues

Levee Mile or Location	Year	Problem/Issue	Document	Page
Wadsworth Canal – Unit 1, left bank - WAD1				
1.0	1997	Heavy seepage	P1GDR	2-9
0.0 to 0.6	1997	Seepage, pin boils	P1GDR	2-3
0.0 to 0.6	1998	Seepage, pin boils	P1GDR	2-3
N/A	N/A	WS berm erosion & rodent holes for much of levee reach	P1GDR	2-10
Interceptor Canal – Unit 2, east canal - INT2				
N/A	N/A	N/A	N/A	N/A

Key to Document Abbreviations

Author	Date	Title	Type	Abbrv
USACE Soil Design Chief	09/15/95	Memorandum for Civil Projects Management Section, Subject: Contract 3 Levee Seepage Investigations	Memo	MEM-95
Levee District 1	02/17/97	Levee District 1 to Honorable Vic Fazio, Summary of Repairs and Improvements required for the Feather River Levee of Levee District No. 1 of Sutter County	Letter	LTR -97
USACE, Chief of Soil Design Section	03/03/97	Memorandum For Civil Projects Management Section, Subject: Levee Performance Letters from LD 1 and MHM regarding LD9	Memo	MEM-97
URS Corporation (for DWR)	03/17/08	Draft Phase 1 Preliminary Geotechnical Evaluation Report (P1GER) Sutter Study Area Urban Levee Geotechnical Evaluations Program	Report	P1GER
URS Corporation (for DWR)	11/14/08	Phase 1 Geotech Data Report (P1GDR) Sutter Study Area Urban Levee Geotechnical Evaluations Program Contract	Report	P1GDR

Table I-1: Sutter County Levee Alterations/Modifications

Levee Mile or Location	Year Complete	Alteration/Modification	Document	Page	USACE Drawing	USACE Spec
Hamilton West Levee (HAM1)						
N/A	1954	Levee reconstructed	152	2	--	--
HAM1 and/or MA07						
Unknown	1963	Levee enlargement	152	2A	4-4-534	2949
Unknown	1965	Bank protection	152	2A	50-4-4118	3283
Site Mile 51.1	N/A	Bank protection	152	2A	50-4-5798	8367
Maintenance Area 07 (MA07)						
N/A	1954	Levee reconstructed	152	2	--	--
1 to 1.2	1999	Bentonite/shredded tire slurry wall and nine monitoring wells installed	P1GDR	2-40	--	--
3 to 3.2	N/A	50-foot deep by 3 ft thick waterside slurry cutoff trench on WS levee slope constructed, covered with impervious blanket & embankment fill	P1GDR	2-52	--	--
4.25	1970	Bank protection	152	2A	50-4-4377	3426
4.7 to 5.7	N/A	Backfill landside irrigation ditch	P1GDR	2-52	--	--
10.2 to 10.5	N/A	2,640 feet of levee crest raised up to 2 feet	P1GDR	2-52	--	--
Near Gridley Bridge	1956	Emergency levee repairs	152	2A	4-4-384	2059
1.93 miles upstream from Gridley Bridge	1956	Emergency bank protection	152	2A	4-4-424	2228
Maintenance Area 16 (MA16)						
Sta. 952+00 to 1380+00	1934	Levee enlargement	148	2	4-4-135	--
MA16 and LD9S						
Fm SPRR (2 mi N of Yuba City) to 12 mi N	1945	Levee enlargement	148	2	50-4-2193 and 4-4-267	--
8 mi N of Yuba City	1948	Berm fill, drainage ditch, and road approaches	148	2	4-4-292	

Table I-1: Sutter County Levee Alterations/Modifications

Levee Mile or Location	Year Complete	Alteration/Modification	Document	Page	USACE Drawing	USACE Spec
Levee District 9 (LD9S)						
2.17	N/A	Replaced levee center section with impervious material, landside slope bolstered with dredge tailing blanket, repaired waterside slopes	P1GDR	2-54	--	--
2.3	N/A	Levee fortified with rock	P1GDR	2-42	--	--
2.5	N/A	Levee fortified with rock	P1GDR	2-42	--	--
3.5 to 3.6	N/A	Levee fortified with rock	P1GER	2-10	--	--
3.65	N/A	Replaced levee center section with impervious material, landside slope bolstered with dredge tailing blanket, repaired waterside slopes	P1GDR	2-54	--	--
4.55-5.46	1997	900-feet of irrigation ditch backfilled	#72	2	--	--
4.65 to 5.05	1960	USACE constructed 4-5 foot high, 60-foot wide 2,100-foot long waterside levee toe berm fill	P1GDR	2-54	--	--
N/A	1960	Levee stabilization	148	N/A	4-4-508	2655
Sta. 952+00 to 1380+00	1934	Levee enlargement	148	2	4-4-135	--
Site Mile 34.0	1974	Bank protection and selective clearing	148	N/A	4-4-599	4815
Site Mile 39.5&41.5	1968	Bank protection	148	N/A	50-4-4078	3288
LD9S and LD1S						
Unknown	1960	Levee stabilization in Levee Districts 1 & 9	148	N/A	4-4-508	2655
Levee District 1 (LD1S)						
Sta. 49+40 to 1380+00	1939	Levee enlargement	144	N/A	44-172-1	--
Shanghai to Starr Bend	1940	Levee enlargement	144	N/A	4-4-205-1	--
2 mi south of Starr Bend to Bear River	1940	Levee enlargement	144	N/A	4-4-205-1	--
Downstream from Yuba City	1956	Emergency repair and reconstruction of 8,000 feet of destroyed levee	144	N/A	4-13-405	--
Starr Bend	1956	Emergency levee repairs and bank paving	144	N/A	--	--
Shanghi Bend	1957	Drainage pump and sump	144	N/A	4-4-438	2295
N/A	1940	USACE reconstructs levee	P1GDR	2-22	--	--
N/A	1952	Section of levee crown "surfaced for patrol road purposes"	144	N/A	--	--

Table I-1: Sutter County Levee Alterations/Modifications

Levee Mile or Location	Year Complete	Alteration/Modification	Document	Page	USACE Drawing	USACE Spec
1.5	1998	Seepage/stability berm constructed	P1GER	2-6	--	--
3.8	1998	Levee raised 1 ft, pervious toe drain & seepage/stability berm installed	P1GDR	2-25	--	--
3.8 to 4.5	1997	Raised levee	P1GDR	2-36	--	--
4.1 to 5	1997	Relief wells installed	P1GDR	2-25	--	--
7.2 to 8.2	1997	Installed toe drain and berm	P1GDR	2-36	--	--
8	1986	Levee raised 1 ft, pervious toe drain & seepage/stability berm installed	P1GDR	2-25	--	--
10.8	1956	Emergency levee repairs	P1GDR	2-25	4-4-433	2252
10.8	1986	LD1 constructed seepage/stability berm	P1GDR	2-25	--	--
10.8	1997	LD1 construct new levee with 25-ft deep slurry wall & 6-ft wide clay core	P1GDR	2-25	--	--
11.0 to 12.8	1957	USACE emergency levee reconstruction outboard of previous location, installation of 42 relief wells	P1GDR	2-25, 26 & 53	4-13-405 & 4-4-435	2256
11.0 to 12.4	1990	Yuba City installed shallow seepage interceptor system along southern portion of site and additional relief wells	P1GDR	2-26	--	--
12.8 to 14.3	1997	4,610 feet of slurry wall, 1,690 feet of toe drain and berm, and 2,700 feet of slurry wall installed	P1GDR	2-35	--	--
12.8 to 14.5	1998?	Impermeable cutoff wall constructed	P1GDR/ P1GER	2-26/2-7	--	--
12.8 to 14.5	1990	Yuba City installed shallow seepage interceptor system along southern portion of site and additional relief wells	P1GER	2-7	--	--
N/A	1957	Emergency levee repairs, relief trench drain installed	P1GDR	2-26	4-4-437	2302
14 to 15.5	1956	Emergency levee repairs	P1GDR	2-26	4-4-431	2238
14 to 15.5	1960	Levee stabilization, 600 lineal feet of cutoff trench installed	P1GDR	2-26&53	4-4-508	2655
14 to 15.5	1986?	Yuba City constructed emergency landside toe berm	P1GDR	2-26	--	--
14 to 15.5	N/A	Emergency landside toe berm replaced with permanent seepage/stability berm from 5th St Bridge to 2,500 ft N of 10th Street Bridge	P1GDR	2-26	--	--
14 to 15.5	1998	Rock slope protection installed	P1GDR	2-26	--	--
From midway between 5th St & SR 20 to 4,000 ft north	N/A	Landside sloping drain and berm with toe trench	P1GDR	2-33	--	--
Mile 24.5	1966	Bank protection	144	N/A	50-4-4004	3154

Table I-1: Sutter County Levee Alterations/Modifications

Levee Mile or Location	Year Complete	Alteration/Modification	Document	Page	USACE Drawing	USACE Spec
Maintenance Area 03 (MA03)						
Sutter By-Pass to Nicolaus Bridge	1943	Enlarged levee	143	2	--	--
N/A	1952	Surfacing levee crown for patrol road purposes	143	2	--	--
N/A	1956	Emergency levee repairs	143	2A	4-4-417	2221
0 to 5.11	1963	Levee stabilization	P1GDR	2-24	4-4-531	2783
3.7	1997	Drainage ditch near levee toe converted to toe drain	P1GDR	2-25	--	--
3.7	1998	Seepage/stability berm constructed	P1GDR	2-25	--	--
Sutter Bypass, E Levee (SBP2)						
Sta. 0+66 to 16+50	1942	Levee enlarged to current dimensions	135	2 & 2A	50-4-1946-2	--
Sta. 1+62 to 484+00	1942	Levee enlarged to current dimensions	135	2	50-4-1945-2	--
Sta. 331+00 to 692+00	1942	Levee enlarged to current dimensions	135	3	50-4-2772	--
Sta. 800+00 to 1137+62	1942	Levee enlarged to current dimensions	135	2 & 2A	50-4-1946-2	--
Wadsworth Canal to Gilsizer Slough	1958	Emergency levee repair	135	3A	50-1-3531	2463
N/A	1968	Bank protection	135	3A	50-4-4393	3492
4.4 to 5.4	2001	12 foot wide pervious toe drain and seepage/stability berm	P1GDR	2-12	--	--
5.4 to 13	1957	Installation of exploration holes backfilled with sand (relief drains)	P1GDR	2-14	--	--
5.4 to 13	1958	Construction of 2 ft wide by 15 ft deep relief drain	P1GDR	2-14	--	--
7	1963	Levee repair, bank protection, channel rect.	135	3	4-4-536	
12.66	N/A	Pressure relief well at landside toe	P1GDR	2-14	--	--
12.7 to 14.6	1992	Construction of 10-ft high, 130-ft long rock relief toe drain and berm with 3-ft thick and 10-ft wide embankment berm	P1GDR	2-14	--	--
12.88	N/A	Pressure relief well at landside toe	P1GDR	2-14	--	--
16.6 to 16.78	N/A	Filled ditch on landside toe, constructed wide berm	P1GDR	2-14	--	--
17.6	2001	791-ft long, 2-ft wide, 5-ft deep relief toe trench/drain and overlying seepage/stability berm	P1GDR	2-14	--	--
19.42 to 19.5	N/A	Bow levee constructed around abandoned landside state pumping plant	P1GDR	2-15	--	--
21.88 to 22.07	2001?	1,000 foot long vertical drain in landside berm	P1GDR	2-14		
Near Nelson Bend	1971	Emergency repairs - 800 ft levee construction; 2,300 ft of bank protection	135	3A	4-4-588	3903

Table I-1: Sutter County Levee Alterations/Modifications

Levee Mile or Location	Year Complete	Alteration/Modification	Document	Page	USACE Drawing	USACE Spec
SBP2 and WAD1						
4.48 (SBP2) to 0.5 (WAD1)	2008	3,000 ft of soil-cement-bentonite cutoff wall to 40 to 61 foot depth, levee reconstruction near 0.4 (WAD1) due to slurry boil at waterside levee toe	135	3A and 3B	50-04-6235	1520
Wadsworth Canal – Unit 1, left bank (WAD1)						
N/A	1942	Enlarged levees to current configuration	135	3	50-4-1949-3	
1.0	2001	USACE constructed pervious toe drain	P1GDR	2-9		
Interceptor Canal – Unit 2, east canal (INT2)						
N/A	N/A	N/A	N/A	N/A	N/A	N/A

ENCLOSURE C

REPORT ON COMP STUDY VERTICAL DATUM CONVERSION

US Army Corps of Engineers, Sacramento District
American River Watershed Common Features, Control Survey
Contract No. W91238-07-D-0001, Task Order 0006 and 0007

Report for Task 5
July 01, 2010

Prepared by:

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REPORT TITLE: Task 5 Report Summarizing Tasks 1 through 5 that have undergone ITR

SUBMITTED BY: HJW GeoSpatial, Inc, July 01, 2010

REPORT STATUS: For review and approval by USACE

PROJECT TITLE AND LOCATION: American River Watershed Common Features, Control Survey, Sacramento CA.

CONTRACT NO: W91238-07-D-0001 Task Order 0006 & 0007
The survey services performed for this project are described in the Statement of Work dated 5 June 2009 and revised 24 July 2009, together with the Supplemental Statement of Work dated 9 December 2009 and Revised 7 January 2010, issued as Task Orders 0006 & 0007 to USACE Contract No. W91238-07-D-0001

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1. Project Description

Background

During the late 1990's and early 2000's, the Sacramento District collected topographic and bathymetric survey data for the Sacramento River Bank Protection Project and Sacramento-San Joaquin River Basins Comprehensive Study. The data covered most of the Central Valley waterways. The mapping data is currently being used by multiple ongoing studies in the region. The primary submittals of the mapping data effort were Digital Terrain Model (DTM) surfaces and annotated contour and planimetric maps generated from the DTM surfaces. Cross sections were cut from the DTM surfaces for hydraulic models.

The comprehensive study mapping was performed by three vendors: Towill (Concord, CA), Andregg Geomatics (Auburn, CA) and Ayres (Sacramento, CA), under contract with the Corps of Engineers. Most of the comprehensive study mapping was collected to meet 1 inch = 200 feet, 2 foot contour interval map accuracy standards. The contract documents specified the mapping was to be based on NGVD29 vertical datum and NAD83 horizontal datum. Control surveys were tied to NGS benchmarks using static GPS network methods and Geoid 96. Most topographic data were collected using aerial photogrammetric methods. However, LiDAR was used for all of the Towill area and a portion of the Ayres/Andregg area. Bathymetric data for all areas were collected using post processed kinematic GPS for vertical and horizontal positioning of soundings. Bathymetric data were merged into the topographic data to create seamless data sets. Figure 1 illustrates the overall project area along with primary and secondary control locations.

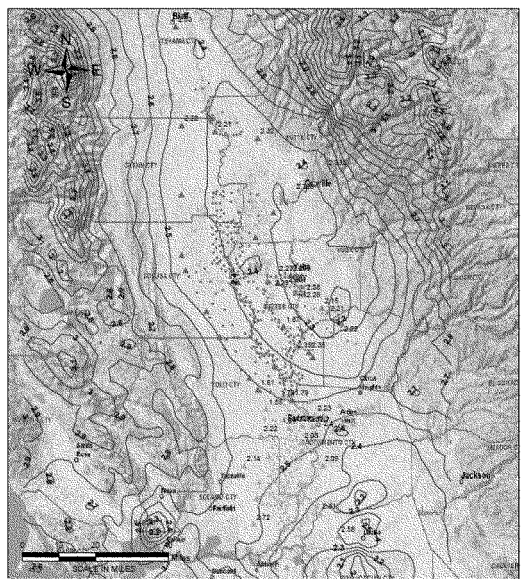


Figure 1- Map of project area and control network

Purpose

The NGS no longer provides elevations adjusted to the NGVD29 datum and recommends that NAVD88 be used for control. The U.S. Army Corps of Engineers, in cooperation with the National Geodetic Survey (NGS), has several engineering manuals including EM 1110-1-1005 Control and Topographic Surveying (Reference a) and EC 1110-2-6065 Comprehensive Evaluation of Project Datums (Reference b), that now mandate all such data and its many applications reference the North American Vertical Datum of 1988 (NAVD 1988). To make the comprehensive study mapping data compatible with recent data collected in the NAVD88 datum, the American River Common Features GRR Project has requested these data be accurately updated to the NAVD88 datum. The purpose of the five tasks described in this report is to develop a project-specific conversion surface to apply to the original mapping deliverables, to convert the datasets into NAVD88.

2. Task 1 Overview

Task Objective
Develop quality control plan and geospatial data management plan

Procedure
HJW developed a quality control plan which was signed and submitted by HJW on October 7th, 2009. This plan illustrates the following elements:

- HJW Quality Statement
- Management approach to quality control
- Project delivery team
- Quality control procedures
- Project milestone quality control timeline
- Independent technical review

On October 8th, 2009, HJW provided the geospatial data management plan, which integrates geospatial data management into project management business process, facilitating the implementation of enterprise data management.

Conclusion
HJW's quality control plan and geospatial data management plans were approved by the USACE, and the project team proceeded to Task 2.

3. Task 2 Overview

Task Objective
Review comprehensive study mapping control

Procedure
Task 2 as listed in the Statement of Work involved the review of the comprehensive study mapping control and GPS network files for the four separate networks. A subset of stations from the four networks was selected to be included in our survey, subject to recovery efforts, and criteria for selecting alternate stations were identified.

As part of Task 2, a technical memorandum was prepared describing the selection of stations for survey, the planned survey method and control. A draft report was prepared in accordance with the original Statement of Work which described a static GPS survey network to be surveyed according to NGS58/59 specifications. Interpretation of these specifications, particularly in regards to station spacing and minimum observation times, revealed that following the strictest interpretation would be unnecessarily prohibitive for this project given the accuracy requirements, and this led to discussion of alternate methods. Upon discussion with the USACE it was determined that network RTK would meet the project needs and the scope was modified by the issuing of a supplemental Statement of Work (dated December 9, 2009 and Revised January 7, 2010) before the control survey had commenced.

Conclusion
A final technical memorandum, dated March, 10 2010, describing the proposed survey was subsequently accepted by the USACE and is included in this submittal as Task 2/Appendix A. Filename: "Appendix A - 100310 Control Memo.pdf".

4. Task 3 Overview

Task Objective
Control survey to achieve the following objectives:

1) Provide adequate NAVD88 vertical constraints to readjust four legacy static GPS networks to the NAVD88 datum. (Upper Feather River, Lower Feather River, Lower Sacramento & Upper Sacramento networks)
2) Resurvey a selection of points from all four legacy GPS networks to establish check points for validation of a conversion surface to be created from the readjusted legacy networks. These points will not be used in developing the conversion surface
3) Establish accurate NAVD88 benchmark elevations at approximately 30 State of California Department of Water Resources (DWR) stream gauging stations, and level elevations to additional marks and features at each site.
4) Establish accurate NAVD88 elevations on approximately 20 existing USED benchmarks
5) Establish accurate NAVD88 elevations on control points used in topographic mapping of five weirs specified by the USACE, to facilitate conversion of the mapping to the NAVD88 datum

Methodology for the control survey is described in the final technical memorandum, submitted as the Task 2 deliverable for the project.

4.1. Schedule

The three main components of the control survey were performed through the following dates:

1) **Control Station Recovery**: Most Stations were recovered between November 23, 2009 and December 17, 2009. Additional recovery efforts for USED Benchmark and stream gage reference marks took place in January through April of 2010.

2) **GPS Surveying:** GPS observations for control stations and Comprehensive Study Mapping control stations were performed between late January 2010 and early March 2010. Additional observations at USED benchmarks, stream gages, and reoccupation of stations with poor repeat precision were performed throughout May and April of 2010.

3) **Leveling:** Most leveling was performed during the second half of March 2010, with some additional leveling performed in April 2010

4.2. Control Station Recovery

Stations were searched for and recovered using handheld GPS receivers (Trimble Juno SB) and ArcPad 8.0 software. Recovered stations were photographed using the onboard camera, and basic recovery information (date, condition, party chief) was stored. An ESRI ArcGIS shapefile was created including all collected information and links to photographs. Photos taken using the Trimble Juno SB hardware were also geotagged if the GPS receiver had a positional fix at the time the photo was taken. Photos and GIS data are delivered with this submission in the folder: Task 3/Monument Photos and GIS Data.

An evenly distributed selection of stations from each of the comprehensive study GPS networks was identified as part of Task 2, and the field staff was instructed to search for these stations. If the selected station was not found or found disturbed, the crews searched for nearby stations until one in good condition was recovered. NAVD88 control stations were also recovered at this time.

4.3. RTK GPS Survey

Through coordination with the USACE it was determined that the best methodology to perform the survey within the time, budget & achieve the positional accuracy required would be to use RTK GPS in conjunction with a Real-Time Network (RTN). To maximize the accuracy of the RTK survey, all stations were observed for a minimum of 5 minutes (300 epochs), and all stations were observed at least twice, with observations a minimum of 3 hours apart in order to obtain significantly different satellite geometry. The two observed heights were then averaged to obtain a final result.

Statistical review of the data obtained in the first few weeks of surveying showed that for repeat observations, the 95% confidence interval for the height component was approximately +/- 0.20 feet between observations. This value was then used as a basis to determine which stations would need to be observed a third time. Any stations for which the two observed heights did not agree within 0.20' were observed a third time and the results were re-evaluated. If two of the heights were in relative agreement and the third was an obvious outlier, then the outlier was discarded and the average of the remaining two was taken. If the third observed height was midway between the first two observed heights, then an average of all three was taken.

Our assessment of the accuracy of the NAVD88 elevations obtained by RTK methods is based on a number of components. Evaluation of repeat observations showed the vertical accuracy of any given measurement to be +/- 0.2 feet at 95% confidence. Derived heights were based on a GPS site calibration to control stations with inherent uncertainty (typically height modernization stations published +/-0.10 foot vertical accuracy), and observations on the control stations have the same uncertainty as all other RTK observations. There is also inherent uncertainty in the Geoid model. We estimate that the overall vertical accuracy of surveyed stations relative to the National Spatial Reference System (NSRS) and NAVD88 will be better than +/-0.33 feet at 95% confidence.

The identical survey methodology was used for all stations observed as part of this survey regardless of purpose, including the comprehensive study mapping control, NAVD88 calibration points, USED benchmarks and stream gage benchmarks. All RTK survey data is included in the "RTK Survey Data" folder in the Task 3 submittal folder.

4.3.1. Equipment

Two of Bestor's RTK rovers were configured to work with either RTN, and two survey parties were dispatched to survey simultaneously. Equipment used consisted of the following:

Rover #1:
Trimble 5800 GPS Receiver / integrated GPS antenna
Trimble TSC-2 Data Collector with Survey Controller Software (v. 12.45)
Verizon MiFi 2200 mobile WiFi data link with Verizon Wireless 3G data service
Fixed-height GPS rover rod with clamp-on tripod.

Rover #2:
Trimble 5700 GPS Receiver
Trimble Zephyr Geodetic GPS Antenna
Trimble TSC-2 Data Collector with Survey Controller Software (v. 12.46)
Motorola Cellular phone with Verizon 3G data service & Bluetooth Dial-up Networking
Fixed-height GPS rover rod with clamp-on tripod.

4.3.2. Real-Time Networks

Two separate Real Time Networks (RTN's) were utilized to perform the RTK survey, maintained by two separate survey equipment vendors. Each network has unique characteristics. It was necessary to use both to networks achieve complete coverage of the project area.

Our primary deciding factor in deciding which to utilize was network coverage. Topcon California's network includes a higher density of stations near the southern end of the project, while the network operated by California Survey and Drafting Supply has coverage that extends further north.

Topcon California RTN:

Bestor is partnered with Topcon California to host a network station from their RTN on our building. This provides us with one user account to use the network, and it was used as the primary network for our survey. A second subscription was purchased in order to allow us to survey with two receivers simultaneously. Coverage for Topcon California's RTN does not extend to the northernmost extents of the project, however, so we used an alternate RTN to survey the northerly stations.

Topcon California's network includes options for network or single-base solutions. Network solutions were used exclusively for this project. While the RTN supports GLONASS observations, our rovers used only GPS for this project.

Real-time corrections for the Topcon California RTN were delivered via the RTCM broadcast format. This format did not allow positions to be store as vectors using our field equipment, therefore all observations were stored as positions.

California Survey and Drafting Supply (Trimble) RTN:

Corrections for the California Survey and Drafting Supply RTN are delivered via the CMR Broadcast format, and using this format we were able to choose to store our observations as vectors. All stored positions were based on a network solution based on the surrounding reference stations, however storing the observations as vectors from the nearest physical reference station can allow additional functionality using Trimble software. While the RTN supports GLONASS observations, our rovers used only GPS for this project.

4.3.3. GPS Site Calibrations

Three separate GPS site calibrations were performed, the results of which are include as GPS Site Calibrations Reports in Appendices B, C & D in the Task 3 submission folder.

As two different RTNs were used to cover different Geographic areas, each needed to include observations on a sufficient number and distribution of control stations to calibrate the given RTN to desired coordinate system and datum. Stations used in the calibrations are identified in the attached GPS Site Calibration Reports.

In addition to the two separate calibrations required by the use of two separate RTNs, the Lower Sacramento mapping area was calibrated to a different set of control stations than the rest of the project, which required a separate site calibration. All observations in the Lower Sacramento area used Topcon California's RTN, so there was no separate calibration of the CSDS RTN to the Lower Sacramento control.

Our survey was designed to include calibration points at approximately a 20 km spacing throughout the project, which we generally accomplished, however not all of the control stations we searched for were recovered which resulted in greater spacing in certain areas.

While performing the site calibrations, stations with high residuals were carefully reviewed, and in some cases obvious outliers were removed from the calibration.

GPS Site Calibrations were based on the following sets of control stations:

Lower Sacramento Mapping Area:

In the Lower Sacramento Mapping area, the Topcon California RTN was calibrated to stations from Delta Height Modernization survey, as published by the NGS. NGS published heights for these stations are derived using GEOID03, and are published with orthometric heights to the 0.1 foot. No surveying was performed in the Lower Sacramento mapping area using the California Survey and Drafting Supply RTN. Please refer to Appendix B in the Task 3 submission folder.

Upper Sacramento, Lower Feather & Upper Feather Mapping Areas:

In all other mapping areas, two separate site calibrations were performed to derived orthometric heights obtained by applying the GEOID09 separation to the unpublished Sacramento Valley Height Modernization Project (SVHMP) ellipsoid heights, as delivered by the USACE. Please refer to Appendix C and D in the Task 3 submission folder.

4.4. Leveling

Leveling was performed at various locations for specific purposes identified in the Statement of Work. Most of the leveling required was to establish elevations on various reference marks at stream gages.

Additional leveling was required for certain USED benchmarks. Where a USED benchmark was recovered but was not in a GPS-suitable location, a temporary benchmark was established nearby and leveling was performed from the temporary benchmark to the USED benchmark.

Equipment used for leveling consisted of Leica NA2 auto levels. All elevations determined through leveling were part of a closed loop.

All leveling was performed using closed loops, and all loop closures were less than 0.02 feet. Local accuracy between stations within one level loop is +/- 0.02 feet.

4.4.1. Stream Gages

The locations of stream gage reference marks were provided by the USACE, who obtained them from the operating agency (California Department of Water Resources or U.S. Geological Survey). At each gage site, our crews attempted to recover the reference marks indicated.

If a reference mark was found in a GPS-suitable location, an elevation was established by GPS methods (described above), and a leveling crew later returned to the gage site to level from the GPS-established benchmark elevation to additional reference marks and the water surface. If no recovered reference marks were GPS-suitable, then a temporary benchmark was established at the site using GPS methods for use as a local benchmark.

Our office prepared a custom form specific for leveling at the stream gage locations, and our leveling crews completed a leveling form for each stream gage. Scans of the completed stream gage leveling forms are attached as Appendix E in the Task 3 submission folder.

The GPS-established reference mark at each stream gage was determined through RTK GPS methods described in Section 4.3. Estimated accuracies for the reference marks with respect to the National Spatial Reference System (NSRS) and NAVD88 are +/-0.33 feet as described above. All leveling at each gage site was performed as part of a closed loop, and all loop closures were less than 0.02 feet. The local accuracy between leveled marks at each gage site is +/- 0.02 feet.

4.4.2. USED Benchmarks

Leveling was performed at certain USED benchmarks, in cases where the recovered benchmark was found in a location not suitable for GPS. The table below summarizes the results of our survey of USED benchmarks. Some of the elevations shown were established by leveling from a temporary benchmark, while others were surveyed directly with GPS methods.

In six locations, no benchmark was recovered after searching for all of the alternates identified on the spreadsheet provided by the USACE. In the general area identified as Tisdale Weir, none of the identified benchmarks were recovered; however we leveled to a USED Brass Disc that we

found in the North End of Weir with the stamping illegible. Some additional "USED" stamped monuments not identified in the table below were also surveyed as reference marks at stream gage locations. Elevations for these monuments can be found on the stream gage leveling forms.

Area ID	General Area	Station ID	Benchmark NAVD88 Elevation (U.S. FT)	NAVD88 Survey Date	Notes
1	Collinsville	USGS BM 1906 5B	8.33	26-Jan-10	
2	Rio Vista	USC & GS BM D-585-JS1797	20.19	25-Jan-10	
3	Isleton	Bm # 15	22.59	27-Jan-10	
4	Walnut Grove	USED # 26 (marked #50)	26.82	27-Jan-10	
	Courtland	USED 61	25.17	2-Feb-10	
5	Courtland		27.14	28-Jan-10	No Requested Stations Found - Surveyed "USE64" in Same Vicinity
6	Freeport	USED 81	28.80	2-Feb-10	
7	Sacramento 1	Tidal 3 -JS2309	34.44	3-Feb-10	
	Sacramento 2	Weir # 1	44.64	3-Feb-10	AKA "SAI-179"
8	Sacramento 2	Weir # 2	44.50	3-Feb-10	AKA "SA-178"
9	Sacramento 3	USGS 21 B	23.68	15-Apr-10	
10	Knights Landing	USED 1001	43.65	3-Mar-10	
11	Tisdale Wier		44.22	3-Mar-10	No Requested Stations Found - Surveyed USED Brass Disc in North End of Weir, stamping illegible
	Middle of Upper Sac	USED 1259 Moulton Weir	84.41	16-Feb-10	
14	Middle of Upper Sac	USED 1257	84.43	16-Feb-10	
18	Yuba/Marysville	USED 3111	73.28	14-Apr-10	
12	Butte		No Benchmarks Recovered		
13	Colusa		No Benchmarks Recovered		
15	Upper/middle sac		No Benchmarks Recovered		
16	Upper Sac River		No Benchmarks Recovered		
17	Lower Feather		No Benchmarks Recovered		
19	Upper Feather		No Benchmarks Recovered		

Table 1: Summary of USED Benchmarks

4.4.3. Weir Surveys

A small amount of leveling was also performed at various weir survey locations for the purpose of establishing NAVD88 elevations on hard features identified in topographic survey drawings. These will be used as reference points to convert these drawings to the NAVD88 datum. Conversion will be done as part of Task 6.

The tables below show comparisons between the surveyed NAVD88 elevations and the NGVD29 elevation of certain benchmarks and features shown on CAD drawings provided by the USACE. At each weir site an average difference has been calculated for use in converting NGVD29 elevations shown on the drawing to NAVD88.

All elevations at any one weir site were determined through differential leveling from a single GPS-established reference mark, with the exception of the Fremont Weir, where a reference mark was established by GPS methods at each end of the weir. Estimated accuracies are +/- 0.02 feet within each closed level loop, and +/- 0.33 feet relative to the National Spatial Reference System (NSRS) and NAVD88.

Moulton Weir				
Point	**NGVD29 Elevation (m)**	**NGVD29 Elevation (USFT)**	**NAVD88 Elevation (USFT)**	**Difference (USFT)**
South Headwall / USED 1257	25.15	82.51	84.43	1.92
North Headwall / USED 1259	25.19	82.64	84.41	1.77
Weir Crest - South End	22.49	73.79	75.87	2.08
Weir Crest - Midpoint	22.55	73.98	75.92	1.94
Weir Crest - North End	22.56	74.02	75.99	1.97
			Average Difference:	**1.94**

Table 2- Elevations for Moulton Weir

Fremont Weir				
Point	**NGVD29 Elevation (m)**	**NGVD29 Elevation (USFT)**	**NAVD88 Elevation (USFT)**	**Difference (USFT)**
East Headwall / "Fremont"	11.84	38.85	41.11	2.26
Weir Crest - East End	9.25	30.35	32.67	2.32
Weir Crest - West End	9.21	30.22	32.42	2.20
		0.00	**Average Difference:**	**2.26**

Table 3- Elevations for Fremont Weir

Colusa Weir				
Point	NGVD29 Elevation (m)	NGVD29 Elevation (USFT)	NAVD88 Elevation (USFT)	Difference (USFT)
North End Weir @ Centerline	17.94	58.86	60.77	1.91
North End Weir @ West Edge	17.86	58.60	60.62	2.02
North End Weir @ East Edge	17.86	58.60	60.58	1.98
			Average Difference:	1.97

Table 4- Elevations for Colusa Weir

Tisdale Weir				
Point	NGVD29 Elevation (m)	NGVD29 Elevation (USFT)	NAVD88 Elevation (USFT)	Difference (USFT)
Weir Crest - North End / USED 1129	12.82	42.06	44.22	2.16
North Headwall / "RP#1"	14.69	48.20	50.33	2.13
			Average Difference:	2.15

Table 5- Elevations for Tisdale Weir

Sacramento Weir				
Point	NGVD29 Elevation (m)	NGVD29 Elevation (USFT)	NAVD88 Elevation (USFT)	Difference (USFT)
F9 01	11.90	39.04	41.28	2.24
SA1-229	12.44	40.81	43.09	2.28
Conc Wall NE Corner Weir / SA-178	12.89	42.29	44.50	2.21
Weir Crest - North End	6.28	20.60	22.87	2.27
Weir Crest - South End	6.39	20.96	22.91	1.95
			Average Difference:	2.26

Table 6- Elevations for Sacramento Weir

5. Task 4 Summary

Task Objective

Readjust Comprehensive Study GPS Network Files into NAVD88.

5.1. Lower Sacramento

The readjustment of the Lower Sacramento Comprehensive Study GPS Network was performed by a third party contracted directly by the USACE. The readjustment was based on stations surveyed by Bestor and provided to the USACE.

The original Lower Sacramento Comprehensive Study network adjustment was performed using a software package that our office was unable to work with (Geolab). Also, digital files containing the original GPS data or processed vectors were not available. Data available from the network consisted of only scanned printouts of the adjusted coordinate listing, and some of the adjustment results.

The USACE contacted the vendor of the Geolab software, Bitwise Solutions, and arranged to transpose the scanned adjustment reports and have Bitwise readjust the network using a current software release. A report documenting the readjustment was prepared by Bitwise Solutions and is included in this submittal in the Task 4 folder, in the "Bitwise Readjustment" subdirectory.

Bestor's involvement was limited to providing surveyed NAVD88 elevations for a sufficient number of stations to facilitate the readjustment, and reviewing the comparison of checkpoint elevations to elevations derived using a surface created from the readjusted elevations.

5.2. Lower Feather River

The comprehensive study GPS network files for the Lower Feather River mapping area were delivered to us by the USACE in Trimble Geomatics Office format, the format generally used by our office for GPS processing.

The project was opened and converted to our current software version (ver. 1.63) and all NGVD29 control elevations were discarded. Our resurveyed NAVD88 elevations were added as constraints, and a least-squares network adjustment was performed. GEOID09 was used in the readjustment.

A horizontal and vertical adjustment was performed, however only the readjusted heights were used in the development of the conversion surface.

A network adjustment report is included in the Task 4 submittal folder, as Appendix F.

5.3. Upper Feather River

HJW arranged to purchase the comprehensive study GPS network files for the Upper Feather River area from the original surveyor, Andregg Geomatics, which were delivered to Bestor on 28 September 2010.

Files were delivered in a Trimble .A1 archive format, which we were able to import into our Trimble Geomatis Office software ver. 1.63. All NGVD29 control point elevations were discarded, and a least-squares network adjustment was performed constraining the NAVD88 resurveyed elevations. GEOID09 was used in the readjustment.

A horizontal and vertical adjustment was performed, however only the readjusted heights were used in the development of the conversion surface.

A network adjustment report is included in the Task 4 submittal folder, as Appendix G, along with the adjustment data, in the "Trimble Geomatics Office" directory.

5.4. Upper Sacramento

The comprehensive study GPS network files for the USACE were provided to us by the USACE in an Ashtech format that is no longer supported. We were therefore not able to open the network files directly with software available to us, however we were able to import the processed vectors into Magellan's GNSS Solutions software, version 3.10.10, which we obtained specifically to work with this data.
s
The Upper Sacramento network files consisted of five separate Ashtech projects, and were readjusted as five separate projects in GNSS Solutions, named "CHICO", "DAVIS", "SCID", "YUBANRTH" & "YUBASTH"

Elevations and coordinates of resurveyed stations were added to the respective projects as constraints, and a least-squares adjustment was performed using the Fillnet component of the GNSS Solutions software. Since the purpose of the readjustment was to establish NAVD88 heights, no attempt was made to perform a precise horizontal readjustment, or to resolve horizontal misclosures.

Survey reports including adjustment reports generated using GNSS Solutions software are included as Appendices H through L, in the Task 4 submittal folder. The network adjustment data is also contained within the "GNSS Solutions" folder in the Task 4 submittal folder.

5.5 Checkpoint Evaluation of Readjusted Networks

For each of the four readjusted Comprehensive Study GPS Networks, the readjusted elevations of a selection of stations were compared to newly surveyed checkpoint elevations of the same stations. Checkpoint elevations were determined by the use of the network RTK methodology described in Section 4.3. The surveyed checkpoint elevations were for evaluation purposes only and were not used in the network readjustments. This comparison provides a measure of how well the readjusted elevations can be expected to represent resurveyed elevations. This is strictly an evaluation of the network readjustments, and is completely independent of the development of the conversion surface (Task 5). Tables and statistics for the checkpoint evaluation of each of the four readjusted networks are shown below. All units shown are U.S. Survey Feet.

Upper Sacramento Readjustment	
RMS Error	0.152
Mean	-0.063
Median	-0.056
Mode	#N/A
Standard Deviation	0.14208
Sample Variance	0.02019
Kurtosis	0.92899
Skewness	-0.61053
Range	0.594
Minimum	-0.404
Maximum	0.19
Sum	-1.131
Count	18

Table 7- Checkpoint analysis of Upper Sacramento readjusted network

One checkpoint, point # 388, was rejected and not used in the RMS calculation for the Upper Sacramento region. The point was a statistical outlier for the dataset, outside the 95% confidence interval (1.96 sigma). The large observed difference between the readjusted elevation and surveyed elevation is likely indicative that the monument has been disturbed since the time of the original Comprehensive Study survey.

Upper Feather Readjustment	
RMS Error	0.049
Mean	-0.015
Median	-0.017
Mode	#N/A
Standard Deviation	0.04922466
Sample Variance	0.00242307
Kurtosis	-1.1690365
Skewness	-0.0034134
Range	0.146
Minimum	-0.087
Maximum	0.059
Sum	-0.152
Count	10

Table 8- Checkpoint analysis of Upper Feather readjusted network

Lower Feather Readjustment	
RMS Error	0.066
Mean	-0.035
Median	-0.026
Mode	#N/A
Standard Deviation	0.059122
Sample Variance	0.003495
Kurtosis	1.771227
Skewness	-0.86275
Range	0.198
Minimum	-0.158
Maximum	0.04
Sum	-0.314
Count	9

Table 9- Checkpoint analysis of Lower Feather readjusted network

Lower Sacramento Readjustment	
RMS Error	0.196
Mean	-0.095
Median	-0.091
Mode	#N/A
Standard Deviation	0.185508
Sample Variance	0.034413
Kurtosis	1.979844
Skewness	1.232794
Range	0.556
Minimum	-0.292
Maximum	0.264
Sum	-0.662
Count	7

Table 10- Checkpoint analysis of the Lower Sacramento readjusted network

One checkpoint, Point # 108, was rejected and not used in the RMS calculation for the Lower Sacramento region. The point was a statistical outlier for the dataset, outside the 95% confidence interval (1.96 sigma). The large observed difference between the readjusted elevation and surveyed elevation is likely indicative that the monument has been disturbed since the time of the original Comprehensive Study survey. Additionally two points, #86 and # 159, were surveyed for checkpoint purposes; however no readjusted elevations were provided for these stations so no comparison could be made.

Conclusion

RMS vertical errors for the four network readjustments range between 0.05' and 0.20' based on our checkpoint evaluation. This is consistent with our expected vertical accuracy of our survey methods used to resurvey the control stations and checkpoints, demonstrating that all four readjustments were successful. The readjusted coordinates represent accurate NAVD88 elevations, and are suitable for use in development of the conversion surface.

6. Task 5 Summary

Task Objective
Develop conversion surface which will be used to convert Comprehensive Study DTM data from original datum into NAVD88.

6.1 Methodology

The Comprehensive Study DTM data was tied into multiple unreliable control networks referencing NGVD29. Because of this lack of reliability, Vertcon alone does not provide an adequate conversion to NAVD88. Therefore, in addition to the Vertcon correction, we also model the "Vertcon error", which we define as the difference between the Vertcon correction and the measured correction at known points. The "Vertcon error" for this network of points acts as the conversion surface; an enhancement to the transformation from NGVD29 to NAVD88 that is applicable only to this dataset- the Comprehensive Study DTM. For clarity, it is important to note that our use of the term "Vertcon error" does not imply that there is error in Vertcon, but rather it describes the error that remains for this particular dataset after applying the Vertcon transformation.

The following steps were taken to develop the conversion surface:

1. For each surveyed point in the control network, we determined the difference between NGVD29 and NAVD88 using Vertcon.
2. We subtracted the Vertcon-derived value of NAVD88 from the newly-surveyed, adjusted value
3. A TIN was created of these differences, which we call the "Vertcon error"
4. The TIN was converted into a DEM at 1,000' point posting
5. CORPSCON was used to determine Vertcon correction values, based upon the horizontal position of each DEM point
6. At each DEM point, the "Vertcon error" is added to the Vertcon value. These are the final correction values that can be applied to the Comprehensive Study DTM in order to convert into NAVD88.
7. The DEM was then represented as a TIN for subsequent contour generation (at 0.1' interval) and utilization as a conversion surface.

Input data used in the development of the conversion surface was provided by Bestor Engineers, as a result of their completion of Task 4. All primary and secondary control points that were surveyed had the following information provided as input to the conversion surface computation:

a. Station Name
b. Horizontal position (Northing and Easting in SPCS NAD 83 Zone II – US Foot)
c. Height in NGVD29
d. Height in NAVD88 – resulting from field survey (primary points), or as a result of network adjustment (secondary points)
e. Vertical differences between NAVD88 and NGVD29 at these locations.

Initially, the team had planned to generate each of the four conversion surfaces independently of each other; that is to say that there will be one conversion surface for Upper Feather, Lower Feather, Upper Sacramento and Lower Sacramento, and each surface will utilize only control

points (primary / secondary) that were part of each region's original survey. This approach was modified after determining that the control networks as planned did not provide suitable geometry for circumscribing the respective mapping areas for interpolation. The solution to this was to create two (rather than four) conversion surfaces.

1. Conversion surface 1 ("CSurface 1"): Lower Feather River Area
2. Conversion surface 2 ("CSurface 2): Lower Sacramento, Upper Sacramento, Upper Feather Areas.

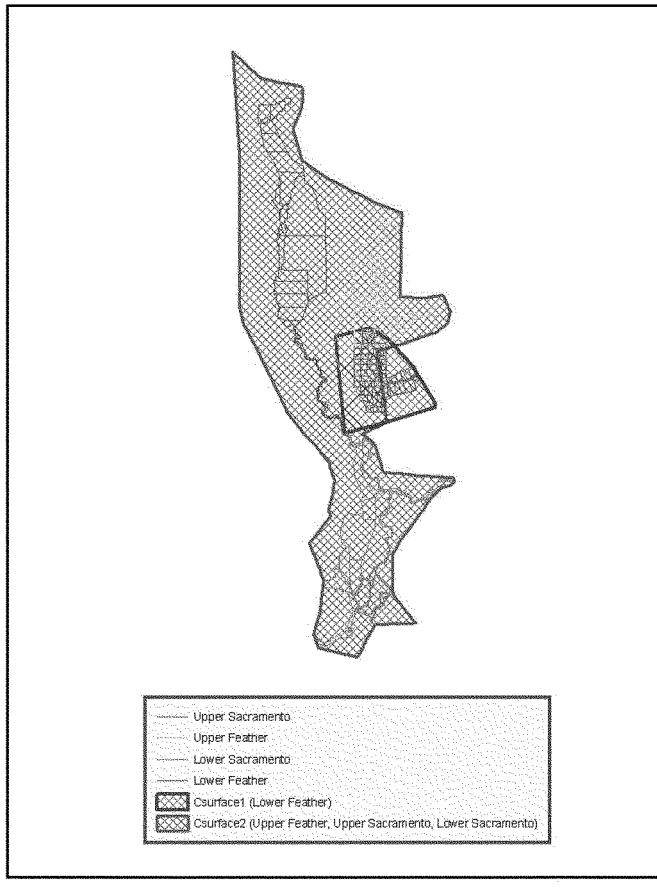


Figure 2: Conversion surface 1 in blue, conversion surface 2 in red

6.1.1 Conversion Surface 1- Lower Feather River Area

For the Lower Feather River area, it was determined that due to the control distribution, another control point external to the planned network was necessary for proper interpolation of the conversion surface. The USACE provided an additional point- NGS station Q213 (see table below) to use for this purpose. All data in the following table is with respect to State Plane Coordinates, Zone 2, NAD83, USFT.

PT	N	E	EL29	EL88	EL_DIFF	VERTCON	VCON_ERROR
Q 213	2229142.12	6816654.03	1814.763	1817.221	2.458	2.451	0.007

PT = Station Name
N = Northing
E = Easting
EL29 = Elevation in NGVD 29
EL88 = Elevation in NAVD 88
EL_DIFF = Elevation difference EL88 – EL29
VERTCON = Vertcon value
VCON_ERROR = Vertcon error values

Table 11- NGS point provided by USACE to complete conversion surface 1 TIN

Conversion Surface 1 covers 403 square miles and utilizes 57 surveyed points. One point was omitted from the surface computation after it was determined to be in error, as it was exhibiting a spike in the surface. Nine checkpoints were tested for this conversion surface.

6.1.2 Conversion Surface 2- Lower Sacramento, Upper Sacramento and Upper Feather River Areas

In Conversion Surface 2, there were four points common to the Upper Sacramento and Lower Sacramento areas that Bestor had surveyed and which were also computed independently by adjustment of an existing dataset. In the conversion surface, we used only the surveyed points in this case. The four points and surveyed coordinates are listed in the table below.

PT	N	E	EL29	EL88	EL_DIFF	VERTCON	VCON_ERROR
AYRES 494	2013742.95	6654790.27	47.621	49.474	1.852	2.661	0.809
AYRES 500	2014208.17	6663022.65	38.520	40.318	1.798	2.694	0.896
DUFOUR RM 2	2039908.19	6606054.47	64.370	66.054	1.684	2.772	1.088
Q858	2069993.26	6697206.30	44.560	46.228	1.667	2.516	0.849

Table 12- Surveyed points used in Upper Sacramento area conversion surface

It was necessary to add three more control points in order to have proper TIN interpolation of the conversion surface. The USACE provided HJW with three additional NGS points, as listed in the table below.

PT	N	E	EL29	EL88	EL_DIFF	VERTCON	VCON_ERROR
S 138	2585481.44	6736182.87	4850.200	4853.616	3.416	3.428	-0.012
Q 213	2229142.12	6816654.03	1814.763	1817.221	2.458	2.451	0.007
G 900	2341925.07	6669223.60	320.925	323.306	2.381	2.375	0.006

Table 13- Additional NGS points provided by USACE for Conversion Surface 2

Conversion Surface 2 covers 3,567 square miles and utilizes 612 surveyed points. Three points were classified as blunders and omitted from the surface computation as they were showing spikes in the conversion surface. 36 checkpoints were used in this conversion surface. Section 6.3 lists the supporting data files and deliverables applicable to this conversion surface.

6.2 Checkpoint Comparison & Conversion Surface QA/QC

Based on the readjusted elevations from the Comprehensive Study GPS networks, two NGVD29 to NAVD88 conversion surfaces were developed for use in converting the mapping to the NAVD88 datum. Methodology for the development of the conversion surfaces was determined by coordination between HJW and the USACE, with minimal involvement from Bestor.

Bestor's role in the QA/QC of the conversion surfaces was primarily the comparison of the elevations of surveyed checkpoints to elevations derived using the conversion surface.

Some outlier checkpoints with excessively high residuals were rejected, and review of the locations of the surveyed monuments found that most of these were in locations that were likely to have been disturbed. In all cases any rejected checkpoints were statistical outliers that were outside the 95% confidence interval (1.96 sigma) for the data set.

A comparison of nine checkpoints to elevations derived using the conversion surface yields the following statistics for the residuals (units are U.S. Survey Feet):

Lower Feather	
RMSE	0.077
Mean	0.005
Median	-0.006
Standard Deviation	0.081
Sample Variance	0.007
Range	0.313
Minimum	-0.124
Maximum	0.189
Sum	0.048
Count	9

Table 14- Checkpoints results for conversion surface 1- Lower Feather River Area

A similar comparison using 36 checkpoints from the remaining three areas (and rejecting points # 388 & 504) gives the following:

Lower / Upper Sacto & Upper Feather	
RMSE	0.133
Mean	-0.032
Median	-0.044
Standard Deviation	0.131
Sample Variance	0.017
Range	0.573
Minimum	-0.296
Maximum	0.277
Sum	-1.144
Count	36

Table 15- Checkpoint results for conversion surface 2- Lower and Upper Sacramento, Upper Feather River Areas

The calculated RMSEz for the two sets of checkpoints indicate that the conversion surfaces should be effective in accurately converting the comprehensive study mapping files to the NAVD88 datum, as the accuracy of surveyed checkpoints will exceed most all map accuracy standards used for aerial mapping that may have been used in the development of the comprehensive study mapping.

6.3 Conclusion

Two conversion surfaces were generated for the four mapping areas (upper and lower Feather, and upper and lower Sacramento River areas) by incorporating measurements of height differences between NGVD29 and NAVD88 at known primary survey points and secondary points determined through network readjustments. This allows for the determination of errors that remain after the Vertcon transformation between datums. Checkpoint analysis of the conversion surface indicates accuracies that are well within mapping specifications for the Comprehensive Study DTM.

Conversion Surface 1

- Applicable area: Lower Feather River mapping area
- Based upon checkpoint comparisons, the RMSE of 0.077' indicates that tested points are well within the requirements of converting the Comprehensive Study DTM data.

Conversion Surface 2

- Applicable areas: Lower Sacramento, Upper Sacramento, Upper Feather River mapping areas.
- Based upon checkpoint comparisons, the RMSE of 0.133' indicates that tested points are well within the requirements for converting the Comprehensive Study DTM data.

Instructions for use of the Conversion Surfaces
Both conversion surfaces area applicable only to the Comprehensive Study DTM data, which was collected in the late 1990's and early 2000's, by three vendors, as illustrated in the introduction to this report. The conversion surface is used to convert elevations from the instance of NGVD29 used in the Comprehensive Study project, into NAVD88. Task 6 is dedicated to the application of this conversion surface to the DTM files.

6.4 Listing of Task 5 Deliverables and Data Directory Index

1. Report summarizing Tasks 1-5, after having undergone independent technical review, including assessment of uncertainty based upon values at checkpoints. Final report in digital and three paper hardcopies.

2. ESRI TIN of conversion surface
    a. Conversion Surface/CSurface1/ESRI/TIN/
        i. CSurf1_vconer
        ii. CSurface1
    b. Conversion Surface/CSurface2/ESRI/TIN/
        i. CSurf2_vconer
        ii. CSurface2

3. Contour map of conversion surface in shapefile format
    a. Conversion Surface\CSurface1\ESRI\Shp\Csurface1_contourlines.shp
    b. Conversion Surface\CSurface2\ESRI\Shp\Csurface2_contourlines.shp

4. Shapefile of final control points- NGVD29 and new values
    a. Conversion Surface/CSurface1/ESRI/Shp/
        i. Csurface1_points_primary.shp
        ii. Csurface1_points_secondary.shp
    b. Conversion Surface/CSurface2/ESRI/Shp/
        i. Csurface2_points_primary.shp
        ii. Csurface2_points_secondary.shp

5. Approval of conversion surface by PLS
    a. Attached: "100526 Conversion Surface Certification.pdf"

6. Map of checkpoints and uncertainties
    a. Conversion Surface\CSurface1\PDF\ CSurface1_CheckpointandUncertaintiesMap.pdf
    b. Conversion Surface\CSurface2\PDF\ CSurface2_CheckpointandUncertaintiesMap.pdf

7. Conversion surface in shapefile format
    a. See item 4- shapefile of final control points. This contains the conversion surface points as well.

8. Conversion surface in Arc Generate ASCII format
    a. Conversion Surface\CSurface1\ESRI\ArcGenerate
    b. Conversion Surface\CSurface2\ESRI\ArcGenerate

9. Conversion surface in InRoads V8 format
    a. Conversion Surface\CSurface1\Bentley\InRoads
    b. Conversion Surface\CSurface2\Bentley\InRoads

10. Conversion surface and contours in DGN format
    a. Conversion Surface\CSurface1\Bentley\Microstation
    b. Conversion Surface\CSurface2\Bentley\Microstation

11. Conversion surface and contours in Microstation V8 ASCII InRoads format
    a. Conversion Surface\CSurface1\Bentley\InRoads
        i. CSurface1_r.dat
        ii. CSurface1_e.dat
    b. Conversion Surface\CSurface2\Bentley\InRoads
        i. CSurface2_r.dat
        ii. CSurface2_e.dat

12. Paper map of conversion surface (22" X 34")
    a. Conversion Surface\CSurface1\PDF\CSurface1_ConversionSurfaceMap.pdf
    b. Conversion Surface\CSurface2\PDF\CSurface2_ConversionSurfaceMap.pdf

13. Quality control certification
    a. Considered complete per PLS approval document "100526 Conversion Surface Certification.pdf"

14. Raw GPS files
    a. All GPS data that was collected for this project is within the RTK Survey Data\ directory.

15. Trimble Geomatics office project
    a. See item 17 "Machine-readable unadjusted and adjusted network files"

16. GPS log sheets and field notes (digital version)
    a. Field notes: Stream Gage Level Data\Stream Gage Benchmark Forms.pdf
    b. USED Benchmarks\Surveyed USED Benchmarks.xls
    c. RTK Survey Data\
        i. 671305 - Lower Sac RTK
        ii. 671305 - Upper Sac RTK – CSDS
        iii. 671305 - Upper Sac RTK – Topnet
    d. Monument Photos & GIS Data\

17. Machine-readable unadjusted and adjusted network files
    a. Network Readjustment Files\
        i. Bitwise (Lower Sacramento Area)
        ii. GNSS Solutions
        iii. Trimble Geomatics Office
            1. Andregg Upper Feather
            2. Towill Feather River

18. Survey results at stream gages
    a. Field notes: Stream Gage Level Data\Stream Gage Benchmark Forms.pdf

Converted DTM Data- Two tiles in the "Converted Tiles" directory.

1. Microstation DGN V8, contours [planimetrics and DTM not converted for these two tiles; not present in input data]
2. Microstation DTM files
3. Microstation DTM files in ASCII format
4. Metadata
5. ESRI DTM files
6. ESRI shapefiles of contours, breaklines, planimetrics, exterior boundaries, etc.
7. ESRI DTM ArcGenerate ASCII files (interior, exterior, etc.)
8. DWG files contours [planimetrics and DTM not converted for these two tiles; not present in input data].

ENCLOSURE D

GEOMORPHOLOGY ASSESSMENTS

WILLIAM LETTIS & ASSOCIATES, INC.
1777 Botelho Drive, Suite 262, Walnut Creek, California 94596
tel (925) 256-6070 fax (925) 256-6076

September 8, 2009

Mr. Juan Vargas
URS Corporation
2870 Gateway Oaks Drive, Suite 150
Sacramento, CA 95833

RE: Surficial geologic mapping and geomorphic assessment, California Department of Water Resources Urban Levees, Wadsworth Canal, Sutter County, California

Dear Mr. Vargas:

This memorandum presents the surficial geologic mapping and preliminary geomorphic assessment of the Wadsworth Canal area, for the California Department of Water Resources (DWR) Urban Project Levees geotechnical characterization. The goal of this mapping and geomorphic assessment is to provide information on the type and distribution of surface and shallow subsurface deposits that likely underlie the project levees along the canal, with respect to potential levee underseepage. This letter presents the technical approach, surficial geologic map, conceptual geomorphic model, and initial results based on map analysis and preliminary review of Phase 1 geotechnical data.

We appreciated the opportunity to provide these geomorphic and geologic data and preliminary interpretations of the shallow stratigraphic conditions in the Wadsworth Canal study area. Please do not hesitate to call either of the undersigned if there are any questions or comments.

Respectfully,

WILLIAM LETTIS & ASSOCIATES, INC.

Justin Pearce, C.E.G. 2421
Senior Project Geologist
(925) 395-2035

Keith Kelson, C.E.G. 1610
Principal Geologist
(925) 395-2032

1.0 Approach

The approach to developing a surficial geologic map of the Wadsworth Canal area (Figure 1, Plate 1) consisted of analysis of the following data: Aerial photography (black and white stereo-pairs taken in 1937, ~1:20,000-scale); early topographic maps (USGS, 1911); published surficial geologic maps (Helley and Harwood, 1985); early and modern soil survey maps (Strahorn et al., 1911; Lytle, et al., 1988); field reconnaissance visit on June, 22, 2007, and other maps and documents (i.e., Chambers, 2002). Synthesis of these data allow for the development of a detailed surficial geologic map that provides an initial understanding of primary geomorphic processes that have acted in the study area during recent geologic and historical time. Through this mapping, primary geomorphic features and associated surficial geologic deposits are identified, such as abandoned paleochannels, marsh and basin deposits, and other features commonly associated with flood basins adjacent to large, active river systems.

The surficial geologic map was developed at the nominal scale of the aerial photography (1:20,000). This scale establishes the resolution of the map (Plate 1). The map unit contacts shown on the surficial geologic map should be considered approximate, and accurate to no more than about 30 feet on either side of the line shown on the map. The 1937 aerial photographs are the primary data set for interpreting the surficial geologic deposits because: (1) they are the oldest high-quality images available and pre-date much of the cultivation and landscape alteration within present-day Sutter County (Figure 2); and, (2) because these data represent a close approximation to the surficial deposits that were likely present at the ground surface prior to construction of the levees. The 1937 photographs generally were taken in later summer or early autumn (i.e., August). By 1937, the area had experienced moderate cultivation that locally obscures geomorphic conditions. However, integration of data from the 1937 photographs, old and recent topography, existing geologic maps, existing soil surveys and historical documents provides sufficient information to delineate many of the pre-historical and historical surficial deposits in detail. Taken together, these data provide key insights to the geomorphic processes and resulting deposits that may affect levee underseepage.

Additional floodplain deposition may have occurred after 1937, due to flood overflows, levee overtopping, or localized levee failure. A time series analysis that interprets successive aerial photographs taken after major flood events (i.e., 1955) or known local levee failures (i.e., 1986) may reveal additional information on surficial deposits in the Wadsworth Canal area. However, such analyses are beyond the scope of this project. The data and interpretations presented herein address the primary goal of characterizing the type and distribution of deposits likely present directly beneath the project levees.

1.1 Report Preparation Quality Control

The surficial geologic map data and geomorphic interpretations presented in this memorandum were subject to quality control and quality assurance procedures as required by the Levee Geotechnical Evaluation Project Management Plan (PMP). The surficial geologic map data developed by this study were reviewed for accuracy and completeness through an internal review and an independent technical review by Dr. Janet Sowers of WLA. Results of QA/QC

review were documented using PMP Exhibit 2.2-3 (Independent Technical Review Report) and are kept on file according filing control plan. Subsurface data shown on diagrams were provided as draft information, and were not verified for accuracy or completeness by this study.

2.0 Geologic Setting

The Wadsworth Canal (WC) study area is southeast of the Sutter Buttes, a presently in-active and dissected rhyolitic and andesitic volcanic neck, and between the Sacrametno River to the west and the Feather River to the east (Figure 1). The WC levee addressed in this study borders the southeastern side of Wadsworth Canal from just north of Butte House Road to the eastern Sutter Bypass levee. The WC levee trends northeast-southwest, and ties in to the eastern Sutter Bypass levee (Figure 1).

The WC levee lies northeast of Sutter Basin, a low-lying area east of the Sacramento River where overflow and floodwaters produce a seasonally marshy area. Except for the Sutter Buttes, the land regional surface is nearly flat, and along the WC area gently slopes southwest at an elevation of about 40 to 50 feet. Construction of the WC levee was completed by 1924, and was subsequently enlarged in 1942 (DWR, 1976). Prior to cultural modification, surface water runoff in the WC area was delivered to the Sutter Basin via intermittent, meandering creeks and sloughs from the northern Central Valley, including: Snake River, Snake Slough, Little Blue Creek, and ephemeral channels emanating from the eastern side of Sutter Buttes. Presently, many of the natural drainages and channels have been replaced by linear ditches, agricultural drains, and canals (Figure 2).

3.0 Surficial Geologic Mapping

Published surficial geologic maps within the WC study area generalized the surficial deposits primarily as Quaternary basin deposits, with localized units of Quaternary alluvium (map unit Qa) and Quaternary Modesto Formation (lower member, map unit Qml) (Helley and Harwood, 1985). These map units were delineated by Helley and Harwood (1985) at a regional scale (i.e., 1:62,500). The current analysis of the WC uses this existing geologic framework as a basis for more detailed mapping of late Holocene alluvium and geomorphic features (Plate 1). The surficial geologic map units in the Wadsworth Canal study area are described below, in order from oldest to youngest.

The oldest map unit exposed in the study area is the Pliocene-Pleistocene tuff breccia (map unit QTm). This rock primarily comprises a peripheral topographic ring around the relatively high relief Sutter Buttes, and consists of consolidated coarse material derived from the volcanic rocks of the Buttes. This bedrock is exposed in the northwest corner of the WC map area (plate 1).

The Quaternary Riverbank Formation (lower and upper members) is exposed at the ground surface adjacent to the tuff breccia (map unit Qrl and Qru, Plate 1). This map unit does not directly underlie the project levees in this study area, but is present in the shallow subsurface as

alluvial-fan deposits derived from the Sutter Buttes during the middle Pleistocene (about 400,000 to 200,000 years ago). The Riverbank Formation is semi-consolidated, and the top of the formation is marked by a hardpan (or, duripan) layer that is a product of soil-forming processes over substantial geologic time. This hardpan layer reflects an ancient land surface that is now buried by younger deposits. In WC area, the upper Riverbank formation is associated with the Sutter clay (Strahorn, et al., 1911), and Marcum clay loam with "siltstone" hardpan (Lytle, 1988).

The late Pleistocene Modesto Formation is exposed at the surface as alluvial-fan deposits emanating from southwestern Sutter Buttes, and is younger than, and inset into, the Riverbank Formation (Plate 1). This unit is divided into two members, a lower (older) unit that is about 42,000 to 29,000 years old (map unit Qml), and an upper member that is about 24,000 to 12,000 years old (map unit Qmu) (Helley and Harwood, 1985). The upper member in the map area is associated with sub-linear low ridges to the east of the WC that have not been completely covered by basin deposits. The Modesto Formation is locally associated with the Sutter sandy loam (Strahorn, et al., 1911), and the Olashes sandy loam (Lytle, et al., 1988); the sand consisting of volcanic lithologies indicating derivation from Sutter Buttes parent material. The latest Pleistocene Modesto Formation, in general, consists of unconsolidated sand, silt, and clay, and is associated with a moderate amount of secondary (pedogenic) clay accumulation that may form laterally continuous zones of low hydraulic conductivity.

Holocene deposits (less than 11,000 years old) in the WC map area consist of basin and alluvial deposits (Qb of Helley and Harwood [1985]; map unit Qn, Plate 1). These widespread basin deposits, about 4 to 8 feet thick, overlie the Modesto Formation. The soils developed on the basin deposits are generally the Gridley clay loam and Oswald clay (Stahorn et al., 1911; Lytle, et al., 1988), immature soils with fine-grained textures. Undifferentiated Quaternary alluvium (map unit Qa) is present near the western margin of the map area, deposited by pre-historic Butte Creek. Holocene alluvium is mapped at the surface as alluvial-fan deposits emanating from southwestern Sutter Buttes, and is younger than, and locally overlies the upper Modesto Formation. These deposits likely consist of poorly sorted mixtures of fine gravel, sand, and silt derived from the volcanic rocks of the Buttes. The Quaternary marsh deposits (map unit Qs, Plate 1) are present between the levees of the Sutter Bypass, and consist of fine grained deposits that are differentiated from basin deposits by generally being underwater or having standing water at the time when the 1937 photographs were taken.

Holocene alluvial channels (map unit Hch, Plate 1) are mapped as a network of moderately sinuous channels with southwesterly orientations. These channels appear to be mostly filled in with sediment on the 1937 photographs, and are not expressed as strong topographic lows in the ground surface. Many of these channels extend beyond, and therefore cross beneath, the eastern Sutter Bypass levee and WC levee (Plate 1). The infilling material in the basal portions of the channel consists of relatively loose, coarse material (i.e., sand), which fines upward into fine-grained, silt and clay. The channel deposits are tentatively associated with the Liveoak series, sandy clay loam soil (Lytle, et al., 1988).

Localized deposits related to the Holocene alluvial channels are in-stream bars (map unit Hb) that typically occur in the medial portions of the channels, and distributary fans (map unit Hdf)

that occur where the channel morphology tapers out and the channel has deposited sediment on the basin floor. These two types of deposits are uncommon in the study area, and have been mapped only distant from the WC levee.

Historical alluvial channels (map unit Rch, Plate 1) also are mapped as a network of moderately sinuous channels that have southwesterly orientations toward Sutter Basin. The term "historical" is applied to deposits that are estimated to be less than 150 years old. The historical channels are differentiated from the slightly older Holocene channels on the basis of cross-cutting relationships, relative degree of geomorphic expression, and correlation with mapped creek positions on the 1911 USGS topographic map. The Wadsworth Canal levee overlies the former locations of these alluvial channels in several locations throughout its length (Plate 1).

4.0 Conceptual Geomorphic Model

Based on synthesis of surficial geologic mapping, early topographic maps, soil surveys, geologic maps, and review of readily available subsurface geotechnical information, this section presents a preliminary conceptual model describing general relationships among surface and subsurface deposits in the Wadsworth Canal area. This conceptual model provides a consistent basis for understanding the type and distribution of surficial geologic deposits, primary geomorphic processes, and shallow subsurface stratigraphy in the area.

The geologic deposits present at the surface and in the shallow subsurface are derived from three general source areas: (1) material eroded from the Sutter Buttes and transported to the adjacent low-lying basin floor forming modest alluvial fans (i.e. Riverbank and Modesto Formations); (2) material deposited on the basin floor as fine silt and clay settled from standing or slow moving floodwaters of large rivers (i.e., basin deposits); and, (3) material transported to the basin by the ephemeral creeks and sloughs that traversed the valley floor prior to present day modification (i.e., channel fill).

The WC project levee trends southwest, and is primarily underlain by clayey basin deposits with some silt and sand (Plate 1, Figure 3). The basin deposits rest directly on the upper Modesto Formation, the upper boundary of which is characterized by a clay hardpan horizon associated with a buried soil. The hard pan layer is generally observed as a very stiff to hard, lean to fat clay, 10YR ¾ colors (Munsell color notation) associated with locally increased density (i.e., blow counts, CPT tip resistance), and likely very low permeability. Thus, the upper Modesto Formation mapped in northwest potion of the map area extends below ground, and dips southeasterly beneath the project levee in the shallow subsurface.

Fine-grained basin deposits overlie the upper Modesto Formation near the WC levees (Figure 3). These deposits accumulated on the valley floor over geologic time resulting from flooding of the major rivers (i.e., Sacramento and/or Feather Rivers), tributaries draining Sutter Buttes, and sheetwash from the generally flat valley floor. This resulted in inundation of the basin with standing water, and subsequent settlement of silt and clay from suspension. The thickness of the basin deposits is about 4 to 8 feet, but locally may be thicker. Review of available Phase 1 and other existing geotechnical data (i.e., Chambers 2002) indicate medium stiff to very stiff

relative density of the basin deposits. However, there is a substantial lateral and vertical variability in the hardness properties of the basin deposits.

Laterally cross-cutting, and vertically inset into the basin deposits, are the Holocene and Historical channel deposits (map units Hch and Rch, Plate 1). These southwest-trending alluvial channel deposits locally underlie the WC levee, and thus result in local differences in material textures beneath the levee (Figure 3). Field reconnaissance on June 22, 2007 reveals that the topographic expression of these channels has been obliterated by cultivation. However, sub-linear to curvilinear differences in ground color (i.e., darker strips) were observed in the cultivated fields in areas that potentially correlate with mapped channels, suggesting a contrast in materials in the shallow subsurface. Review of subsurface geotechnical data indicate that the channel fill deposits include a lower channel fill consisting of relatively loose, coarser material (i.e., sand), fining upward and grading into fine-grained silt and clay. Many of these channels extend across, and therefore continue beneath, the WC levees (Plate 1, Figure 3).

Figure 3 illustrates the relationships between the surficial channels, basin deposits, and shallow stratigraphy that underlie the WC project levee, wherein dense, semi-consolidated Pleistocene deposits are overlain by a layer of fine-grained basin deposits, locally cut by alluvial channel deposits.

5.0 Applications to the Urban Levee Project

Based on synthesis of the surficial geologic map with preliminary Phase 1 boring and cone penetrometer (CPT) data, and historical geotechnical subsurface exploration data (i.e., Chambers, 2002), the WC levee is underlain by relatively young fine-grained clay and sandy clay deposits that are laterally interrupted by local coarser channel fill deposits (Figure 3). Mud rotary borehole WSEWWC-002B penetrates a mapped surficial channel unit (Figure 3, Plate 1), and indicates the channel fill is silty sand that grades upward into clay, with an uncorrected SPT blow count of 5 blows per foot. This suggests locally loose and unconsolidated, and therefore likely permeable, material in the shallow subsurface. Initial review of subsurface boring profiles completed along the eastern landside of the Wadsworth Canal near the tie-in to the Sutter Bypass levee (Chambers, 2002) also shows relatively loose and soft sandy deposits (i.e., blow counts of 0 to 5) that are overlain by a layer of medium stiff clay-rich material.

Synthesis of the surficial mapping and geotechnical data indicate that subsurface stratigraphy the WC area locally may be conducive to levee underseepage. Shallow strata typically include denser and probably semi-cemented material (i.e., Modesto Formation) that likely contains a low-permeability hardpan horizon. The hardpan may or may not be laterally continuous, depending on post-depositional soil formation and erosional processes. The Modesto formation is overlain by about 4 to 6 feet of medium stiff to stiff clay (i.e., basin deposits). Surficial mapping indicates that the basin materials locally are cross-cut by relatively loose, sandy channel deposits; subsurface geotechnical data show lateral and vertical variations in texture and density that are probably related to buried channel deposits. Therefore, this shallow subsurface stratigraphy may promote levee underseepage along certain areas of the WC project

levees where geologically young, loose, sandy channel material lies between the dense Pleistocene deposits and relatively stiff, low-permeability clay-rich surface "blanket" layer.

Lateral and vertical variability in the shallow subsurface deposits has resulted from past geomorphic processes. The conceptual subsurface stratigraphic framework suggests that stratigraphic relationships may promote localized levee underseepage, given certain hydraulic conditions. Further spatial analyses of the surficial geologic mapping and subsurface geotechnical exploration data are needed to better constrain and characterize areas that are most susceptible to underseepage in the study area.

6.0 Limitations

This geomorphic assessment and associated data interpretation have been performed in accordance with the standard of care commonly used as the state-of-practice in the geologic engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this geographic area performing the same services under similar circumstances during the same time period.

Discussions of surface and subsurface conditions summarized in this technical memorandum are based on geologic interpretations of subsurface soil data at limited exploration locations available to this assessment through July of 2007. Variations in subsurface conditions may exist between exploration locations, and the project team may not be able to identify all adverse conditions in the levee and its foundation. This memorandum is for the use and benefit of DWR. Use by any other party is at their own discretion and risk.

7.0 References

California Department of Water Resources (DWR), Northern District, 1976, "Sutter Bypass Study"

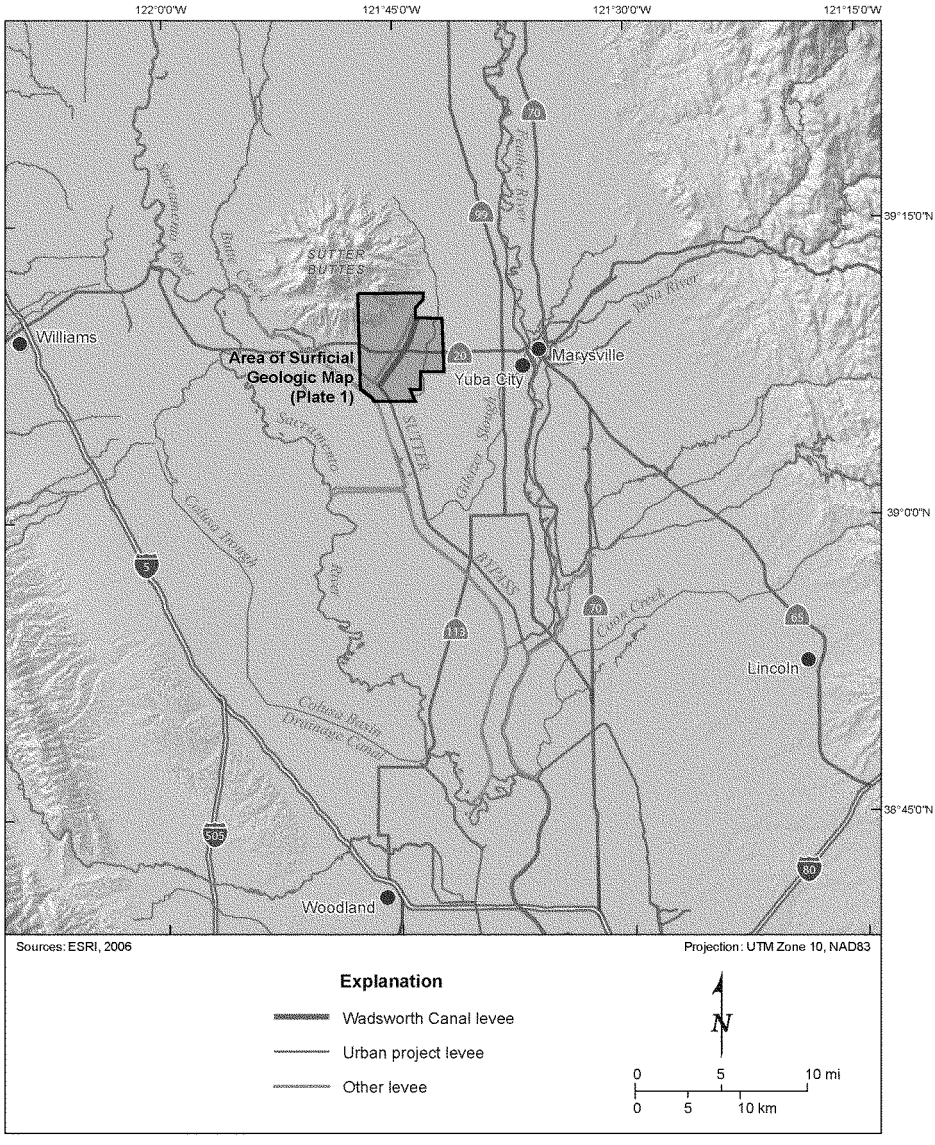
Chambers, J., 2002, US Army Corps of Engineers, Geotechnical Branch, Soil Design Section, "SAC-18 Wadsworth Canal – Dean Property Site"

Helley, E.J., and Harwood, D.S., 1985, Geologic map of the late Cenozoic deposits of the Sacramento Valley and Northern Sierran foothills, California; 1:62,500, USGS Map File MF-1790

Lytle, D.J., Kurowski, R.G., Whiting, M.L., Vinson, E.N., Vonich, P.W., Hansen, R.W., 1988, Soil Survey of Sutter County, California, 1:24,000, USDA Soil Conservation Service

Strahorn, A.T., Mackie, W.W., Holmes, L.C., Westover, H.L., Van Duyne, C., 1911, Soil Survey of the Marysville Area, California; 1:62,500, USDA Bureau of Soils

USGS, Sutter topographic quadrangle, surveyed 1909, published 1911; map scale 1:31,680, five foot contour interval.



Sources: ESRI, 2006

Projection: UTM Zone 10, NAD83

Explanation

- Wadsworth Canal levee
- Urban project levee
- Other levee

N

0 5 10 mi

0 5 10 km

WLA

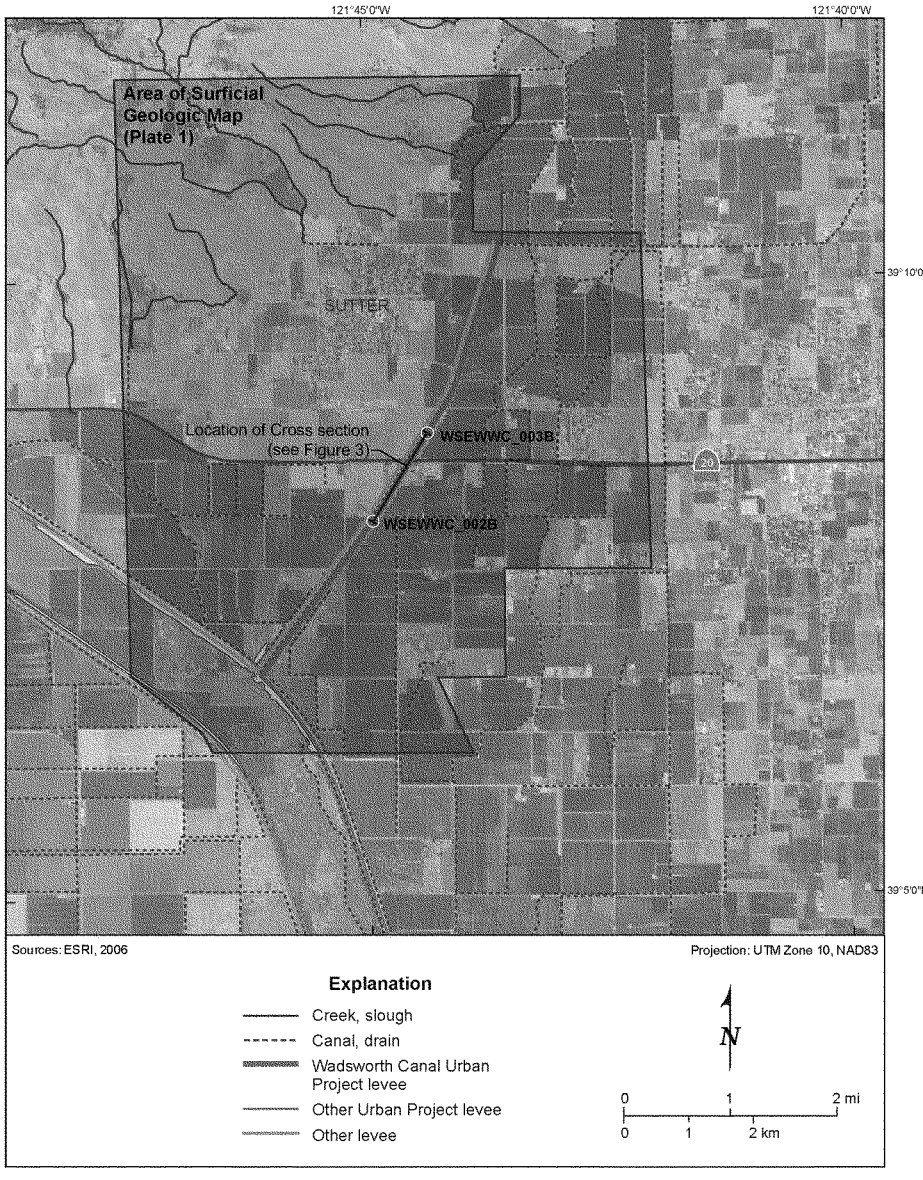
Map of Northern Central Valley, California

DWR URBAN LEVEE PROJECT

Figure 1

1881 Wadsworth Canal

Modified 09.03.09



WLA

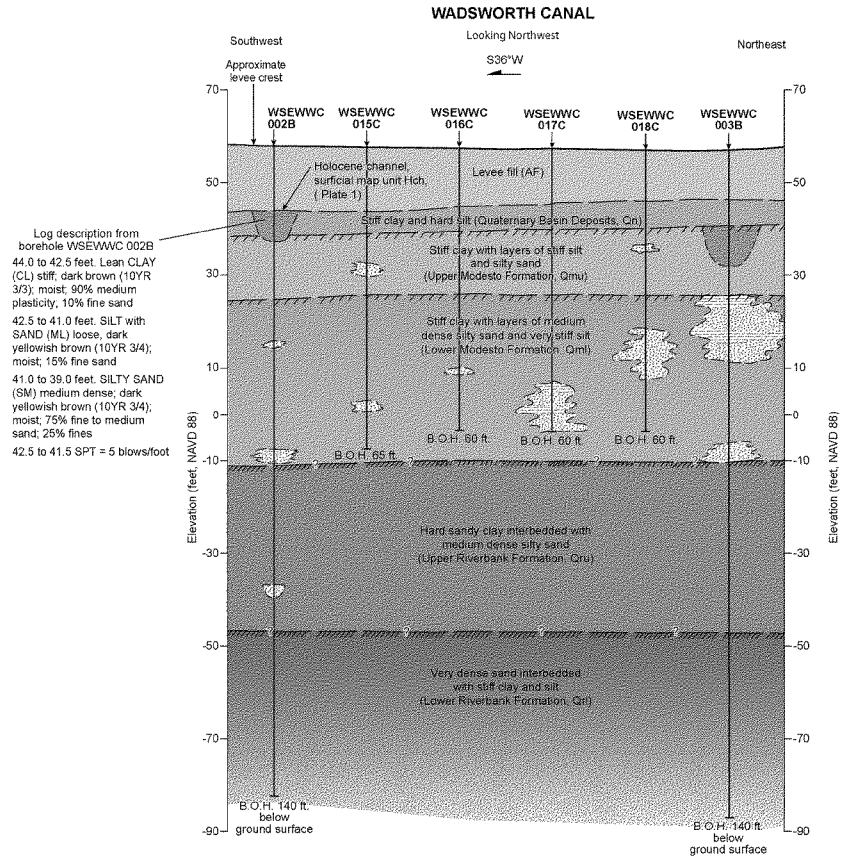
Sutter Bypass and Wadsworth Canal

DWR URBAN LEVEE PROJECT

Figure 2

1881 Wadsworth Canal

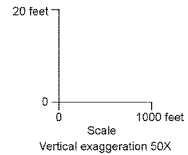
Modified 09.03.09



Explanation

- Channel identified on surficial geologic map or as fining upward sequence of sediments in boreholes
- Localized sand and gravel; possible channel; interpreted from suburface borehole data
- Moderate paleosol (hardpan)
- Strong paleosol (hardpan)

Notes:
1. Borehole ground elevation values from Engeo, Inc. draft borehole logs as estimated from map (NAVD 88). Absolute elevations of geologic contacts could change if reported ground elevations of boreholes are revised.
2. CPT borehole surface elevations are approximate, placed on projected ground surface between continuous boreholes WSEWWC-002B and 003B.
3. All depths (vertical axis) shown as elevation values (NAVD88), as shown on Engeo, Inc. borehole logs.
4. Bottom of hole (B.O.H.) values shown as total depth below ground surface.
5. Borehole names and and horizontal distance shown above (from Engeo logs and location maps). Geologic relations could change if borehole locations are revised.
6. Drilling method indicated as last letter in borehole name:
   B = Mud Rotary borehole with SPT
   C = Cone Penetrometer Test
7. See Figure 2 for location of cross section.



1121

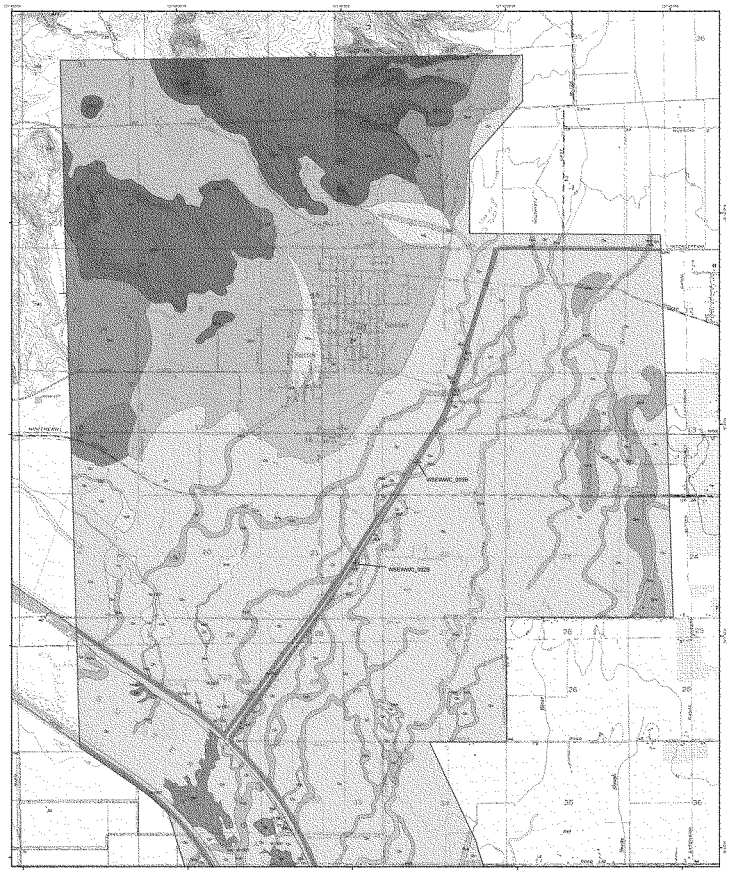
WLA

Conceptual Cross Section along Eastern Levee Crest Wadsworth Canal

DWR URBAN LEVEE PROJECT
Figure 3

1881 Wadsworth Canal

Modified 09.03.09



Explanation

Geologic contact; dashed where approximate, dotted where concealed; queried where uncertain; solid contacts have a resolution no better than about 30'

WSEWAR_0028 Geotechnical borehole, approximately located.

W Water visible on 1937 aerial photography.

Geologic Units

HISTORICAL

Qaf Artificial fill; visible on 1937 aerial photography.

Qhb Channel deposits; dotted bands bed silty sand; finely spaced.

HOLOCENE

Qhs Crevasse splay deposits; fine to coarse sand, silt and clay.

Qhd Distributary channels; sand, silt, and clay.

Qhf Distributary fan deposits; gravel, silt and clay.

Qhi Alluvial deposits undifferentiated; sand, silt, and minor lenses of gravel; under cultivation in 1937.

Qhh Channel deposits; vertical bands and x-hs; finely spaced.

Qhb Channel bar deposits; fine sand, and silt deposited in or along channel lateral margins.

Qhy Alluvial fan deposits; well graded gravel, sand, silt and clay; volcanic lithologies.

Qha Alluvial deposits, undifferentiated; sand, silt, and minor lenses of gravel; under cultivation in 1937.

Qh Basin deposits; fine sand, silt and clay, dark yellow to dark yellowish brown; under cultivation in 1937.

Qhm Marsh deposits; silt and clay; likely organic-rich; perennially or seasonally submerged on 1937 photography.

PLEISTOCENE

Qpm Modesto Formation; upper member; unconsolidated to semi-consolidated gravel, sand, silt, and clay.

Qpm Modesto Formation; lower member; unconsolidated gravel, sand, silt and clay.

Qpr Riverbank Formation; upper member; semi-consolidated to unconsolidated gravel, sand, silt and minor clay.

Qpr Riverbank Formation; lower member; consolidated gravel, sand, silt, and clay; generally associated with strong duripan horizon.

PLIOCENE-PLEISTOCENE

Qpvt Tuff breccia; Volcanic tuff breccia (pumiceous and rhyolitic) from Stefani Bluffs, latest Pliocene.

Stratigraphic Correlation Chart

Time		Depositional Environment			
Epoch	Channel deposits	Floodplain and alluvial fan deposits		Flood basin deposits	Colluvial deposits
Historical	Qhb				
Holocene	Qhs	Qhf	Qhy, Qha	Qhi, Qhm, Qh	Qal
Latest Pleistocene	Qpm				
Pleistocene	Qpm, Qpr				
Pliocene/ Pleistocene	Qpvt				

1:20,000

0 0.5 1 Miles

0 0.5 1 Kilometers

N

Map projection: UTM Zone 10S
Horizontal datum: NAD83
Vertical datum: NGVD29

Plate 1 - Surficial Geologic Map of the Wadsworth Canal Area

WILLIAM LETTIS & ASSOCIATES, INC
Walnut Creek, CA

Letter_PHOT_Plate1_Qdepositsfin.mxd 3/14/2018

WLA

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tel (925) 256-6070 fax (925) 256-6076

September 8, 2009

Mr. Juan Vargas
URS Corporation
2870 Gateway Oaks Drive, Suite 150
Sacramento, CA 95833

RE: Surficial geologic mapping and geomorphic assessment, California Department of Water Resources Urban Levees Project, Sutter Bypass, Sutter County, California

Dear Mr. Vargas:

This memorandum presents the surficial geologic mapping and preliminary geomorphic assessment of the eastern Sutter Bypass area, for the California Department of Water Resources (DWR) Urban Levees Project geotechnical characterization. The goal of this mapping and geomorphic assessment is to provide information on the type and distribution of surface and shallow subsurface deposits that likely underlie the project levees along the eastern part of the bypass. The purpose of this study is to develop spatially-continuous geologic data and a conceptual model that allows reasonable stratigraphic interpretations between widely-spaced subsurface explorations, with respect to potential levee underseepage (i.e., Llopis et al., 2007). This letter presents the technical approach, surficial geologic map, conceptual geomorphic model, and initial results based on map analysis and preliminary review of available Phase 1 geotechnical data.

We appreciate the opportunity to provide these geomorphic and geologic data and preliminary interpretations of the shallow stratigraphic conditions in the Sutter Bypass study area. Please do not hesitate to call either of the undersigned if there are any questions or comments.

Respectfully,

WILLIAM LETTIS & ASSOCIATES, INC.

Justin Pearce, C.E.G. 2421
Senior Geologist
(925) 256-6070

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Principal Geologist
(925) 256-6070

1.0 Approach

The approach to developing a surficial geologic map of the Sutter Bypass area (Figure 1, Plate 1) consisted of analysis of the following data: Aerial photography (black and white stereo-pairs taken in 1937, ~1:20,000-scale); early USGS topographic maps (i.e., 1911); published surficial geologic maps (Helley and Harwood, 1985); early and modern soil survey maps (Strahorn et al., 1911; Lytle, et al., 1988); field reconnaissance visit on June 22, 2007; and other maps and documents. Synthesis of these data allow for the development of a detailed surficial geologic map that provides an initial understanding of primary geomorphic processes that have acted in the study area during recent and historical geologic time. Through this mapping, we identify primary geomorphic features and associated surficial geologic deposits, such as abandoned paleochannels, marsh and basin deposits, flood-basin deposits, and other features commonly associated with flood-basins adjacent to large, active river systems. Knowledge of fluvial processes and the ability to recognize depositional environments in the geologic record are key to identifying locations along levees where underseepage is most likely to occur (Llopis, 2007).

The surficial geologic map was developed at the nominal scale of the aerial photography (1:20,000). This scale establishes the resolution of the map (Plate 1). The map unit contacts shown on the surficial geologic map should be considered approximate, and accurate to no more than about 30 feet on either side of the line shown on the map. The 1937 aerial photographs are the primary data set for interpreting the surficial geologic deposits because: (1) they are the oldest high-quality images that pre-date much of the urbanization and landscape alteration within present-day Sutter County (Figure 2); and, (2) these data represent a close approximation to the surficial deposits that were likely present at the ground surface prior to the construction of the levees. The 1937 photographs generally were taken in late summer or early autumn (i.e., August). By 1937, the area had experienced moderate cultivation that locally obscures geomorphic conditions. However, integration of data from the 1937 photography, old and recent topographic maps, geologic maps, soil surveys and historical documents provides sufficient information to delineate many of the pre-historic and historic surficial deposits in detail. Taken together, these data provide key insights to the geomorphic processes and resulting deposits that may affect levee underseepage.

Additional flood-basin or floodplain deposition may have occurred after 1937, due to flood overflows, levee overtopping, or localized levee failure. A time series analysis that interprets successive aerial photographs taken after major flood events (i.e., 1955) or known local levee failures (i.e., 1986) may reveal additional information on surficial deposits in the Sutter Bypass area. Such analyses are beyond the scope of this study. The data and interpretations presented herein address the primary goal of characterizing the type and distribution of deposits likely present directly beneath the project levees.

1.1 Report Preparation Quality Control

The surficial geologic map data and geomorphic interpretations presented in this memorandum were subject to quality control and quality assurance procedures as required by the Levee

Geotechnical Evaluation Project Management Plan (PMP). The surficial geologic map data developed by this study were reviewed for accuracy and completeness through an internal review and an independent technical review by Dr. Janet Sowers of WLA. Results of QA/QC review were documented using PMP Exhibit 2.2-3 (Independent Technical Review Report) and are kept on file according filing control plan. Subsurface data shown on diagrams were provided as draft information, and were not verified for accuracy or completeness by this study.

2.0 Geologic Setting

The Sutter Bypass (Bypass) study area lies southeast of the volcanic Sutter Buttes, between the Sacramento and Feather Rivers. The project levee addressed in this study borders the eastern side of the Sutter Bypass, extending from the Wadsworth Canal southeast to the Feather River (Figure 1). The Bypass levee generally trends northwest-southeast, and ties in to the Feather River west bank levee.

The Bypass levee lies northeast of Sutter Basin, a low-lying area east of the Sacramento River and west of the Feather River, where overflow and floodwaters from Butte Basin (located northwest of the Sutter Buttes), the Sacramento River, and the Feather River produced a seasonally marshy area. Except for the Sutter Buttes area, the regional land surface is nearly flat, and along the Bypass area gently slopes southwest at an elevation of about 30 to 40 feet. Construction of the Sutter Bypass was completed in 1924 to serve as an overflow for Sacramento River floods in the winter, and a source of irrigation in the summer (DWR, 1976). The eastern levee was enlarged in 1942 (Corps of Engineers, 1953). Prior to cultural modification, surface water runoff in the Bypass area was delivered to the Sutter Basin via intermittent, meandering creeks and sloughs from the northern Central Valley, including: Snake River, Snake Slough, Gilsizer Slough, Nelson Slough, and flood overflow channels emanating from the western side of the Feather River. The construction of the Bypass levee blocks water from the east that normally drains to the Sutter Basin and Sacramento River (DWR, 1976). Presently, many of the natural drainages and channels have been replaced by linear ditches, agricultural drains, and canals (Figure 2).

3.0 Surficial Geologic Mapping

Published surficial geologic maps of the Sutter Bypass study area generalized the surficial deposits primarily as late Quaternary basin (map unit Qb) deposits, with localized units of late Quaternary alluvium, Quaternary Modesto Formation (lower member), and Quaternary Riverbank Formation (lower member) (Helley and Harwood, 1985). These map units were delineated at a regional scale (i.e., 1:62,500). The current analysis of the Bypass uses this geologic framework as a basis for more detailed mapping of late Holocene alluvium and geomorphic features (Plate 1). The surficial geologic map units within the Sutter Bypass study area are described below, in order from oldest to youngest.

The oldest map unit exposed in the study area is the late Quaternary Riverbank Formation (lower member), and is mapped in the south portion of the study area east of Nelson Slough,

where it likely directly underlies the project levee near the latitude of Laurel Avenue (Plate 1). This formation (map unit Qrl) is present in the shallow subsurface beneath much of the bypass area, and consists of alluvial-fan deposits derived from the Sierra Nevada during the middle Pleistocene (about 400,000 to 200,000 years ago). The Riverbank Formation is semi-consolidated, and is associated with the presence of a well-developed hardpan (or, duripan) layer that is a product of soil-forming processes over substantial geologic time. This hardpan layer reflects an ancient land surface that locally is buried by younger deposits. Soils developed on the Riverbank Formation in the Bypass area include the San Joaquin loam of Strahorn et al. (1911) and the Yuvas loam (Lytle et al., 1988), both of which document a strongly cemented hardpan at depths of about 1.5 to 3 feet below ground surface.

The late Pleistocene Modesto Formation is younger than the Riverbank Formation and is present in the map area primarily along the margin of Gilsizer Slough and directly east of Highway 113 (Plate 1). This unit is divided into two members, a lower (older) unit that is about about 42,000 to 29,000 years old (Qml), and an upper member that is about 24,000 to 12,000 years old (Qmu) (Helley and Harwood, 1985). The Modesto Formation, in general, consists of unconsolidated sand, silt, and clay, and is associated with a moderate amount of secondary (pedogenic) clay accumulation. This clay-rich horizon may form laterally continuous zones of low hydraulic conductivity. These soil horizons may extend across boundaries between coarse and fine-grained strata within the latest Pleistocene alluvium, and may form relatively continuous zones of low vertical hydraulic conductivity within the Modesto Formation. Soils developed on the Modesto Formation include the Gridley loam of Strahorn et al. (1911) and the Marcum clay loam with "siltstone" hardpan (Lytle, 1988).

Younger surficial deposits overlying the Riverbank and Modesto Formation include late Quaternary marsh, basin, and alluvial deposits (map units Qs, Qn, and Qa, respectively), which are considered Holocene age (i.e., less than 11,000 years old). The widespread basin deposits are about 4 to 8 feet thick and bury the gently southwest dipping Modesto Formation (Figure 3). The thickness of the basin deposits increases to the southwest, in the direction of Sutter Basin (Figure 3). The soils developed on the basin deposits generally are associated with the Stockton clay adobe and Marcuse clay of Strahorn et al. (1911) and the Oswald clay (Lytle et al., 1988), and thus represent immature soils with overall fine-grained textures. Undifferentiated alluvial deposits (map Qa, Plate 1) are present along Gilsizer Slough, and are inset (i.e., topographically lower) into the adjacent Modesto Formation. The Quaternary marsh deposits (map unit Qs, Plate 1) are present between the Sutter Bypass levees northwest of Gilsizer Slough, and are also fine-grained deposits that are differentiated from basin deposits by usually being underwater or having standing water at the time when the 1937 photographs were taken (usually late summer to early autumn).

Inset into the units described above are deposits of Holocene alluvial channels (map unit Hch, Plate 1), which are a network of moderately sinuous channels with southwesterly orientations. These channels appear to be mostly filled with sediment by the time of 1937 photographs, and are expressed only locally as subtle topographic lows in the ground surface. Many of these channels extend west of, and therefore cross beneath, the eastern Sutter Bypass levee (Plate 1). The alluvial channels west of Gilsizer Slough start on the alluvial plain as intermittent creeks, and are not directly connected to the Feather River (USGS Tisdale Weir quadrangle, 1911).

The channel deposits are tentatively associated with the Liveoak series, sandy clay loam soil (Lytle et al., 1988), and consist of a lower, sandy unit that fines-upward into an upper, silt and clay layer.

Subdivisions of the Holocene channels include sloughs (map unit Hsl, Plate 1), distributary channels (map unit Hdc), and overflow channels (map unit Hofc). These deposits, in general, also consist of a fining-upward sequence of sand, silt, and clay. The sloughs are present primarily east of Highway 113 (Plate 1) and have southwesterly orientations. The sloughs are ephemeral channels that drain the alluvial plain between Gilsizer Slough and the Feather River. The term "slough" in this study does not mean tidally-influenced channels, but instead channels that likely conveyed relatively slow-moving water from direct precipitation and sheet-flow runoff. The overflow channels convey flood flows that overtop the banks of the Feather River onto the floodplain, and are interpreted as higher-energy channel systems relative to the sloughs. The distributary channels route flow from and sediment onto the floodplain, and end at distributary-fan deposits. The overflow and distributary channel deposits are present in the southeastern portion of the Bypass area, south of the latitude of Laurel Avenue (Plate 1).

Localized deposits related to the Holocene alluvial channels are bars (map unit Hb) that typically occur in the medial and lateral portions of the channels, and distributary fan deposits (map unit Hdf) that occur where the channel becomes unconfined and has deposited sediment on the basin floor. Channel bars are relatively uncommon in the Sutter Bypass study area. Distributary fans are common in the southeast portion of the Bypass area, south of the latitude of Sacramento Avenue (Plate 1). The distributary-fan deposits likely consist of unconsolidated fine sand and silt (i.e., Strahorn et al., 1911).

Historical geologic deposits are present along the length of the Bypass study area (i.e., map unit Rch, map unit Rdf). The term "historical" is applied to deposits that are estimated to be less than 150 years old. These deposits share the same genetic origin as the Holocene deposits described above. The historical channel deposits are differentiated from the Holocene channel deposits on the basis of cross-cutting relationships with other map units, relative degree of geomorphic expression and/or dissection, and correlation with land surface expression on the early and modern topographic maps. The Bypass eastern levee overlies the former locations of Holocene and historical alluvial channels in several locations throughout its length (Plate 1).

Undifferentiated Holocene and historical alluvium (map units Ha and Ra) is mapped in the southeastern Bypass area, near the confluence of the Sutter Bypass and the Feather River, generally east of Sawtelle Road (Plate 1). The undifferentiated map unit is delineated where the morphology of these deposits is indistinguishable on 1937 photographs as a result of cultural modifications (i.e., agriculture). The soils developed on the undifferentiated historical alluvium generally correspond with the Sacramento series fine sandy loam and silt loam of Strahorn et al. (1911) and the Shanghai silt loam (Lytle et al., 1988). There is no hardpan layer associated with these soils, supporting the interpretation of geologically young deposits.

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4.0 Conceptual Geomorphic Model

Based on synthesis of surficial geologic mapping, topographic maps, soil surveys, geologic maps, and review of readily available subsurface geotechnical information, we present a preliminary conceptual geomorphic model describing general relationships among surface and subsurface deposits along the Sutter Bypass study area. This conceptual model provides a consistent basis for understanding the type and distribution of surficial geologic deposits, primary geomorphic processes, and shallow subsurface stratigraphy in the area. Identification of subsurface stratigraphic formations is challenging, primarily because of a lack of distinctive and laterally extensive stratigraphic marker beds within late Quaternary deposits of the northern Central Valley (i.e., Page, 1986), and because there is little apparent difference in lithology between the late Quaternary formations (i.e., Helley and Harwood, 1985). This study relies heavily on the identification and local correlation of hardpan horizons and deposit color and density changes to delineate subsurface formations.

In a general sense, the Sutter Bypass levees traverse across the distal portions of ancient alluvial-fan deposits that were derived from the Sierra Nevada, and prograded westward onto the valley floor (i.e., Riverbank and Modesto Formations). These Pleistocene deposits are exposed at the ground surface northeast of the Bypass study area (Helley and Harwood, 1985; Page, 1986), dip to the southwest and are mantled by younger fine-grained basin deposits (Figure 3). In contrast, the Modesto Formation is exposed at the ground surface along Gilsizer Slough and directly east of Highway 113 (Plate 1). The surficial map pattern of the Modesto deposits in these locations suggests depositional lobes from an ancestral Gilsizer Slough. These deposits may have been related to discharges and sediment loads that were higher than present-day conditions. These deposits may, perhaps, represent an ancestral Feather River channel location that occupied the present-day Gilsizer Slough during the latest Pleistocene and was subsequently abandoned.

The surficial geologic mapping (Plate 1) shows differences in deposit type and distribution from northwest to southeast along the Bypass, which are associated with changes in watershed production of water and sediment, related geomorphic processes, soil profile development, and the underlying subsurface hardpan layer. These differences illustrate the diversity of past geomorphic processes along and near the Bypass and, as a consequence, the type of geologic deposits at and near the ground surface. The surficial geologic map allows the interpretation of "reaches" along the Bypass within which geomorphic processes and their associated deposits are likely to be relatively consistent. The Bypass study area consists of four general reaches, from northwest to southeast, each having characteristic deposit types and distributions (Plate 1).

The westernmost reach of the Bypass study area extends from the junction with the Wadsworth Canal to directly south of the Tisdale Weir ("Reach I", Plate 1). The levee along this reach, about 8.1 miles long, primarily overlies fine grained basin deposits accumulated on the valley floor over geologic time. This deposition resulted from flooding of the Sacramento and Feather Rivers, tributaries draining Sutter Buttes, and sheet flow from the generally flat valley floor. Holocene and historical channel deposits (map units Hch and Rch, Plate 1) are inset into the basin deposits. These southwest-trending alluvial channel deposits locally underlie the Bypass

levee, and result in local differences in material textures beneath the levee (Figure 4). About 27 abandoned channels traverse the levee along this reach (approximately 3 channels per levee mile). The channels are about 250 feet wide, but range from about 100 to 300 feet wide (Plate 1). In this area, the channels are about 6 to 8 feet deep, and are typically filled with sand, silt, and clay in a fining-upward sequence, i.e., coarser-grained sand overlain by about one to two feet of silt and clay. This sedimentary sequence may be conducive to seepage where relatively more-permeable channel sands are overlain by a relatively thin, fine-grained "blanket" layer.

The second reach along the Bypass, about 1.1 miles long, extends across Gilsizer Slough ("Reach II", Plate 1), where Modesto Formation deposits are present at the ground surface. Undifferentiated alluvium (map unit Qa, Plate 1) is present along the historically-active Gilsizer channel floor, and is inset to the Modesto Formation (Figure 5). The Gilsizer Slough alluvium extends beneath the eastern and western Bypass levee, and thus represents the progradation of younger deposits with respect to the Modesto Formation. Along this reach, the Bypass levee is underlain by younger Gilsizer Slough alluvium flanked by the relatively denser, semi-consolidated late Pleistocene Modesto deposits (Figure 5). Areas where the levee directly overlies the Modesto Formation may be relatively less conducive to underseepage, as the associated hardpan layer may form locally continuous zones of low hydraulic conductivity.

The third reach along the Bypass extends from the Gilsizer Slough to the latitude directly south of Laurel Avenue, and is about 6.6 miles long ("Reach III", Plate 1). This reach is generally similar to Reach I, except Reach III has Pleistocene deposits (i.e., lower Modesto and Riverbank Formations) exposed at or very near the ground surface, and has a sparser channel density (about 2 channels per levee mile) compared to Reach I. About 14 southerly-oriented sloughs are mapped across this reach and locally underlie the Bypass levee (Plate 1). The sloughs originate from the Feather River, near Star Bend and Shanghai Bend, extending southward toward the Bypass. The sloughs along Reach III are about 250 feet wide, but range from about 100 to 300 feet wide, similar to Reach I (Plate 1). In this area, the channels are also probably about 6 to 8 feet deep, and probably filled with sand fining-upward to silt and clay. These channel deposits may be conducive to underseepage because of the deposit stratigraphy that has coarser-grained sand overlain by about one to two feet of silt and clay. Late Quaternary Riverbank Formation is at the ground surface along the southwestern end of Reach III (Plate 1), and likely is not conducive to seepage due to the dense and strongly-developed hardpan clay layer that is usually at about 1.5 to 4 feet depth below ground surface.

The fourth reach along the Bypass extends from directly south of the latitude of Laurel Avenue to the confluence with the Feather River west bank levee ("Reach IV", Plate 1). Reach IV, about 1.9 miles long, has Holocene and historical alluvium at the ground surface along this reach of the Bypass, primarily because of the proximity to the Feather and Bear Rivers (Plate 1). About 8 distributary channels, usually 90 feet wide but ranging from 45 to 190 feet wide, cross the floodplain in southwesterly orientations, leading to geologically young distributary-fan sediments. These sediments, primarily consisting of fine to coarse sand and silt, probably were deposited as a result of increased sediment and water input contributed to the Feather River from the Bear River; the confluence located directly upstream from this reach of the Bypass (Figure 1). Historically, the Feather River and the Bear River have aggraded from substantial mining debris input, thus reducing channel cross sectional area (i.e., James, 1999).

This reduction of cross section area, coupled with the trajectory of floodflow from the Bear River watershed, resulted in water overtopping the Feather River channel banks, and depositing sediment onto the western floodplain where the Bypass levee is located (Plate 1).

5.0 Applications to the Urban Levee Project

Based on synthesis of the surficial geologic map with preliminary Phase 1 borehole and cone penetrometer (CPT) data, the Bypass levee generally is underlain by relatively young fine-grained clay and sandy clay deposits that are laterally interrupted by local coarser channel fill deposits (i.e., Figures 3, 4, 5, and 6).

The northernmost reach of the Bypass levee ("Reach I") is predominantly underlain in the shallow subsurface by relatively young fine-grained clay and sandy clay deposits. These basin deposits are laterally interrupted by coarser-grained deposits filling abandoned channels that are about 250 wide (Plate 1, Figure 4). Mud rotary borehole WSESBP_011B, which penetrated channel unit Rch norths of Gilsizer Slough (Plate 1), indicates the channel deposit is about four-feet thick, consisting of about 60% fine to coarse sand (medium dense) with clayey sand. The clayey sand grades upward into clay, of about 45% sand fraction. This suggests locally coarse and unconsolidated, and therefore likely permeable, material in the channel fill. Based on review of adjacent borehole data, the basin deposits (Figure 4) generally consist of stiff clay, with less than 10% fine sand. It is likely that most or all of the small channels mapped herein as unit Rch are similar in textural characteristics and depths, because of similar genetic origin and geomorphic process of channel development and infilling. These deposits underlie Reach I in at least 27 places between Wadsworth Canal and Gilsizer Slough (Plate 1).

Reach II crosses late Pleistocene and Holocene geologic deposits associated with Gilsizer Slough (Plate 1). Review of subsurface borehole and CPT data indicate that the basin deposits north of the slough consist of medium stiff to stiff clays (Figure 5). The channel fill deposits within Gilsizer Slough (map unit Qa, Plate 1) consist of alternating beds of sandy gravel and clay. These channel deposits are inset into the lower Modesto Formation which, in this area, consists of very stiff sandy clay interbedded with silty sand and localized dense sand. Directly south of Gilsizer Slough, the lower Modesto Formation is at the ground surface (Plate 1). Subsurface data suggest that a hardpan horizon is encountered at about 3 to 4 feet below the ground surface. The uppermost deposit above the hardpan consists of sand and silty sand, and probably is weathered and/or culturally re-worked materials of the lower Modesto Formation. Thus, north of Gilsizer Slough, potentially low-permeability basin materials blanket the Modesto, and are locally cut by channel deposits, whereas at and south of Gilsizer Slough the local channel deposits are inset directly into the dense Modesto Formation. Where the Bypass levee rests on the unconsolidated Qa deposits within Gilsizer Slough, these coarse deposits may be associated with higher probabilities of levee underseepage. In constrast, the sections of the levee underlain directly by the Modesto Formation containing consolidated (hardpan) horizons are much less likely to experience underseepage.

Reach III is similar in geomorphic nature to Reach I, except it has a lower frequency of channels as compared to Reach I (Plate 1). It is probable that the composition of these deposits

generally will be consistent with those along Reach I (i.e., coarse-grained channel fill with upper fine-grained layers). These channels are more likely to promote seepage beneath the levee compared to the basin deposits. Additionally, the Pleistocene materials that likely directly underlie the project levees along this reach (Plate 1) are relatively dense and the associated hardpan layer may form a relatively continuous zone of lower hydraulic conductivity. Where the levee directly overlies Modesto formation (NW ¼, Section 20; southeast of the Sutter Causeway), there is a lower likelihood of underseepage. There is also a lower likelihood of underseepage where the levee rests on the Riverbank Formation in lower length of Reach III (SW ½, Section 34).

Along Reach IV, geologically young Holocene and historical alluvium is beneath the Bypass levee (Plate 1). This uppermost layer, about five-feet thick, is locally cross-cut by channel deposits that also consist of silt and sand (Figure 6). Quaternary basin deposits do not directly underlie the Bypass levee along this reach. Review of Phase 1 subsurface geotechnical data indicates that these alluvial deposits consist of silty sand and sandy silt textures. Based on review of Phase 1 data in other Project areas (i.e., Marysville), the uppermost alluvium generally has low densities (i.e. loose to medium dense), and consequently relatively high permeability. The surficial mapping indicates that essentially all of this reach of the levee (about1.9 miles) is underlain by loose, unconsolidated sandy alluvium, which may be susceptible to substantial underseepage. The local recent channels (map units Ra and Rdc; Plate 1) may contain coarser deposits and may be more susceptible to underseepage.

Synthesis of the surficial mapping and geotechnical data indicate that subsurface stratigraphy along the Sutter Bypass area locally may be conducive to levee underseepage. Shallow strata typically include denser and probably semi-consolidated material (i.e., Modesto Formation) that likely contains a moderately developed low-permeability hardpan horizon. The hardpan may or may not be laterally continuous, depending on post-depositional soil formation and erosional processes. Along Reach I and III, the Modesto formation is overlain by about 4 to 6 feet of medium stiff to stiff clay (i.e., basin deposits). The basin materials locally are cross-cut by relatively loose, sandy channel deposits that have a thin fine-grained upper "blanket" layer. Therefore, this shallow subsurface stratigraphy may promote levee underseepage along certain areas of the Bypass project levees that overlie geologically young, loose, sandy channel material lies between the dense Pleistocene deposits and relatively thin, low-permeability clay-rich "blanket" layer. Along Reach IV, a layer Holocene and historical alluvium from the Feather River mantles the Modesto Formation, and also may promote levee underseepage.

Lateral and vertical variability in the shallow subsurface deposits has resulted from past geomorphic processes. The conceptual subsurface stratigraphic framework suggests that stratigraphic relationships may promote localized levee underseepage, given certain hydraulic conditions. Further spatial analyses of the surficial geologic mapping and subsurface geotechnical exploration data are needed to better constrain and characterize areas that are most susceptible to underseepage in the study area.

6.0 Limitations

This geomorphic assessment and associated data interpretation have been performed in accordance with the standard of care commonly used as the state-of-practice in the geologic engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this geographic area performing the same services under similar circumstances during the same time period.

Discussions of surface and subsurface conditions summarized in this technical memorandum are based on geologic interpretations of subsurface soil data at limited exploration locations available to this assessment through August of 2007. Variations in subsurface conditions may exist between exploration locations, and the project team may not be able to identify all adverse conditions in the levee and its foundation. This memorandum is for the use and benefit of DWR. Use by any other party is at their own discretion and risk.

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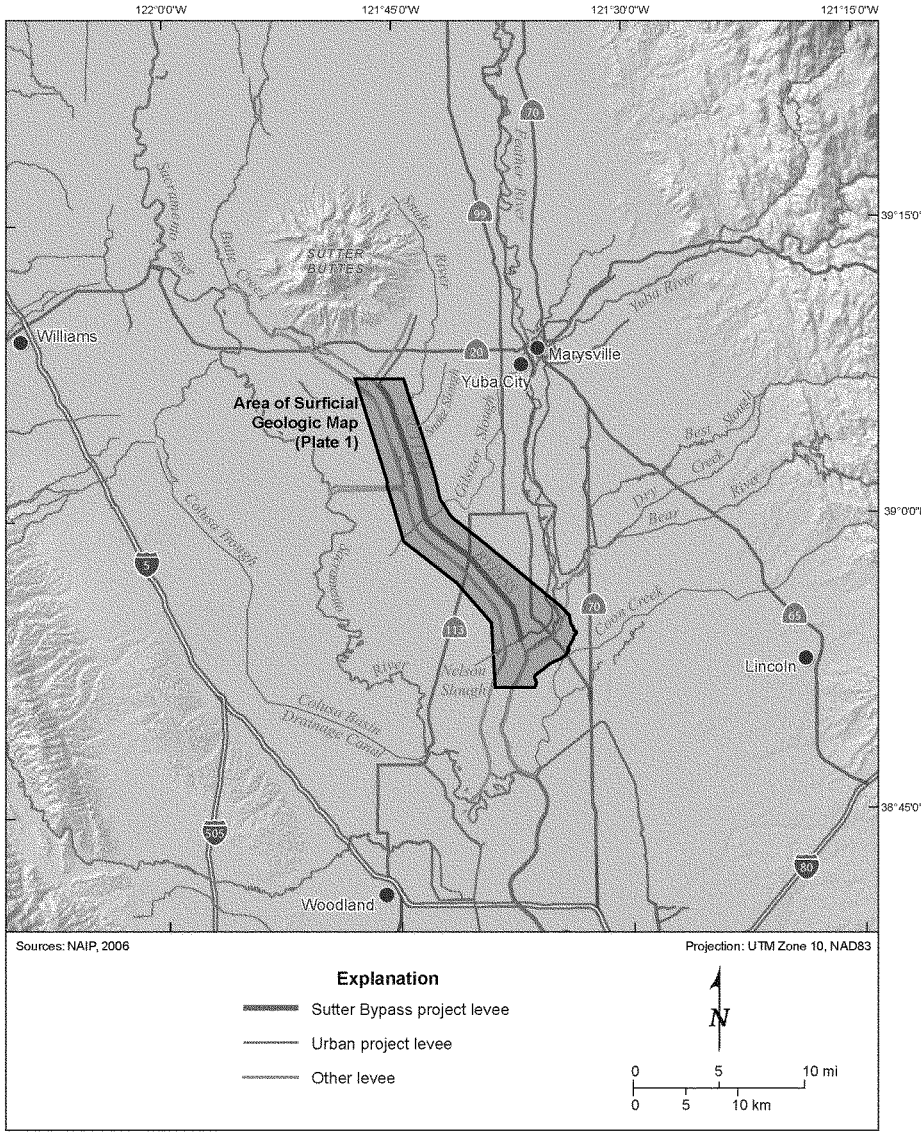
USGS, Marcuse topographic quadrangle, surveyed 1909, published 1911; map scale 1:31,680, five foot contour interval.

USGS, Nicolaus topographic quadrangle, surveyed 1908, published 1910; map scale 1:31,680, five foot contour interval.

USGS, Tisdale Weir topographic quadrangle, surveyed 1909, published 1911; map scale 1:31,680, five foot contour interval.



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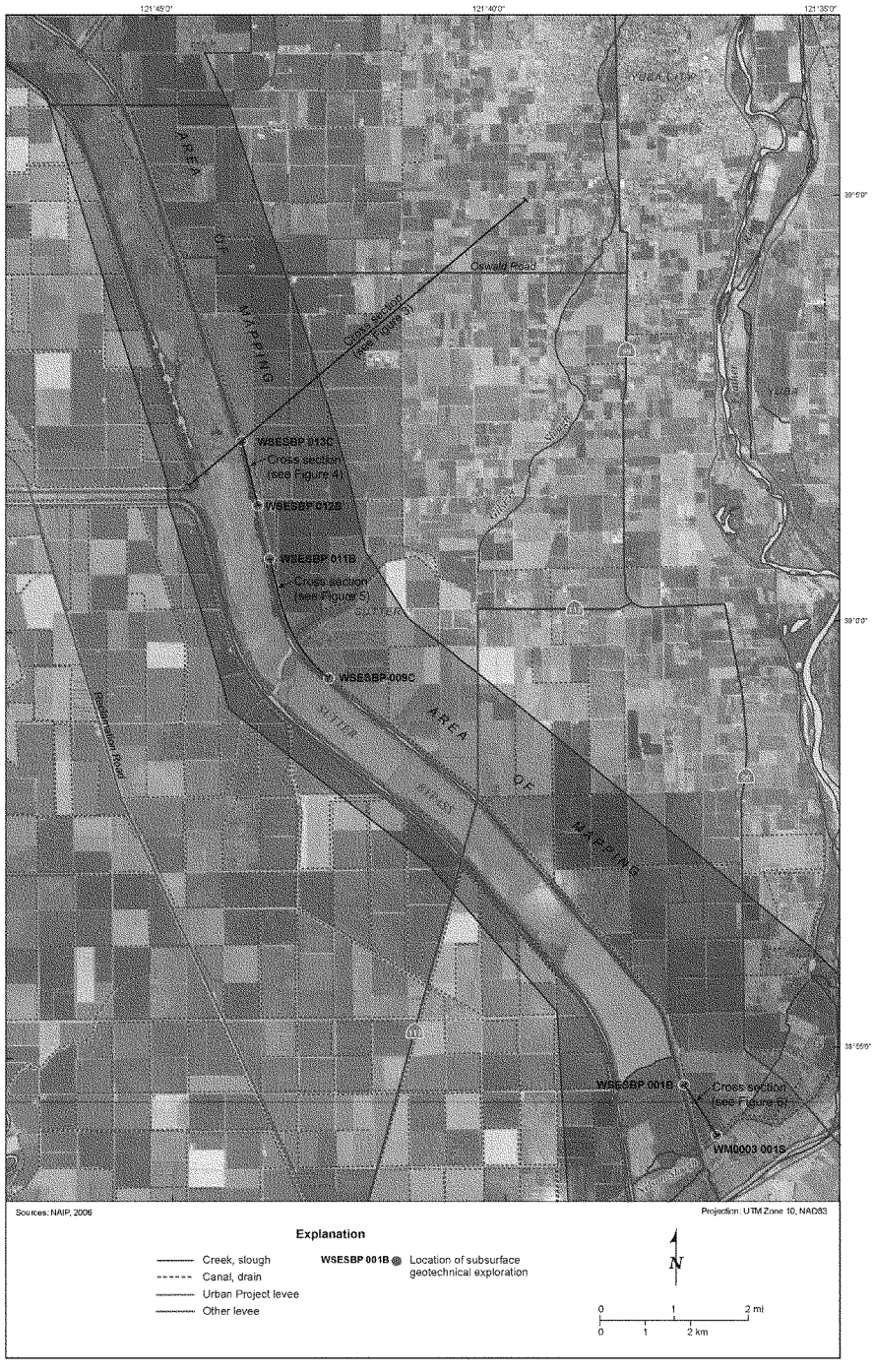
Map of Northern Central Valley, California

DWR URBAN LEVEE PROJECT
Figure 1

1881 Sutter Bypass

Modified 09.03.09



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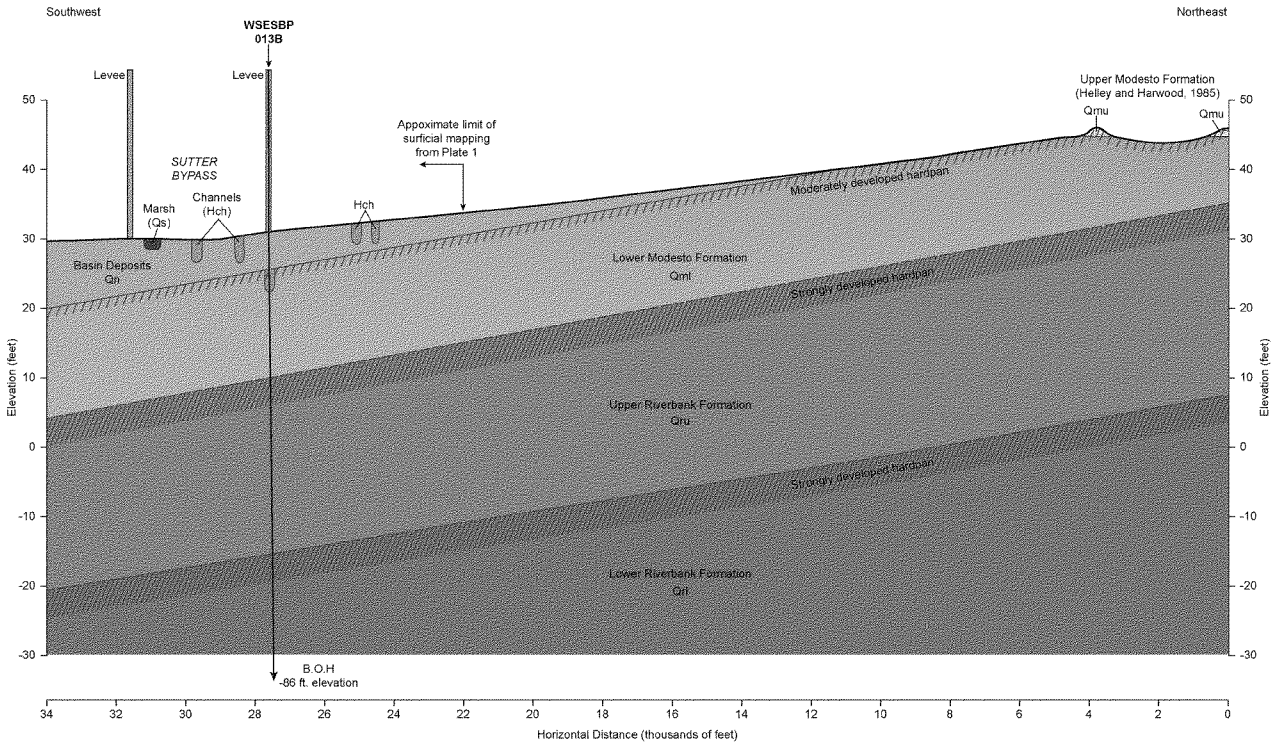
Sutter Bypass

DWR URBAN LEVEE PROJECT
Figure 2

1881 Sutter Bypass

Modified 09.03.09



Notes: 1. See Figure 2 for location of cross section.
2. Surficial geologic units and contacts from this study and Helley and Harwood (1985).
3. Ground surface elevation from USGS Gilsizer Slough topographic map, 5-foot contour interval.

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1881 Sutter Bypass

Conceptual Cross Section Transverse to Sutter Bypass

DWR URBAN LEVEE PROJECT

Figure 3

Modified 09.03.09

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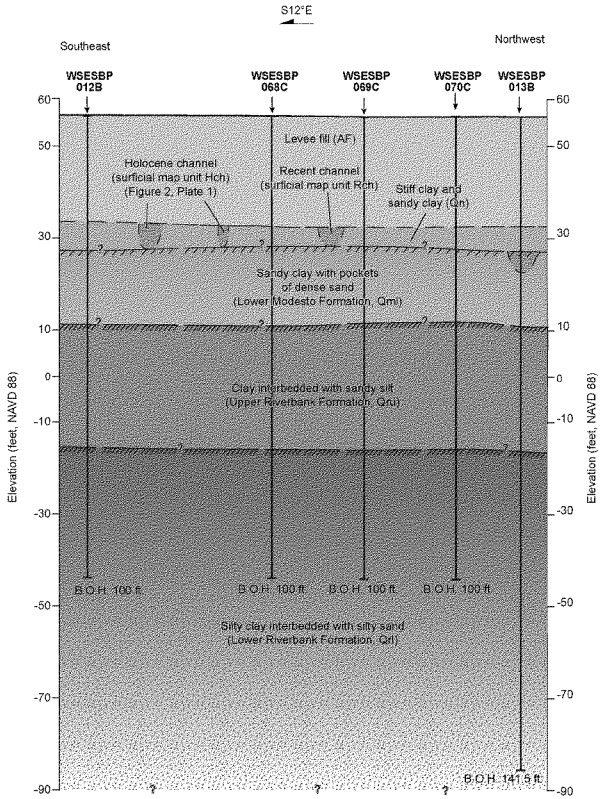


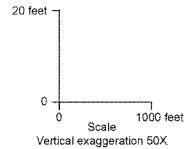
Explanation

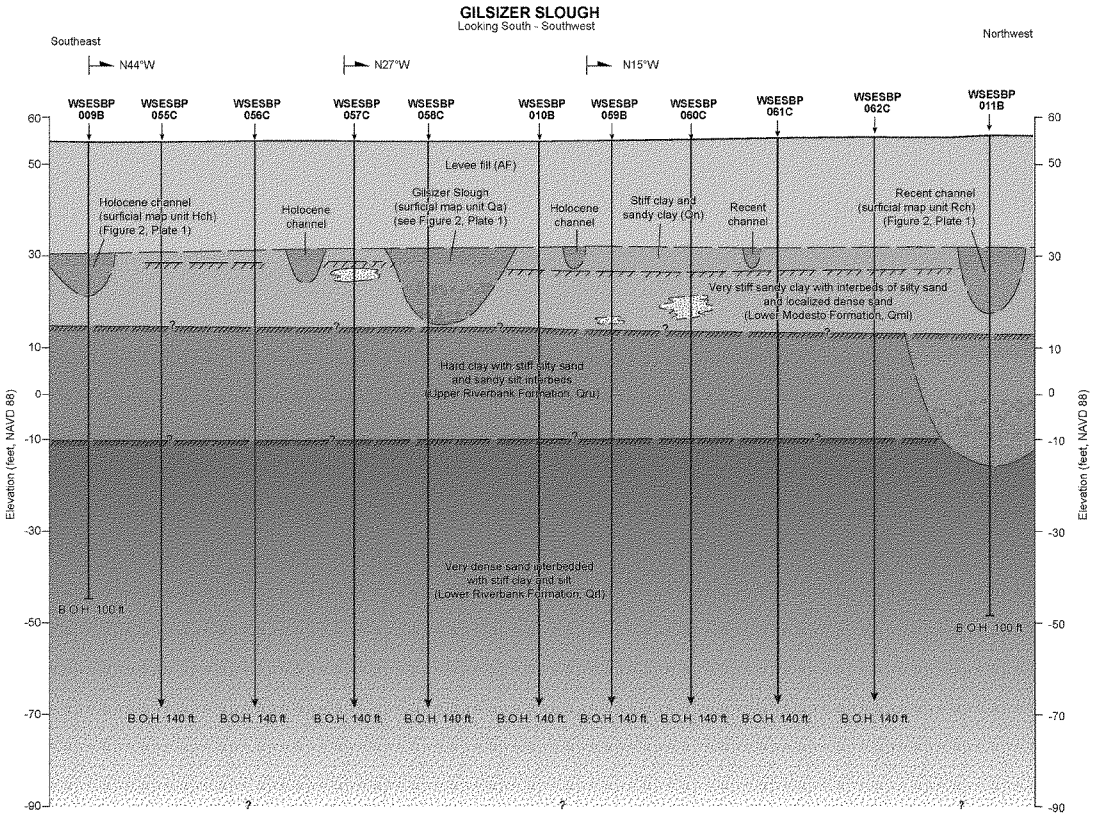
Channel identified on surficial geologic map or as fining upward sequence of sediments in boreholes

Moderate paleosol (hardpan)

Strong paleosol (hardpan)

Notes:
1. Borehole ground elevation values from URS Corp., and reported in the Boring Location Survey, DWR task #10. (NAVD 88).
2. CPT borehole surface elevations are approximate, placed on projected ground surface between boreholes WSESBP_012B and WSESBP_013B.
3. Bottom of hole (B.O.H.) values shown as total depth below ground surface.
4. Borehole names and horizontal distance shown above from draft URS logs and location maps. Geologic relations could change if borehole locations are revised.
5. Drilling method indicated as last letter in borehole names.
   B = Mud Rotary unit with SPT
   C = Cone Penetrometer Test.

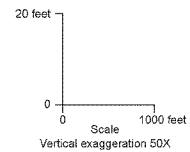


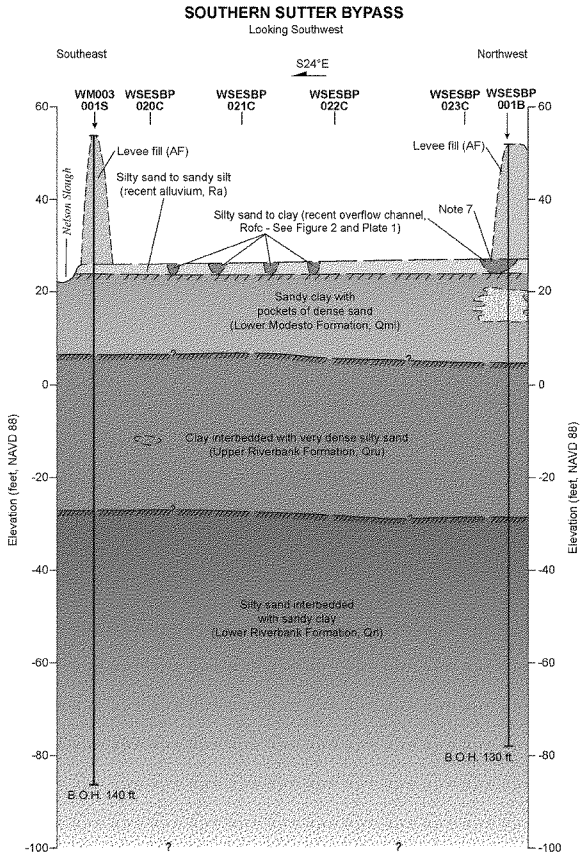


Explanation

- Channel identified on surficial geologic map or as fining upward sequence of sediments in boreholes
- Localized sand and gravel; possible channel interpreted from borehole logs
- Moderate paleosol (hardpan)
- Strong paleosol (hardpan)
- Bend in levee
- N16°W Azimuth of levee segment

Notes:
1. Borehole ground elevation values from URS Corp., and reported in the Boring Location Survey, DWR task #10.(NAVD 88).
2. CPT borehole surface elevations are approximate, placed on projected ground surface between continuous boreholes WSESBP-009B, WSESBP-010B, and WSESBP-011B.
3. Bottom of hole (B.O.H.) values shown as total depth below ground surface.
4. Borehole names and horizontal distance shown above (from draft URS logs and location maps). Geologic relations could change if borehole locations are revised.
5. Drilling method indicated as last letter in borehole names.
   B = Mud Rotary unit with SPT
   C = Cone Penetrometer

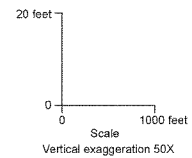




Explanation

- Channel identified on surficial geologic map or as fining upward sequence of sediments in boreholes
- Localized sand and gravel; possible channel interpreted from borehole logs
- Moderate paleosol (hardpan)
- Strong paleosol (hardpan)
- Levee widths and side slopes are schematically shown

Notes:
1. Borehole ground elevation values from URS Corp., and reported in the Boring Location Survey, DWR task #10. (NAVD 88).
2. CPT borehole surface elevations are approximate, placed on projected ground surface between boreholes WM00_001S and WSESBP_001B.
3. Bottom of hole (B.O.H.) values shown as total depth below ground surface.
4. Borehole names and horizontal distance shown above from draft URS logs and location maps. Geologic relations could change if borehole locations are revised.
5. Drilling method indicated as last letter in borehole names.
   B = Mud Rotary unit with SPT
   S = Sonic vibracore
   C = Cone Penetrometer Test.
6. Cone penetrometer borehole locations projected to the trend of this cross section.
7. Recent over flow channel shown beneath the northwestern levee intersects the levee at a sub-orthogonal angle. This conceptual cross section intersects the levee and the over flow channel at an oblique angle, as shown in the channel asymmetry.



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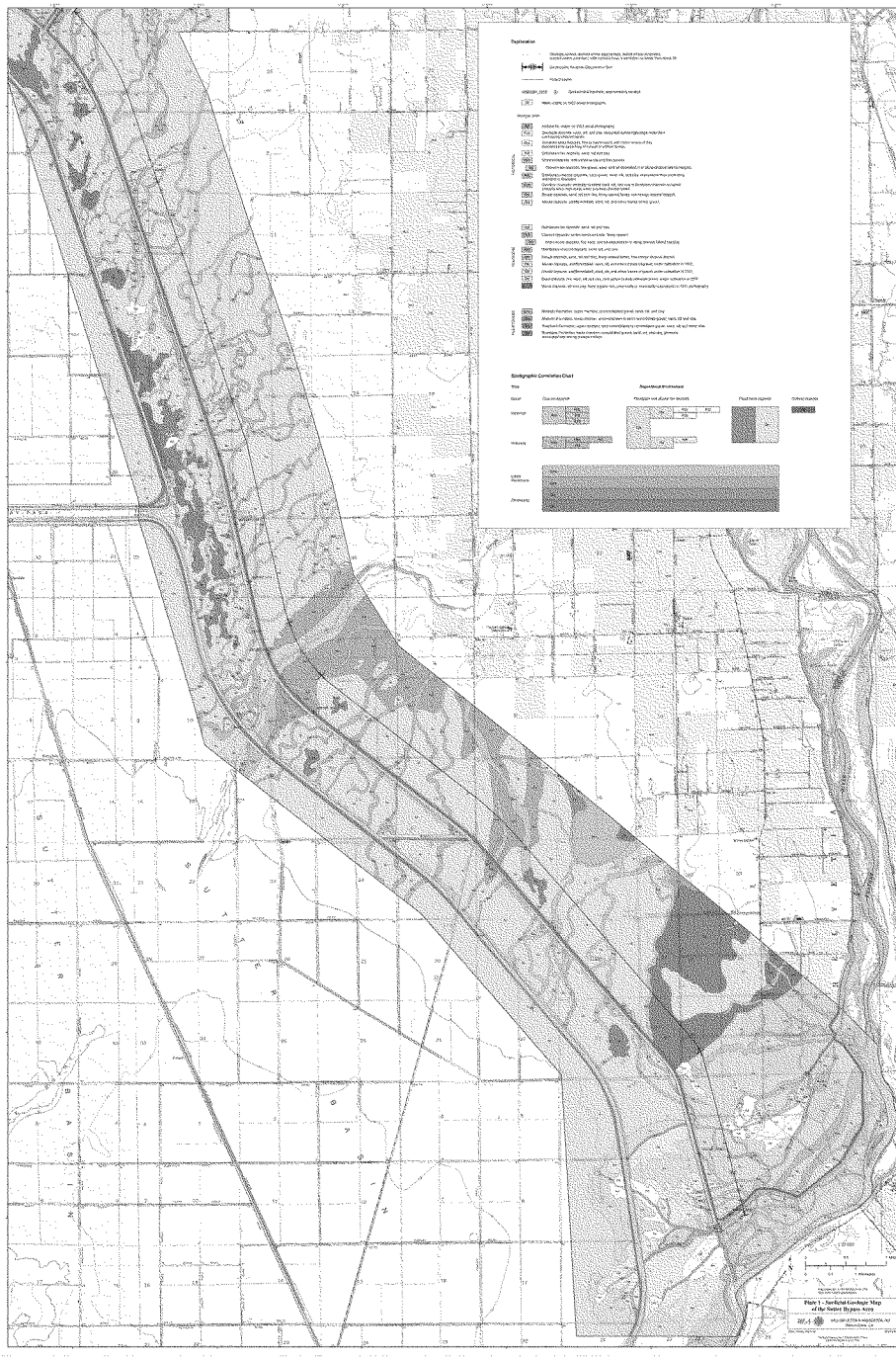
Conceptual Subsurface Diagram across the Eastern Levee of the Sutter Bypass Confluence with the Feather River

DWR URBAN LEVEE PROJECT
Figure 6

1881 Sutter Bypass

Modified 09.03.09


Explanation
Stratigraphic Correlation Chart
Plate 1 - Surficial Geologic Map of the Sutter Bypass Area

WLA

WILLIAM LETTIS & ASSOCIATES, INC.
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tel (925) 256-6070 fax (925) 256-6076

September 8, 2009

Mr. Juan Vargas
URS Corporation
2870 Gateway Oaks Drive, Suite 150
Sacramento, CA 95833

RE: Surficial geologic mapping and geomorphic assessment, California Department of Water Resources Urban Levees Project, Sutter Bypass, Sutter County, California

Dear Mr. Vargas:

This memorandum presents the surficial geologic mapping and preliminary geomorphic assessment of the eastern Sutter Bypass area, for the California Department of Water Resources (DWR) Urban Levees Project geotechnical characterization. The goal of this mapping and geomorphic assessment is to provide information on the type and distribution of surface and shallow subsurface deposits that likely underlie the project levees along the eastern part of the bypass. The purpose of this study is to develop spatially-continuous geologic data and a conceptual model that allows reasonable stratigraphic interpretations between widely-spaced subsurface explorations, with respect to potential levee underseepage (i.e., Llopis et al., 2007). This letter presents the technical approach, surficial geologic map, conceptual geomorphic model, and initial results based on map analysis and preliminary review of available Phase 1 geotechnical data.

We appreciate the opportunity to provide these geomorphic and geologic data and preliminary interpretations of the shallow stratigraphic conditions in the Sutter Bypass study area. Please do not hesitate to call either of the undersigned if there are any questions or comments.

Respectfully,

WILLIAM LETTIS & ASSOCIATES, INC.

Justin Pearce, C.E.G. 2421
Senior Geologist
(925) 256-6070

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Principal Geologist
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1.0 Approach

The approach to developing a surficial geologic map of the Sutter Bypass area (Figure 1, Plate 1) consisted of analysis of the following data: Aerial photography (black and white stereo-pairs taken in 1937, ~1:20,000-scale); early USGS topographic maps (i.e., 1911); published surficial geologic maps (Helley and Harwood, 1985); early and modern soil survey maps (Strahorn et al., 1911; Lytle, et al., 1988); field reconnaissance visit on June 22, 2007; and other maps and documents. Synthesis of these data allow for the development of a detailed surficial geologic map that provides an initial understanding of primary geomorphic processes that have acted in the study area during recent and historical geologic time. Through this mapping, we identify primary geomorphic features and associated surficial geologic deposits, such as abandoned paleochannels, marsh and basin deposits, flood-basin deposits, and other features commonly associated with flood-basins adjacent to large, active river systems. Knowledge of fluvial processes and the ability to recognize depositional environments in the geologic record are key to identifying locations along levees where underseepage is most likely to occur (Llopis, 2007).

The surficial geologic map was developed at the nominal scale of the aerial photography (1:20,000). This scale establishes the resolution of the map (Plate 1). The map unit contacts shown on the surficial geologic map should be considered approximate, and accurate to no more than about 30 feet on either side of the line shown on the map. The 1937 aerial photographs are the primary data set for interpreting the surficial geologic deposits because: (1) they are the oldest high-quality images that pre-date much of the urbanization and landscape alteration within present-day Sutter County (Figure 2); and, (2) these data represent a close approximation to the surficial deposits that were likely present at the ground surface prior to the construction of the levees. The 1937 photographs generally were taken in late summer or early autumn (i.e., August). By 1937, the area had experienced moderate cultivation that locally obscures geomorphic conditions. However, integration of data from the 1937 photography, old and recent topographic maps, geologic maps, soil surveys and historical documents provides sufficient information to delineate many of the pre-historic and historic surficial deposits in detail. Taken together, these data provide key insights to the geomorphic processes and resulting deposits that may affect levee underseepage.

Additional flood-basin or floodplain deposition may have occurred after 1937, due to flood overflows, levee overtopping, or localized levee failure. A time series analysis that interprets successive aerial photographs taken after major flood events (i.e., 1955) or known local levee failures (i.e., 1986) may reveal additional information on surficial deposits in the Sutter Bypass area. Such analyses are beyond the scope of this study. The data and interpretations presented herein address the primary goal of characterizing the type and distribution of deposits likely present directly beneath the project levees.

1.1 Report Preparation Quality Control

The surficial geologic map data and geomorphic interpretations presented in this memorandum were subject to quality control and quality assurance procedures as required by the Levee

Geotechnical Evaluation Project Management Plan (PMP). The surficial geologic map data developed by this study were reviewed for accuracy and completeness through an internal review and an independent technical review by Dr. Janet Sowers of WLA. Results of QA/QC review were documented using PMP Exhibit 2.2-3 (Independent Technical Review Report) and are kept on file according filing control plan. Subsurface data shown on diagrams were provided as draft information, and were not verified for accuracy or completeness by this study.

2.0 Geologic Setting

The Sutter Bypass (Bypass) study area lies southeast of the volcanic Sutter Buttes, between the Sacramento and Feather Rivers. The project levee addressed in this study borders the eastern side of the Sutter Bypass, extending from the Wadsworth Canal southeast to the Feather River (Figure 1). The Bypass levee generally trends northwest-southeast, and ties in to the Feather River west bank levee.

The Bypass levee lies northeast of Sutter Basin, a low-lying area east of the Sacramento River and west of the Feather River, where overflow and floodwaters from Butte Basin (located northwest of the Sutter Buttes), the Sacramento River, and the Feather River produced a seasonally marshy area. Except for the Sutter Buttes area, the regional land surface is nearly flat, and along the Bypass area gently slopes southwest at an elevation of about 30 to 40 feet. Construction of the Sutter Bypass was completed in 1924 to serve as an overflow for Sacramento River floods in the winter, and a source of irrigation in the summer (DWR, 1976). The eastern levee was enlarged in 1942 (Corps of Engineers, 1953). Prior to cultural modification, surface water runoff in the Bypass area was delivered to the Sutter Basin via intermittent, meandering creeks and sloughs from the northern Central Valley, including: Snake River, Snake Slough, Gilsizer Slough, Nelson Slough, and flood overflow channels emanating from the western side of the Feather River. The construction of the Bypass levee blocks water from the east that normally drains to the Sutter Basin and Sacramento River (DWR, 1976). Presently, many of the natural drainages and channels have been replaced by linear ditches, agricultural drains, and canals (Figure 2).

3.0 Surficial Geologic Mapping

Published surficial geologic maps of the Sutter Bypass study area generalized the surficial deposits primarily as late Quaternary basin (map unit Qb) deposits, with localized units of late Quaternary alluvium, Quaternary Modesto Formation (lower member), and Quaternary Riverbank Formation (lower member) (Helley and Harwood, 1985). These map units were delineated at a regional scale (i.e., 1:62,500). The current analysis of the Bypass uses this geologic framework as a basis for more detailed mapping of late Holocene alluvium and geomorphic features (Plate 1). The surficial geologic map units within the Sutter Bypass study area are described below, in order from oldest to youngest.

The oldest map unit exposed in the study area is the late Quaternary Riverbank Formation (lower member), and is mapped in the south portion of the study area east of Nelson Slough,

where it likely directly underlies the project levee near the latitude of Laurel Avenue (Plate 1). This formation (map unit Qrl) is present in the shallow subsurface beneath much of the bypass area, and consists of alluvial-fan deposits derived from the Sierra Nevada during the middle Pleistocene (about 400,000 to 200,000 years ago). The Riverbank Formation is semi-consolidated, and is associated with the presence of a well-developed hardpan (or, duripan) layer that is a product of soil-forming processes over substantial geologic time. This hardpan layer reflects an ancient land surface that locally is buried by younger deposits. Soils developed on the Riverbank Formation in the Bypass area include the San Joaquin loam of Strahorn et al. (1911) and the Yuvas loam (Lytle et al., 1988), both of which document a strongly cemented hardpan at depths of about 1.5 to 3 feet below ground surface.

The late Pleistocene Modesto Formation is younger than the Riverbank Formation and is present in the map area primarily along the margin of Gilsizer Slough and directly east of Highway 113 (Plate 1). This unit is divided into two members, a lower (older) unit that is about about 42,000 to 29,000 years old (Qml), and an upper member that is about 24,000 to 12,000 years old (Qmu) (Helley and Harwood, 1985). The Modesto Formation, in general, consists of unconsolidated sand, silt, and clay, and is associated with a moderate amount of secondary (pedogenic) clay accumulation. This clay-rich horizon may form laterally continuous zones of low hydraulic conductivity. These soil horizons may extend across boundaries between coarse and fine-grained strata within the latest Pleistocene alluvium, and may form relatively continuous zones of low vertical hydraulic conductivity within the Modesto Formation. Soils developed on the Modesto Formation include the Gridley loam of Strahorn et al. (1911) and the Marcum clay loam with "siltstone" hardpan (Lytle, 1988).

Younger surficial deposits overlying the Riverbank and Modesto Formation include late Quaternary marsh, basin, and alluvial deposits (map units Qs, Qn, and Qa, respectively), which are considered Holocene age (i.e., less than 11,000 years old). The widespread basin deposits are about 4 to 8 feet thick and bury the gently southwest dipping Modesto Formation (Figure 3). The thickness of the basin deposits increases to the southwest, in the direction of Sutter Basin (Figure 3). The soils developed on the basin deposits generally are associated with the Stockton clay adobe and Marcuse clay of Strahorn et al. (1911) and the Oswald clay (Lytle et al., 1988), and thus represent immature soils with overall fine-grained textures. Undifferentiated alluvial deposits (map Qa, Plate 1) are present along Gilsizer Slough, and are inset (i.e., topographically lower) into the adjacent Modesto Formation. The Quaternary marsh deposits (map unit Qs, Plate 1) are present between the Sutter Bypass levees northwest of Gilsizer Slough, and are also fine-grained deposits that are differentiated from basin deposits by usually being underwater or having standing water at the time when the 1937 photographs were taken (usually late summer to early autumn).

Inset into the units described above are deposits of Holocene alluvial channels (map unit Hch, Plate 1), which are a network of moderately sinuous channels with southwesterly orientations. These channels appear to be mostly filled with sediment by the time of 1937 photographs, and are expressed only locally as subtle topographic lows in the ground surface. Many of these channels extend west of, and therefore cross beneath, the eastern Sutter Bypass levee (Plate 1). The alluvial channels west of Gilsizer Slough start on the alluvial plain as intermittent creeks, and are not directly connected to the Feather River (USGS Tisdale Weir quadrangle, 1911).

The channel deposits are tentatively associated with the Liveoak series, sandy clay loam soil (Lytle et al., 1988), and consist of a lower, sandy unit that fines-upward into an upper, silt and clay layer.

Subdivisions of the Holocene channels include sloughs (map unit Hsl, Plate 1), distributary channels (map unit Hdc), and overflow channels (map unit Hofc). These deposits, in general, also consist of a fining-upward sequence of sand, silt, and clay. The sloughs are present primarily east of Highway 113 (Plate 1) and have southwesterly orientations. The sloughs are ephemeral channels that drain the alluvial plain between Gilsizer Slough and the Feather River. The term "slough" in this study does not mean tidally-influenced channels, but instead channels that likely conveyed relatively slow-moving water from direct precipitation and sheet-flow runoff. The overflow channels convey flood flows that overtop the banks of the Feather River onto the floodplain, and are interpreted as higher-energy channel systems relative to the sloughs. The distributary channels route flow from and sediment onto the floodplain, and end at distributary-fan deposits. The overflow and distributary channel deposits are present in the southeastern portion of the Bypass area, south of the latitude of Laurel Avenue (Plate 1).

Localized deposits related to the Holocene alluvial channels are bars (map unit Hb) that typically occur in the medial and lateral portions of the channels, and distributary fan deposits (map unit Hdf) that occur where the channel becomes unconfined and has deposited sediment on the basin floor. Channel bars are relatively uncommon in the Sutter Bypass study area. Distributary fans are common in the southeast portion of the Bypass area, south of the latitude of Sacramento Avenue (Plate 1). The distributary-fan deposits likely consist of unconsolidated fine sand and silt (i.e., Strahorn et al., 1911).

Historical geologic deposits are present along the length of the Bypass study area (i.e., map unit Rch, map unit Rdf). The term "historical" is applied to deposits that are estimated to be less than 150 years old. These deposits share the same genetic origin as the Holocene deposits described above. The historical channel deposits are differentiated from the Holocene channel deposits on the basis of cross-cutting relationships with other map units, relative degree of geomorphic expression and/or dissection, and correlation with land surface expression on the early and modern topographic maps. The Bypass eastern levee overlies the former locations of Holocene and historical alluvial channels in several locations throughout its length (Plate 1).

Undifferentiated Holocene and historical alluvium (map units Ha and Ra) is mapped in the southeastern Bypass area, near the confluence of the Sutter Bypass and the Feather River, generally east of Sawtelle Road (Plate 1). The undifferentiated map unit is delineated where the morphology of these deposits is indistinguishable on 1937 photographs as a result of cultural modifications (i.e., agriculture). The soils developed on the undifferentiated historical alluvium generally correspond with the Sacramento series fine sandy loam and silt loam of Strahorn et al. (1911) and the Shanghai silt loam (Lytle et al., 1988). There is no hardpan layer associated with these soils, supporting the interpretation of geologically young deposits.

4.0 Conceptual Geomorphic Model

Based on synthesis of surficial geologic mapping, topographic maps, soil surveys, geologic maps, and review of readily available subsurface geotechnical information, we present a preliminary conceptual geomorphic model describing general relationships among surface and subsurface deposits along the Sutter Bypass study area. This conceptual model provides a consistent basis for understanding the type and distribution of surficial geologic deposits, primary geomorphic processes, and shallow subsurface stratigraphy in the area. Identification of subsurface stratigraphic formations is challenging, primarily because of a lack of distinctive and laterally extensive stratigraphic marker beds within late Quaternary deposits of the northern Central Valley (i.e., Page, 1986), and because there is little apparent difference in lithology between the late Quaternary formations (i.e., Helley and Harwood, 1985). This study relies heavily on the identification and local correlation of hardpan horizons and deposit color and density changes to delineate subsurface formations.

In a general sense, the Sutter Bypass levees traverse across the distal portions of ancient alluvial-fan deposits that were derived from the Sierra Nevada, and prograded westward onto the valley floor (i.e., Riverbank and Modesto Formations). These Pleistocene deposits are exposed at the ground surface northeast of the Bypass study area (Helley and Harwood, 1985; Page, 1986), dip to the southwest and are mantled by younger fine-grained basin deposits (Figure 3). In contrast, the Modesto Formation is exposed at the ground surface along Gilsizer Slough and directly east of Highway 113 (Plate 1). The surficial map pattern of the Modesto deposits in these locations suggests depositional lobes from an ancestral Gilsizer Slough. These deposits may have been related to discharges and sediment loads that were higher than present-day conditions. These deposits may, perhaps, represent an ancestral Feather River channel location that occupied the present-day Gilsizer Slough during the latest Pleistocene and was subsequently abandoned.

The surficial geologic mapping (Plate 1) shows differences in deposit type and distribution from northwest to southeast along the Bypass, which are associated with changes in watershed production of water and sediment, related geomorphic processes, soil profile development, and the underlying subsurface hardpan layer. These differences illustrate the diversity of past geomorphic processes along and near the Bypass and, as a consequence, the type of geologic deposits at and near the ground surface. The surficial geologic map allows the interpretation of "reaches" along the Bypass within which geomorphic processes and their associated deposits are likely to be relatively consistent. The Bypass study area consists of four general reaches, from northwest to southeast, each having characteristic deposit types and distributions (Plate 1).

The westernmost reach of the Bypass study area extends from the junction with the Wadsworth Canal to directly south of the Tisdale Weir ("Reach I", Plate 1). The levee along this reach, about 8.1 miles long, primarily overlies fine grained basin deposits accumulated on the valley floor over geologic time. This deposition resulted from flooding of the Sacramento and Feather Rivers, tributaries draining Sutter Buttes, and sheet flow from the generally flat valley floor. Holocene and historical channel deposits (map units Hch and Rch, Plate 1) are inset into the basin deposits. These southwest-trending alluvial channel deposits locally underlie the Bypass

levee, and result in local differences in material textures beneath the levee (Figure 4). About 27 abandoned channels traverse the levee along this reach (approximately 3 channels per levee mile). The channels are about 250 feet wide, but range from about 100 to 300 feet wide (Plate 1). In this area, the channels are about 6 to 8 feet deep, and are typically filled with sand, silt, and clay in a fining-upward sequence, i.e., coarser-grained sand overlain by about one to two feet of silt and clay. This sedimentary sequence may be conducive to seepage where relatively more-permeable channel sands are overlain by a relatively thin, fine-grained "blanket" layer.

The second reach along the Bypass, about 1.1 miles long, extends across Gilsizer Slough ("Reach II", Plate 1), where Modesto Formation deposits are present at the ground surface. Undifferentiated alluvium (map unit Qa, Plate 1) is present along the historically-active Gilsizer channel floor, and is inset to the Modesto Formation (Figure 5). The Gilsizer Slough alluvium extends beneath the eastern and western Bypass levee, and thus represents the progradation of younger deposits with respect to the Modesto Formation. Along this reach, the Bypass levee is underlain by younger Gilsizer Slough alluvium flanked by the relatively denser, semi-consolidated late Pleistocene Modesto deposits (Figure 5). Areas where the levee directly overlies the Modesto Formation may be relatively less conducive to underseepage, as the associated hardpan layer may form locally continuous zones of low hydraulic conductivity.

The third reach along the Bypass extends from the Gilsizer Slough to the latitude directly south of Laurel Avenue, and is about 6.6 miles long ("Reach III", Plate 1). This reach is generally similar to Reach I, except Reach III has Pleistocene deposits (i.e., lower Modesto and Riverbank Formations) exposed at or very near the ground surface, and has a sparser channel density (about 2 channels per levee mile) compared to Reach I. About 14 southerly-oriented sloughs are mapped across this reach and locally underlie the Bypass levee (Plate 1). The sloughs originate from the Feather River, near Star Bend and Shanghai Bend, extending southward toward the Bypass. The sloughs along Reach III are about 250 feet wide, but range from about 100 to 300 feet wide, similar to Reach I (Plate 1). In this area, the channels are also probably about 6 to 8 feet deep, and probably filled with sand fining-upward to silt and clay. These channel deposits may be conducive to underseepage because of the deposit stratigraphy that has coarser-grained sand overlain by about one to two feet of silt and clay. Late Quaternary Riverbank Formation is at the ground surface along the southwestern end of Reach III (Plate 1), and likely is not conducive to seepage due to the dense and strongly-developed hardpan clay layer that is usually at about 1.5 to 4 feet depth below ground surface.

The fourth reach along the Bypass extends from directly south of the latitude of Laurel Avenue to the confluence with the Feather River west bank levee ("Reach IV", Plate 1). Reach IV, about 1.9 miles long, has Holocene and historical alluvium at the ground surface along this reach of the Bypass, primarily because of the proximity to the Feather and Bear Rivers (Plate 1). About 8 distributary channels, usually 90 feet wide but ranging from 45 to 190 feet wide, cross the floodplain in southwesterly orientations, leading to geologically young distributary-fan sediments. These sediments, primarily consisting of fine to coarse sand and silt, probably were deposited as a result of increased sediment and water input contributed to the Feather River from the Bear River; the confluence located directly upstream from this reach of the Bypass (Figure 1). Historically, the Feather River and the Bear River have aggraded from substantial mining debris input, thus reducing channel cross sectional area (i.e., James, 1999).

This reduction of cross section area, coupled with the trajectory of floodflow from the Bear River watershed, resulted in water overtopping the Feather River channel banks, and depositing sediment onto the western floodplain where the Bypass levee is located (Plate 1).

5.0 Applications to the Urban Levee Project

Based on synthesis of the surficial geologic map with preliminary Phase 1 borehole and cone penetrometer (CPT) data, the Bypass levee generally is underlain by relatively young fine-grained clay and sandy clay deposits that are laterally interrupted by local coarser channel fill deposits (i.e., Figures 3, 4, 5, and 6).

The northernmost reach of the Bypass levee ("Reach I") is predominantly underlain in the shallow subsurface by relatively young fine-grained clay and sandy clay deposits. These basin deposits are laterally interrupted by coarser-grained deposits filling abandoned channels that are about 250 wide (Plate 1, Figure 4). Mud rotary borehole WSESBP_011B, which penetrated channel unit Rch norths of Gilsizer Slough (Plate 1), indicates the channel deposit is about four-feet thick, consisting of about 60% fine to coarse sand (medium dense) with clayey sand. The clayey sand grades upward into clay, of about 45% sand fraction. This suggests locally coarse and unconsolidated, and therefore likely permeable, material in the channel fill. Based on review of adjacent borehole data, the basin deposits (Figure 4) generally consist of stiff clay, with less than 10% fine sand. It is likely that most or all of the small channels mapped herein as unit Rch are similar in textural characteristics and depths, because of similar genetic origin and geomorphic process of channel development and infilling. These deposits underlie Reach I in at least 27 places between Wadsworth Canal and Gilsizer Slough (Plate 1).

Reach II crosses late Pleistocene and Holocene geologic deposits associated with Gilsizer Slough (Plate 1). Review of subsurface borehole and CPT data indicate that the basin deposits north of the slough consist of medium stiff to stiff clays (Figure 5). The channel fill deposits within Gilsizer Slough (map unit Qa, Plate 1) consist of alternating beds of sandy gravel and clay. These channel deposits are inset into the lower Modesto Formation which, in this area, consists of very stiff sandy clay interbedded with silty sand and localized dense sand. Directly south of Gilsizer Slough, the lower Modesto Formation is at the ground surface (Plate 1). Subsurface data suggest that a hardpan horizon is encountered at about 3 to 4 feet below the ground surface. The uppermost deposit above the hardpan consists of sand and silty sand, and probably is weathered and/or culturally re-worked materials of the lower Modesto Formation. Thus, north of Gilsizer Slough, potentially low-permeability basin materials blanket the Modesto, and are locally cut by channel deposits, whereas at and south of Gilsizer Slough the local channel deposits are inset directly into the dense Modesto Formation. Where the Bypass levee rests on the unconsolidated Qa deposits within Gilsizer Slough, these coarse deposits may be associated with higher probabilities of levee underseepage. In constrast, the sections of the levee underlain directly by the Modesto Formation containing consolidated (hardpan) horizons are much less likely to experience underseepage.

Reach III is similar in geomorphic nature to Reach I, except it has a lower frequency of channels as compared to Reach I (Plate 1). It is probable that the composition of these deposits

generally will be consistent with those along Reach I (i.e., coarse-grained channel fill with upper fine-grained layers). These channels are more likely to promote seepage beneath the levee compared to the basin deposits. Additionally, the Pleistocene materials that likely directly underlie the project levees along this reach (Plate 1) are relatively dense and the associated hardpan layer may form a relatively continuous zone of lower hydraulic conductivity. Where the levee directly overlies Modesto formation (NW ¼, Section 20; southeast of the Sutter Causeway), there is a lower likelihood of underseepage. There is also a lower likelihood of underseepage where the levee rests on the Riverbank Formation in lower length of Reach III (SW ½, Section 34).

Along Reach IV, geologically young Holocene and historical alluvium is beneath the Bypass levee (Plate 1). This uppermost layer, about five-feet thick, is locally cross-cut by channel deposits that also consist of silt and sand (Figure 6). Quaternary basin deposits do not directly underlie the Bypass levee along this reach. Review of Phase 1 subsurface geotechnical data indicates that these alluvial deposits consist of silty sand and sandy silt textures. Based on review of Phase 1 data in other Project areas (i.e., Marysville), the uppermost alluvium generally has low densities (i.e. loose to medium dense), and consequently relatively high permeability. The surficial mapping indicates that essentially all of this reach of the levee (about1.9 miles) is underlain by loose, unconsolidated sandy alluvium, which may be susceptible to substantial underseepage. The local recent channels (map units Ra and Rdc; Plate 1) may contain coarser deposits and may be more susceptible to underseepage.

Synthesis of the surficial mapping and geotechnical data indicate that subsurface stratigraphy along the Sutter Bypass area locally may be conducive to levee underseepage. Shallow strata typically include denser and probably semi-consolidated material (i.e., Modesto Formation) that likely contains a moderately developed low-permeability hardpan horizon. The hardpan may or may not be laterally continuous, depending on post-depositional soil formation and erosional processes. Along Reach I and III, the Modesto formation is overlain by about 4 to 6 feet of medium stiff to stiff clay (i.e., basin deposits). The basin materials locally are cross-cut by relatively loose, sandy channel deposits that have a thin fine-grained upper "blanket" layer. Therefore, this shallow subsurface stratigraphy may promote levee underseepage along certain areas of the Bypass project levees that overlie geologically young, loose, sandy channel material lies between the dense Pleistocene deposits and relatively thin, low-permeability clay-rich "blanket" layer. Along Reach IV, a layer Holocene and historical alluvium from the Feather River mantles the Modesto Formation, and also may promote levee underseepage.

Lateral and vertical variability in the shallow subsurface deposits has resulted from past geomorphic processes. The conceptual subsurface stratigraphic framework suggests that stratigraphic relationships may promote localized levee underseepage, given certain hydraulic conditions. Further spatial analyses of the surficial geologic mapping and subsurface geotechnical exploration data are needed to better constrain and characterize areas that are most susceptible to underseepage in the study area.

6.0 Limitations

This geomorphic assessment and associated data interpretation have been performed in accordance with the standard of care commonly used as the state-of-practice in the geologic engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this geographic area performing the same services under similar circumstances during the same time period.

Discussions of surface and subsurface conditions summarized in this technical memorandum are based on geologic interpretations of subsurface soil data at limited exploration locations available to this assessment through August of 2007. Variations in subsurface conditions may exist between exploration locations, and the project team may not be able to identify all adverse conditions in the levee and its foundation. This memorandum is for the use and benefit of DWR. Use by any other party is at their own discretion and risk.

7.0 References

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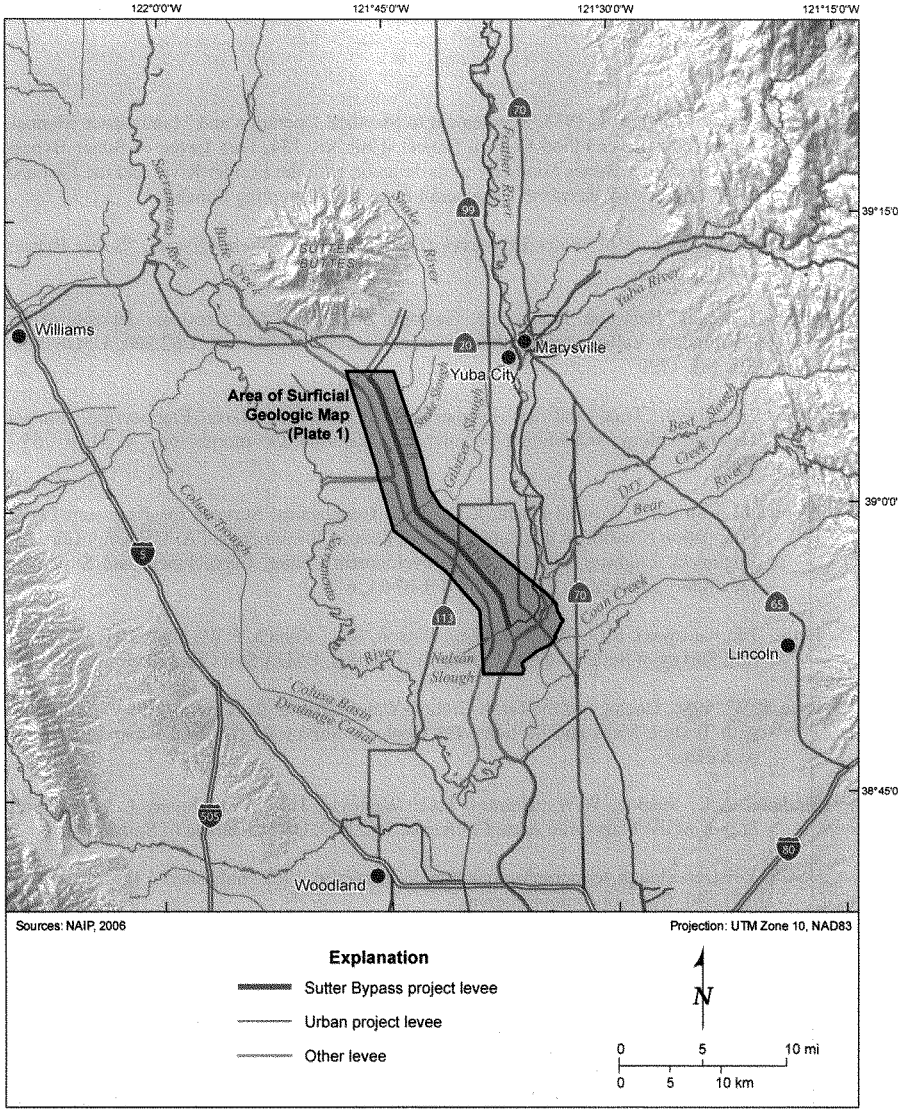
USGS, Tisdale Weir topographic quadrangle, surveyed 1909, published 1911; map scale 1:31,680, five foot contour interval.



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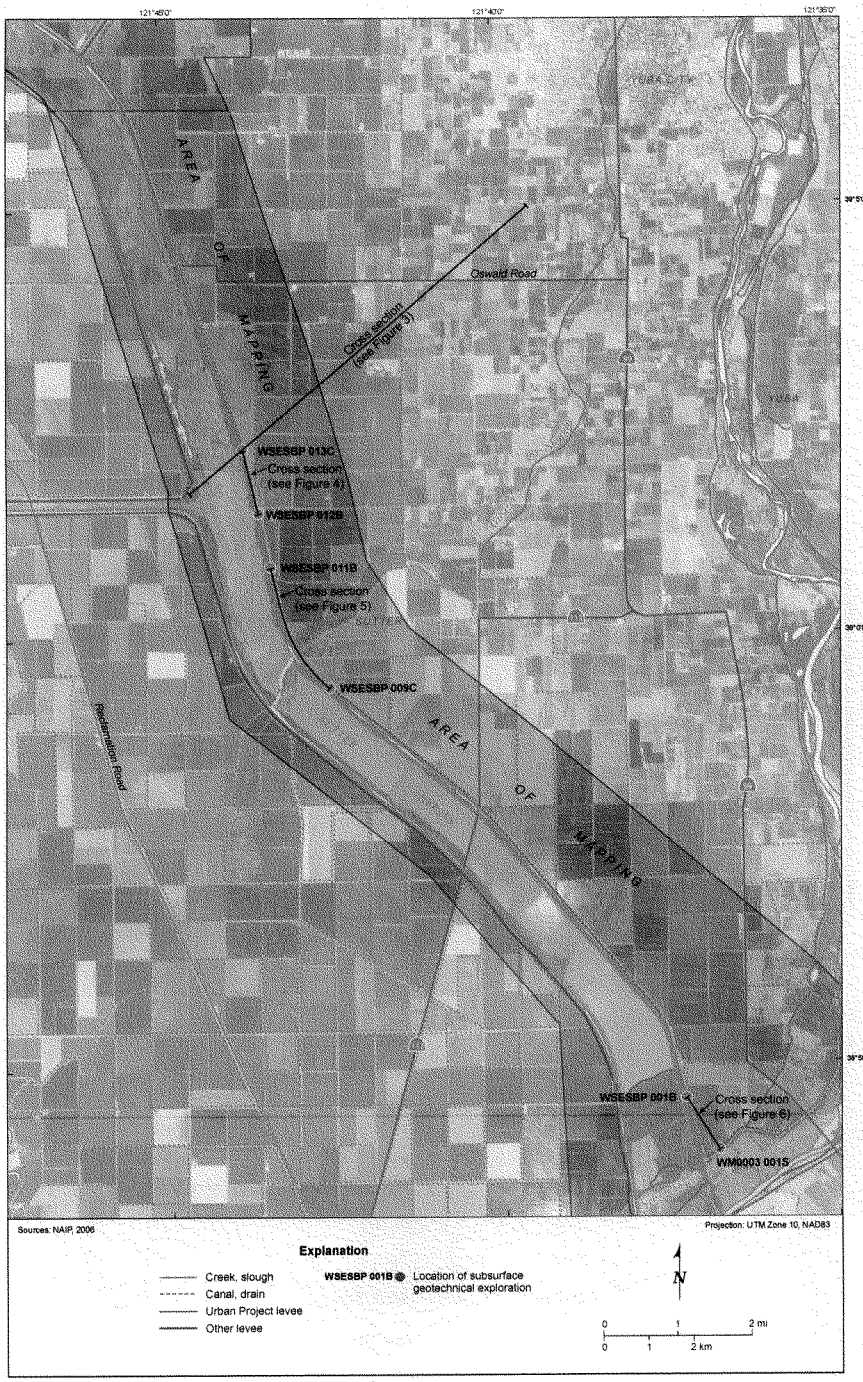
Map of Northern Central Valley, California

DWR URBAN LEVEE PROJECT

Figure 1

1881 Sutter Bypass

Modified 09.03.09



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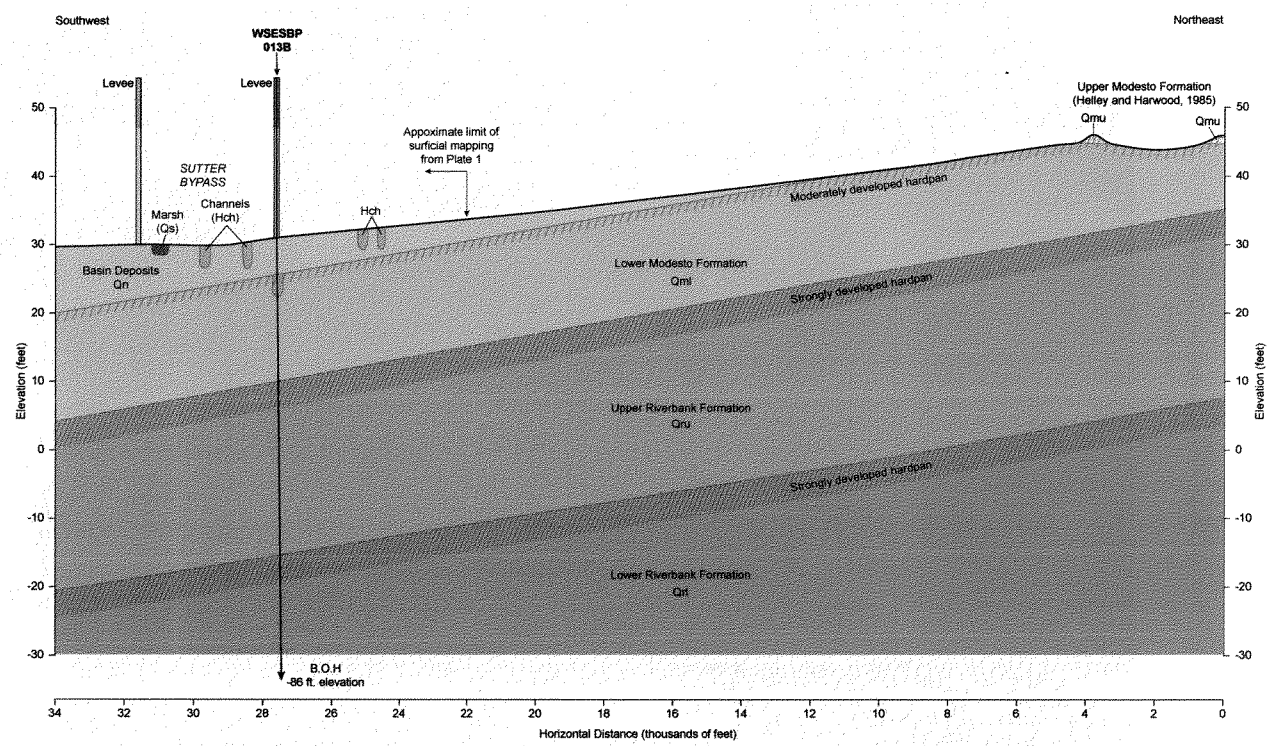
Sutter Bypass

DWR URBAN LEVEE PROJECT

Figure 2

Modified 09-03-09



Notes: 1. See Figure 2 for location of cross section.
2. Surficial geologic units and contacts from this study and Helley and Harwood (1985).
3. Ground surface elevation from USGS Gilsizer Slough topographic map, 5-foot contour interval.

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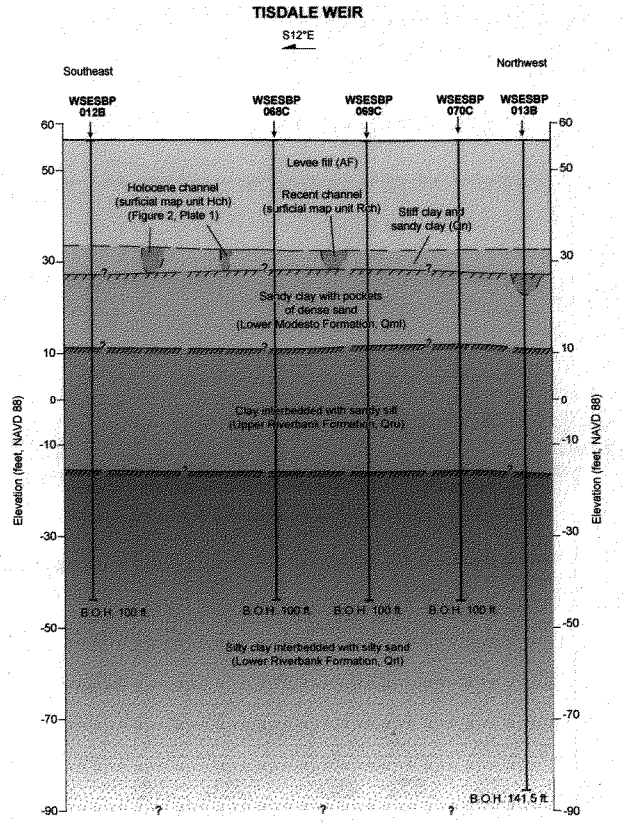
1881 Sutter Bypass

Conceptual Cross Section Transverse to Sutter Bypass

DWR URBAN LEVEE PROJECT

Figure 3

Modified 09 03 09



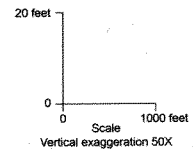
Explanation

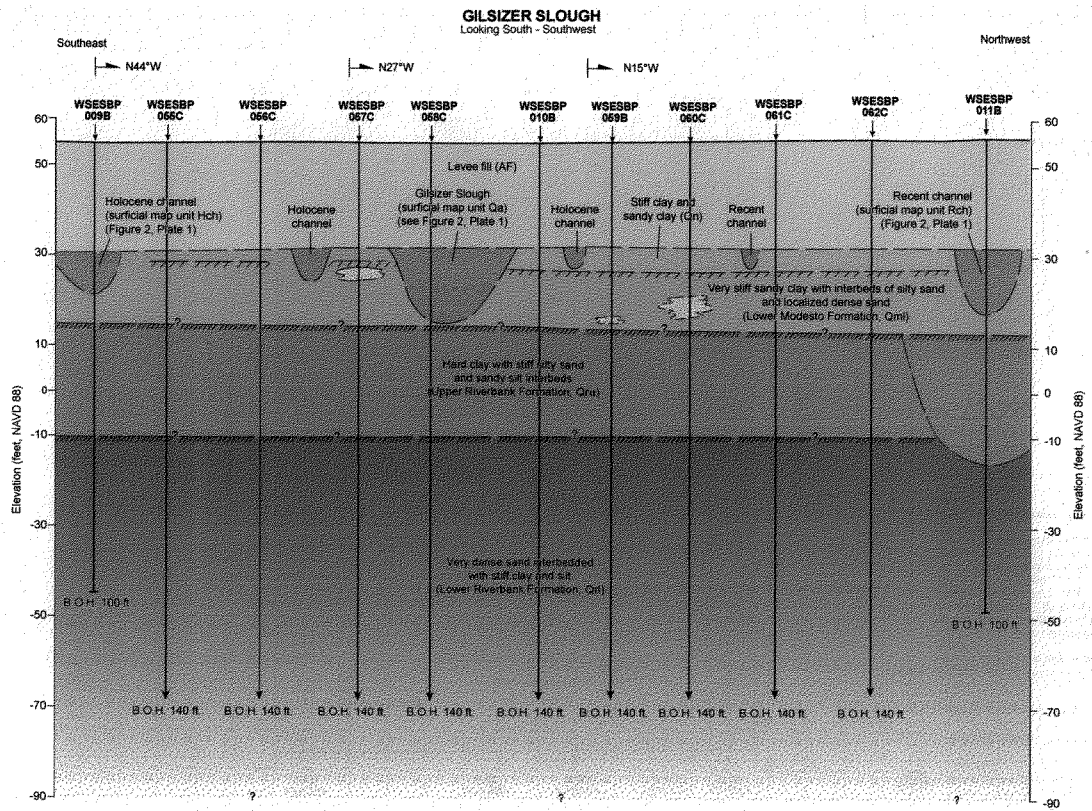
Channel identified on surficial geologic map or as fining upward sequence of sediments in boreholes

Moderate paleosol (hardpan)

Strong paleosol (hardpan)

Notes:
1. Borehole ground elevation values from URS Corp., and reported in the Boring Location Survey, DWR task #10. (NAVD 88).
2. CPT borehole surface elevations are approximate, placed on projected ground surface between boreholes WSESBP_012B and WSESBP_013B.
3. Bottom of hole (B.O.H.) values shown as total depth below ground surface.
4. Borehole names and horizontal distance shown above from draft URS logs and location maps. Geologic relations could change if borehole locations are revised.
5. Drilling method indicated as last letter in borehole names.
   B = Mud Rotary unit with SPT
   C = Cone Penetrometer Test.





Explanation

- Channel identified on surficial geologic map or as fining upward sequence of sediments in boreholes
- Localized sand and gravel; possible channel interpreted from borehole logs
- Moderate paleosol (hardpan)
- Strong paleosol (hardpan)
- Bend in levee
- N16°W Azimuth of levee segment

Notes:
1. Borehole ground elevation values from URS Corp., and reported in the Boring Location Survey, DWR task #10.(NAVD 88).
2. CPT borehole surface elevations are approximate, placed on projected ground surface between continuous boreholes WSESBP-009B, WSESBP-010B, and WSESBP-011B.
3. Bottom of hole (B.O.H.) values shown as total depth below ground surface.
4. Borehole names and horizontal distance shown above (from draft URS logs and location maps). Geologic relations could change if borehole locations are revised.
5. Drilling method indicated as last letter in borehole names.
   B = Mud Rotary unit with SPT
   C = Cone Penetrometer

20 feet
0
0
1000 feet
Scale
Vertical exaggeration 50X

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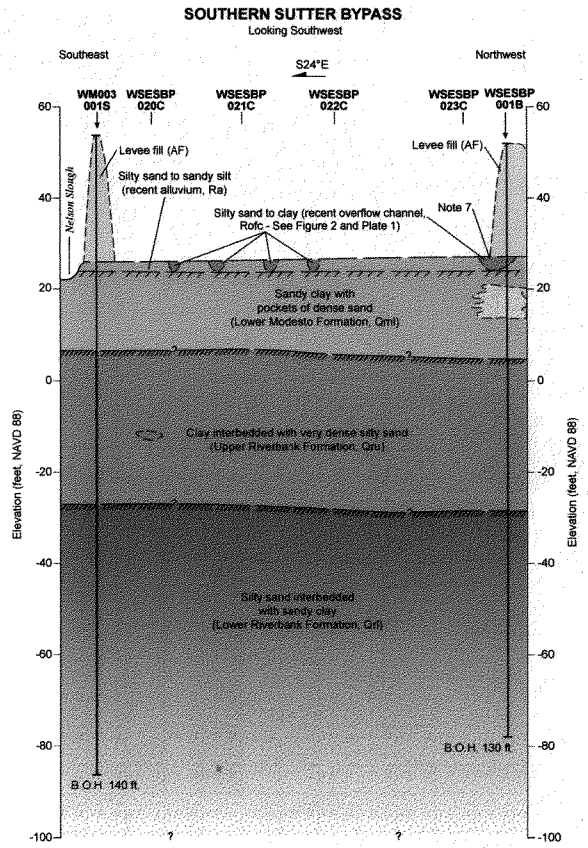
1841 Sutter Bypass

Conceptual Subsurface Diagram across Eastern Levee Crest at Gilsizer Slough

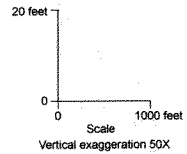
DWR URBAN LEVEE PROJECT
Figure 5
Modified 09 03 09



Explanation

- Channel identified on surficial geologic map or as fining upward sequence of sediments in boreholes
- Localized sand and gravel; possible channel interpreted from borehole logs
- Moderate paleosol (hardpan)
- Strong paleosol (hardpan)
- Levee widths and side slopes are schematically shown

Notes:
1. Borehole ground elevation values from URS Corp., and reported in the Boring Location Survey, DWR task #10. (NAVD 88).
2. CPT borehole surface elevations are approximate, placed on projected ground surface between boreholes WM00_001S and WSESBP_001B.
3. Bottom of hole (B.O.H.) values shown as total depth below ground surface.
4. Borehole names and horizontal distance shown above from draft URS logs and location maps. Geologic relations could change if borehole locations are revised.
5. Drilling method indicated as last letter in borehole names.
   - B = Mud Rotary unit with SPT
   - S = Sonic vibracore
   - C = Cone Penetrometer Test.
6. Cone penetrometer borehole locations projected to the trend of this cross section.
7. Recent over flow channel shown beneath the northwestern levee intersects the levee at a sub-orthogonal angle. This conceptual cross section intersects the levee and the over flow channel at an oblique angle, as shown in the channel asymmetry.



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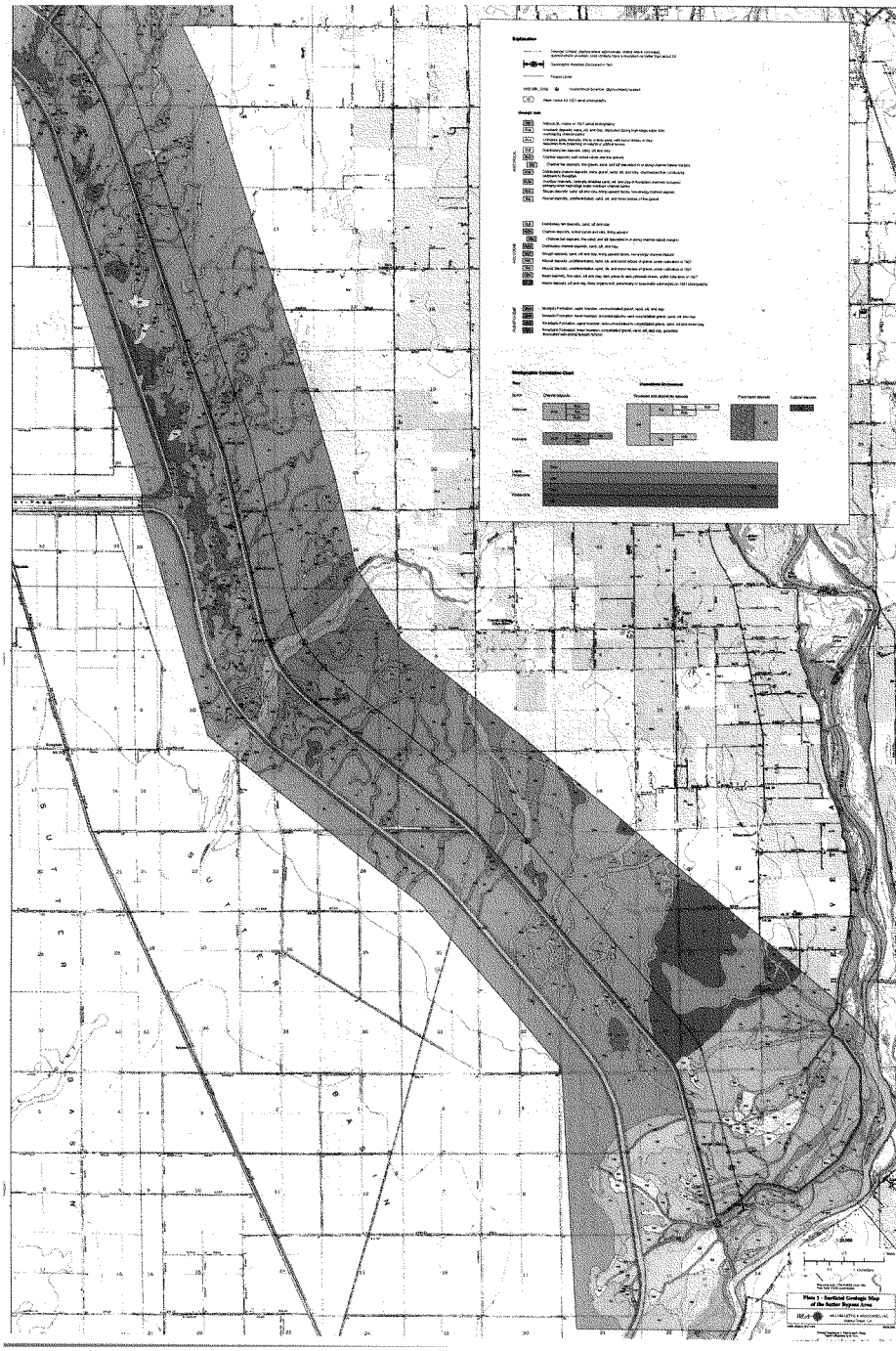
Conceptual Subsurface Diagram across the Eastern Levee of the Sutter Bypass Confluence with the Feather River

DWR URBAN LEVEE PROJECT
Figure 6

1881 Sutter Bypass

Modified 09.03.08


Explanation
Geologic Correlation Chart
Plate 1 - Surficial Geologic Map of the Butte Bypass Area

WILLIAM LETTIS & ASSOCIATES, INC.
1777 Botelho Drive, Suite 262, Walnut Creek, California 94596
tel (925) 256-6070 fax (925) 256-6076

September 8, 2009

Mr. Juan Vargas
URS Corporation
2870 Gateway Oaks Drive, Suite 150
Sacramento, CA 95833

RE: Surficial geologic mapping and geomorphic assessment, California Department of Water Resources Urban Levees Project, Southern Feather River, Sutter County, California

Dear Mr. Vargas:

This memorandum presents the surficial geologic mapping and preliminary geomorphic assessment of the southern Feather River study area, for the California Department of Water Resources (DWR) Urban Levees Project geotechnical characterization. The goal of this mapping and geomorphic assessment is to provide information on the type and distribution of surface and shallow subsurface deposits that likely underlie the project levees along the western bank of the Feather River. The purpose of this study is to develop spatially-continuous geologic data and a conceptual model that provides a framework for stratigraphic interpretations between widely-spaced subsurface explorations. A primary goal is to provide a geologic framework for the geotechnical assessment of potential levee underseepage. This memo presents the technical approach, surficial geologic map, conceptual geomorphic model, and initial results based on map analysis and preliminary review of Phase 1 geotechnical data.

We appreciated the opportunity to provide these geomorphic and geologic data and preliminary interpretations of the shallow stratigraphic conditions in the southern Feather River study area. Please do not hesitate to call either of the undersigned if there are any questions or comments.

Respectfully,

WILLIAM LETTIS & ASSOCIATES, INC.

Justin Pearce, C.E.G. 2421
Senior Geologist

Ashley Streig
Senior Staff Geologist

Keith Kelson, C.E.G. 1610
Principal Geologist

1.0 Approach

The approach to developing a surficial geologic map of the southern Feather River project area (Figure 1, Plate 1) consisted of analysis of the following data: Aerial photography (black and white stereo-pairs taken in 1937, ~1:20,000-scale); early USGS topographic maps (i.e., 1911); published surficial geologic maps (Helley and Harwood, 1985); early and modern soil survey maps (Strahorn et al., 1909; Lytle, et al., 1988); and other maps and documents (Busacca et al., 1989). Synthesis of these data allow for the development of a detailed surficial geologic map that provides an initial understanding of primary geomorphic processes that have acted in the study area during recent and historical geologic time. Through this mapping, primary geomorphic features and associated surficial geologic deposits are identified, such as abandoned paleochannels, channel deposits, floodplain deposits, basin deposits and other features commonly associated with surficial deposits with large active river systems. Knowledge of fluvial processes and the ability to recognize depositional environments in the geologic record are key to identifying locations along levees where underseepage is most likely to occur (Llopis
et al., 2007).

The surficial geologic map was developed at the nominal scale of the aerial photography (1:20,000). This scale establishes the resolution of the map (Plate 1), such that analysis of the map data at a more detailed scale than 1:20,000 may introduce uncertainties beyond the original resolution of the data. The map unit boundaries shown on the surficial geologic map should be considered approximate, and accurate within 30 feet on either side of the line shown on the map. The 1937 aerial photographs are the primary data set for interpreting the surficial geologic deposits because: (1) they are the oldest high-quality images that pre-date much of the urbanization and landscape alteration within present-day Sutter County (i.e. Figure 2); and, (2) these data represent a close approximation to the surficial deposits that were likely present at the ground surface prior to the construction of the levees. The 1937 photographs generally were taken in late summer or early autumn (i.e., August). By 1937, the area had experienced moderate cultivation that locally obscures geomorphic conditions. However, integration of data from the 1937 photography, old and recent topographic maps, geologic maps, soil surveys and historical documents provides sufficient information to delineate many of the pre-historical and historical surficial deposits in detail. Taken together, these data provide key insights to the characteristics of shallow deposits beneath the levees, as well as the geomorphic processes responsible for their distribution.

Additional floodplain deposition may have occurred after 1937, due to flood overflows, levee overtopping, or localized levee failure. A time series analysis that interprets successive aerial photographs taken after major flood events (i.e., USDA, black and white stereo-pairs taken in 1958, ~1:20,000-scale) or known local levee failures (i.e., 1986) may reveal additional information on surficial deposits in the southern Feather River area. Such analyses are beyond the scope of this study. The data and interpretations presented herein address the primary goal of characterizing the type and distribution of deposits likely present directly beneath the project levees.

WLA

1.1 Report Preparation Quality Control

The surficial geologic map data and geomorphic interpretations presented in this memorandum were subject to quality control and quality assurance procedures as required by the Levee Geotechnical Evaluation Project Management Plan (PMP). The surficial geologic map data developed by this study were reviewed for accuracy and completeness through an internal review and an independent technical review by Dr. Janet Sowers of WLA. Results of QA/QC review were documented using PMP Exhibit 2.2-3 (Independent Technical Review Report) and are kept on file according filing control plan. Subsurface data shown on diagrams were provided as draft information, and were not verified for accuracy or completeness by this study.

2.0 Geologic Setting

The southern Feather River study area lies in the Central Sacramento Valley, between the Coast Ranges to the west and the Sierra Nevada foothills to the east. Feather River drains the western slope of the Sierra Nevada, and emerges from the mountains south of the Thermalito Afterbay (Figure 1). The river flows southward from the Thermalito Afterbay, over middle-to late Pleistocene dissected alluvium derived from the Sierra Nevada. The regional land surface is nearly flat, with a gentle west-southwest slope that flattens out south of the Sutter Buttes, in Sutter Basin. The Feather River is entrenched into middle to late Pleistocene semi-consolidated sediments. Holocene alluvium deposited by the Feather River is present between the present-day levees, inset to the older formations, as well as on the western floodplain as subdued natural levees. The river trends roughly south until its confluence with the Bear River, where it curves
to the southwest (Figure 1). The Feather River lies east of, and is a tributary to the Sacramento River, converging near the town of Nicolaus (Figure 1). A primary influence on the historic processes in the river system was the hydraulic mining that began in the 1850's. Mining occurred through the early 1900's in the Feather, Yuba and Bear River watersheds, and abruptly introduced large quantities of sediment, drastically changing the geomorphic characteristics of these river systems (DWR, 2004; Ellis, 1939). Aggradation within the stream channel was a primary response to the introduction of substantial mining debris (James, 1999), consequently young alluvial deposits are common throughout the study area.

3.0 Surficial Geologic Mapping

Previous geologic mapping in the study area along the Feather River and surrounding areas generalize the surficial deposits as: Quaternary Alluvium (Qa) and Quaternary stream channel deposits (Qsc) within and proximal to the modern Feather River channel, (Helley and Harwood, 1985). These map units are considered Holocene age (less than 11,000 years old). Late Quaternary Modesto Formation (Qmu, Qml) is mapped along the western margin of the floodplain. These map units were delineated by Helley and Harwood (1985) at a regional scale (i.e., 1:62,500). The current analysis of the Feather River uses this geologic framework as a basis for more detailed mapping of late Holocene alluvium and geomorphic features (Plate 1).

The surficial geologic map units within the southern Feather River study area are described below, in order from oldest to youngest. Surficial geologic mapping for this study subdivides these map units and delineates individual deposits based on relative age and depositional process or environment (Plate 1). The map units depicted on Plate 1 are based primarily on analysis of 1937-vintage photography, and thus the map essentially is a "snapshot" of geologic conditions at this time.

The oldest unit exposed along the Feather River is the lower member of the Riverbank Formation (Qrl) of Helley and Harwood (1985). This unit is a highly dissected alluvial surface with textures of weathered gravel, sand and silt with strong soil-profile development. The Riverbank Formation is semi-consolidated, and is associated with the presence of a well-developed hardpan (or, duripan) layer that is a product of soil-forming processes over substantial geologic time. This hardpan layer reflects an ancient land surface that locally is buried by younger deposits. The Riverbank Formation is late to middle Pleistocene in age, and is estimated to be 130,000 to 450,000 yrs old (Helley and Harwood, 1985). The upper member is unconsolidated dark brown to red alluvium consisting of gravel, sand, silt and minor clay (Busacca et al., 1989, Helley and Harwood, 1985).

The Modesto Formation is divided into two members, a lower (older) unit that is latest Pleistocene in age (about 29,000 to 49,000 years old), and consists of unconsolidated slightly weathered gravel, sand, silt and clay. The upper member, a younger unit, is latest Pleistocene age (circa 12,000 to 26,000 years old) (Helley and Harwood, 1985). This unit (Qmu) is composed of sand, silt, and some gravel, comprising river channel and floodplain deposits, and is associated with a moderate amount of secondary (pedogenic) clay accumulation. This clay-rich horizon may form laterally continuous zones of low hydraulic conductivity, and may extend across boundaries between coarse and fine-grained strata within the latest Pleistocene alluvium. Soils on the Modesto Formation deposits include the Gridley loam of Strahorn et al. (1909) and the Conejo complex of Lytle et al. (1988).

Latest Holocene deposits overlie or are inset into the Modesto Formation, and are categorized as channel, floodplain, and basin deposits (Plate 1). Channel deposits include Holocene channels (Hch), distributary channels (Hdc), overflow channels (Hofc), sloughs (Hsl), in-stream or lateral bars (Hb), and meander scrolls (Hms). These deposits likely consist of fine to coarse sand, silty sand, and clayey sand, with trace fine gravel. Holocene channel deposits (Hch), which are present along Gilsizer Slough and the western floodplain as secondary channels, contain fining-upward sequences of sand, silt and clay. Overflow channels (Hofc) transport water across the land surface during high flow stages toward Sutter Basin. Networks of sloughs wander across the distal floodplain, and are likely filled with a fining-upward sequence of silt and clay (map unit Hsl). These deposits are associated with former channels, and generally are present landside (outboard) of the present-day human-made levees.

Holocene floodplain deposits include crevasse splays (Hcs), distributary fans (Hdf), and overbank deposits (Hob). Crevasse splays (Hcs) are sandy deposits that form from breaching of river banks or natural levees. Distributary fan deposits (Hdf) occur when water and velocity within a distributary channel decreases, can no longer transport its sediment load, and sediment is laid down on the floodplain. Overbank sediments are formed by localized overtopping of

river banks or natural levees, subsequent deposition from shallow sheet flow or standing water. Basin deposits occur on the distal floodplain and include undifferentiated basin deposits (Qn), and marsh deposits (Qs). Basin and marsh deposits are present in the topographically low areas west of the present-day natural levees along the Feather River. These deposits consist of fine sand, silt, and clay laid down in a relatively low-energy depositional environment. Soils developed on these deposits are the Sacramento series silt loam, fine sandy loam, clay, Alamo clay loam adobe and Stockton clay adobe. Marsh deposits are generally saturated and are often underwater in the present-day environment. Undifferentiated Holocene and Quaternary alluvium (Ha and Qa, respectively) usually are proximal to the river channel, and this map unit is used in areas where geomorphic features are obscured or obliterated by historical (1937-era) agriculture or cultivation. The deposits within these agriculturally modified areas are assigned a relative age (Ha or Qa) based on overlapping and cross cutting relationships with the surrounding deposits as follows: Ha if the agriculture-modified area is mapped within or shown overlying Holocene deposits; or Qa where it is difficult to evaluate the surface age based on the nearby deposits. Soils associated with these, undifferentiated units (Qa) are the Sacramento silt loam and Sacramento fine sandy loam, (Strahorn et al., 1909), and the Columbia fine sandy loam of Lyle et al. (1988), which are weakly developed soils commonly developed on relatively young deposits.

Historical deposits mapped in the area include stream channel and floodplain deposits, as well as artificial fill deposits (L and SP) (Plate 1). Historical deposits are estimated to be less than 150 years old, dating from approximately 1800 to 1937. Historical stream channels (Rch), distributary channels (Rdc), and overflow channels (Rofc) within the floodplain are recently abandoned channels or reflect active channels with low water flow. Lateral bar deposits (Rb) and meander scrolls (Rms) are located adjacent to the present-day Feather River, and are generally present inboard (waterside) of the present-day Feather River levees. When the river overtops its banks, distributary channels (Rdc) and recent overflow channels (Rofc) transport water and sediment across the floodplain. These channel deposits likely consist of silt and sand with traces of gravel. The upper few feet of these deposits probably are filled with debris from upstream hydraulic mining activities. Historical sloughs transport low velocity water flow derived from distributary channels proximal to the Feather River onto the distal floodplain and into the Sutter Basin. Slough deposits (Rsl) likely consist of fining-upward silt and clay.

Historical flood plain deposits include crevasse splay (Rcs), distributary fan (Rdf), and overbank (Rob) deposits, which generally consist of a fining upward or episodic fining upward sequence of sand, silt, and clay. Historical overbank (Rob) deposits are slightly finer grained sand, silt, and clay deposited via sheet flow when the river is at flood-stage and overtops natural and artificial levees. These historical deposits are differentiated based on cross-cutting and superposition relationships relative to existing cultural deposits visible on the 1937 photographs. Historical alluvial deposits (Ra), generally located within the Feather River channel, consist of undifferentiated sand, silt, and minor lenses of gravel. Historical artificial fills (map units L and SP) are culturally-emplaced heterogeneous deposits, with varying amounts of clay, silt, sand, and gravel from local sources. These deposits include levee structures and canal levee systems (L), and some undifferentiated soil piles (SP), and are shown on the surficial geologic map where present and identifiable on the 1937 photography.

Mapping of historical and Holocene deposits shown on Plate 1 generally is consistent with early, less-detailed soil survey mapping along the western banks of the Feather River as areas of Gridley loam, Sacramento Series fine sand, sandy loam and silt loam soils (Strahorn et al., 1909). The Gridley loam occurs along the northern Feather River from Thermalito south to the confluence with the Bear River, and closely corresponds to the Modesto Formation of Helley and Harwood (1985). The relationship between the mapped surficial geologic units and the potential for underseepage is summarized below.

4.0 Geomorphic Conceptual Model

The preliminary conceptual model described here is based on general relationships among surface and subsurface geologic deposits along the Feather River, as described above and shown on Plate 1. This conceptual model provides a consistent basis for understanding the type and stratigraphy in the area.

Published geologic maps of the project area identify a complex series of westward aggrading alluvial fans and terraces derived from the Sierra Nevada, identified as the Riverbank and Modesto formations. The Riverbank Formation and Modesto Formation are semi-consolidated to unconsolidated deposits characterized by intraformational paleochannels and lateral and vertical stratigraphic complexity related to past fluvial processes and buried paleo-topography. The Riverbank Formation unconformably overlies the Laguna Formation, which is a deeply dissected alluvial surface (Busacca et al., 1989).

Subsurface deposits about 150 feet beneath the ground surface rest on a resistant volcanic tuff capped by interbedded alluvial gravel, sand and silt, interpreted as Pliocene-Pleistocene age Laguna Formation that represents a period of relatively stable landscape conditions (Helley and Harwood, 1985). The Laguna Formation is overlain by the Pleistocene Riverbank Formation, (very dense gravel deposits) that are, in turn, overlain by a medium dense sand and gravelly sand package of the latest Pleistocene Modesto Formation (Busacca et al., 1989). The upper member of the Modesto Formation is exposed at the ground surface adjacent to the western bank of the Feather River south of Marysville and Yuba City. The Modesto Formation is mantled by unconsolidated deposits of Holocene age that comprise most of the surficial geologic deposits along the western side of the Feather River (Plate 1).

Geomorphic evidence suggests that the Feather River system south of Yuba City may have been located west of its present course (Figure 3). The present-day Gilsizer Slough diverges from the modern Feather River directly north of Yuba City and trends southwestward toward the Sacramento River. Alluvial deposits of Gilsizer Slough are inset (i.e. incised) into the Modesto Formation from Yuba City southward. The ancestral Gilsizer Slough perhaps extended to as far as the Sacramento River (Figure 3), based on surficial mapping not included in this report, and inspection of topographic maps. The ancestral Gilsizer Slough deposits are related to discharges and sediment loads that were higher than present-day conditions, and perhaps is an ancestral course of the Feather River.

Surficial geologic deposits near the Yuba City airport indicate the Feather River occupied an intermediate position between ancestral and present locations. The river occupied an abandoned channel arm north of Shanghai Bend, located between Gilsizer Slough and the modern Feather River (Figure 3). From this point the river continued southward in nearly its present location. This paleochannel had a sharp, more exaggerated bend than the present-day channel at Shanghai Bend (Figure 2). The channel subsequently moved eastward, laterally backfilling and abandoning the meander above Shanghai Bend, and moved to the rivers' present location closer to Marysville. Today, Gilsizer Slough is a natural bypass for high water flow stages on the Feather River, in the area between Marysville and Yuba City (Ellis, 1939).

Surficial geologic mapping (Plate 1) shows differences in deposit type and distribution from north to south along the Feather River, which is associated with changes in watershed production of water and sediment, related geomorphic processes, soil profile development, and the underlying subsurface hardpan layer. These differences illustrate the diversity of past geomorphic processes along the river and, as a consequence, the type of geologic deposits at and near the ground surface. The surficial geologic map allows the delineation of reaches along the river within which geomorphic processes and their associated deposits appear to be relatively consistent.

Between Yuba City on the north to the confluence with the Sutter Bypass on the south, the southern Feather River consists of four major reaches, each having characteristic deposit types and distributions. The river reaches are numbered Southern Feather one through four (SF-I through SF-IV), sequentially from north to south (Plate 1, Figure 3). This report describes the surficial geologic characteristics of Reach SF-I, SF-II, SF-III and SF-IV of the southern part of the Feather River, extending from Yuba City, south to the confluence with the Sutter Bypass.

Reach SF-I, extends from the north end of Yuba City to the Yuba City airport, and is about 1.15 miles long (Plate 1, Figure 3). The Project levee along Reach SF-I trends roughly north-south, and overlies alluvial sediments deposited by the Feather River. In Yuba City the levee rests on Holocene deposits associated with Gilsizer Slough that are inset into the upper member of the Modesto Formation. The active Feather River channel is east of, and inset to these Holocene channel deposits (Figure 4).

The second reach of south Feather River project area, SF-II, extends from the Yuba City airport south to Shanghai Bend, and is about 2.9 miles long. Near the Yuba City airport, and south of the confluence of the Feather and Yuba Rivers, young channel deposits are inset against the Gilsizer Slough channel deposits (Plate 1). From the Yuba City airport, south to Epley Drive (about 1.5 miles), the levees overlie historical alluvium of mining debris origin, map unit Ra. From Epley Drive south to Shanghai Bend Road the levees (about 1.4 miles) overlie historical meander scrolls, map unit Rms, (Figure 2, Plate 1). The levee along this reach, SF-II, primarily overlies Holocene channel fill, historical alluvium and overbank deposits. These channels are likely filled with a fining-upward sequence of gravel, sand and silt, the upper few feet of these features are probably covered by a veneer of sediment derived from upstream hydraulic mining activities (Figure 4).

River Reach SF-III extends from Shanghai Bend on the north to just south of the confluence with Bear River, and is approximately 12 miles long (Plate 1). Along Reach SF-III, the active river floodplain is inset into the upper member of the Modesto Formation. Over geologic time, flooding has lead to the vertical accretion of overbank and crevasse splay deposits onto the Modesto Formation west of the Feather River. Overflow channels and related deposits (Rofc) are common along this reach of the river. Beginning at Shanghai Bend and continuing southward are seven overflow channels that range from approximately 100 to 200 feet wide. The Project levees overlie these channels in the area around Messick Road (Plate 1). A few overflow channels conduct water flow immediately landside of the levees, across a short distance between Shanghai Bend and Oswald Avenue, then converge with the Feather River. The overflow channels are slightly inset to the Modesto Formation, and based on borehole data from locations where these channels cross the Sutter Bypass, are probably 6 to 15 feet deep. These channels are likely filled with episodic fining upward sequences of silt, sand and gravel, representing multiple flood events on the Feather River. The upper few feet of these channels are probably filled with sediment from upstream historic hydraulic mining activities. The river channel widens considerably between Country Club Road (0.5 mile width) and Obanion Road (1 mile width), (Plate 1). Feather River meanders along the eastern edge of Abbott Lake, swings sharply southward into Star Bend, where the river is deflected eastward by a resistant knob of Modesto Formation (which forms Star Bend). Historical crevasse splay and overbank deposits overlie the Modesto Formation from Abbott Road to Star Bend Road, along the western edge of Abbot Lake (Figure 5). These crevasse splay deposits are likely filled with a fining-upward sequence of fine gravel, sand and silt, The upper few feet of these features are probably covered by a veneer of hydraulic mining sediment.

The southernmost reach, Reach SF-IV, extends from the area south of the confluence with the Bear River to the confluence of the Feather River and Sutter Bypass, and is roughly 4 miles long (Plate 1). The sediments underlying the levee along this reach are geomorphically complex, resulting from depositional convergence between the Feather River and Bear River. The Bear River channel deposits large amounts of sediment across the ground surface adjacent to the confluence. The Modesto and Riverbank Formations are exposed at the ground surface adjacent to natural levees immediately north of the Bear River confluence, and north of this reach (Plate 1). These formations are covered by historical alluvium, sourced from the Feather and Bear Rivers. Much of the historical activity along this reach is located near the levee at Laurel Avenue. Here, consisting eight distributary channels (Rdc), typically 90 feet wide but ranging from 45 to 190 feet wide, cross the floodplain in southwesterly orientations, terminating in geologically young distributary-fan sediments. These sediments, primarily consisting of fine to coarse sand and silt, probably were deposited as a result of increased sediment and water input contributed to the Feather River from the Bear River. Historically, the Feather River and the Bear River have aggraded from substantial mining debris input, thus reducing channel cross sectional area (i.e., James, 1999). This reduction of cross section area, coupled with the trajectory of flood flow from the Bear River watershed, resulted in water overtopping the Feather River channel banks, and depositing sediment onto the floodplain between the confluence of the Feather River and Sutter Bypass (Plate1).

5.0 Applications to the Urban Levee Project

Based on an initial analysis of surface geologic and geomorphic data, the levees bordering the western side of the Feather River from Yuba City to the Sutter Bypass, (Reaches SF-I, SF-II, SFIII and SF-IV) probably are underlain by a veneer of near-surface sandy deposits, or by buried channels that are inset into the Modesto Formation. The preliminary conceptual surface and subsurface geologic relationships as they relate to levee structures and potential underseepage along each reach of the river are described below. This study does not account for any existing seepage mitigation structures, i.e. slurry wall or cutoff wall, which may be present.

Reach SF-I contains the Gilsizer paleochannel deposits, this channel intersects the levees roughly 660 feet south of Lynn Way to Colusa Avenue (Plate 1). Along this length the levees are underlain by coarse channel deposits. These coarse grain deposits are likely laterally continuous and poorly consolidated and relatively highly permeable, and likely are susceptible to underseepage.

Levees along the reach SF-II are underlain by a Holocene paleochannel and historical meander scroll deposits (Figure 2, Plate 1). These deposits are coarse grained, laterally continuous and poorly consolidated, and likely are susceptible to underseepage. The presence of this paleochannel deposit suggests locally permeable material (channel fill) directly underlying the levees. Historical alluvium most likely of mining debris origin, blankets the Yuba City airport paleochannel and meander scroll deposits. The levees along this reach are underlain by a thick sequence of young, permeable alluvium of meander scroll deposits that are highly susceptible to seepage (Glynn and Kuszmaul, 2004).

Reach SF-III consists of coarse-grained avulsion deposits (overbank, crevasse splay and overflow channel deposits) overlying the Modesto Formation. Overflow channels (Rofc) are common along this reach, are relatively thin, slightly inset to the Modesto Formation and are filled with poorly consolidated sediments that may provide local pathways for underseepage. Individual shallow coarse deposits may be laterally discontinuous and may be separated by clayey interbeds (i.e. thin blankets). Local coarse deposits may be associated with higher likelihoods of levee underseepage. Deeper deposits probably consist of consolidated Modesto Formation with occasional small, but unconsolidated, overflow channel deposits incised into resistant strata.

Along Reach SF-IV the levee is underlain by laterally-continuous sandy deposits formed by distributary overbank fans and by the south flowing ancestral Feather River (Gilsizer Slough). These coarse-grained deposits likely are permeable and susceptible to underseepage. Near Laurel Avenue distributary channel deposits underlie the levees and may be relatively coarser than the surrounding alluvium.

6.0 Summary

Lateral and vertical variability in the shallow subsurface deposits has resulted from past geomorphic processes. Surficial geologic mapping along the south Feather River allows reach classifications within which conditions may be relatively consistent. The conceptual subsurface stratigraphic framework suggests that stratigraphic relationships may promote localized levee underseepage, given certain hydraulic conditions, particularly along reach SF-I and II. Further spatial analyses of the surficial geologic mapping and subsurface geotechnical exploration data are needed to better constrain and characterize areas that are most susceptible to underseepage in the study area.

7.0 Limitations

This geomorphic assessment and associated data interpretation have been performed in accordance with the standard of care commonly used as the state-of-practice in the geologic engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this geographic area performing the same services under similar circumstances during the same time period.

Discussions of surface and subsurface conditions summarized in this technical memorandum are based on geologic interpretations of subsurface soil data at limited exploration locations available to this assessment through August of 2007. Variations in subsurface conditions may exist between exploration locations, and the project team may not be able to identify all adverse conditions in the levee and its foundation. This memorandum is for the use and benefit of DWR. Use by any other party is at their own discretion and risk.

WLA

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USGS, Sutter topographic quadrangle, surveyed 1909, published 1911; map scale 1:31,680, five foot contour interval.

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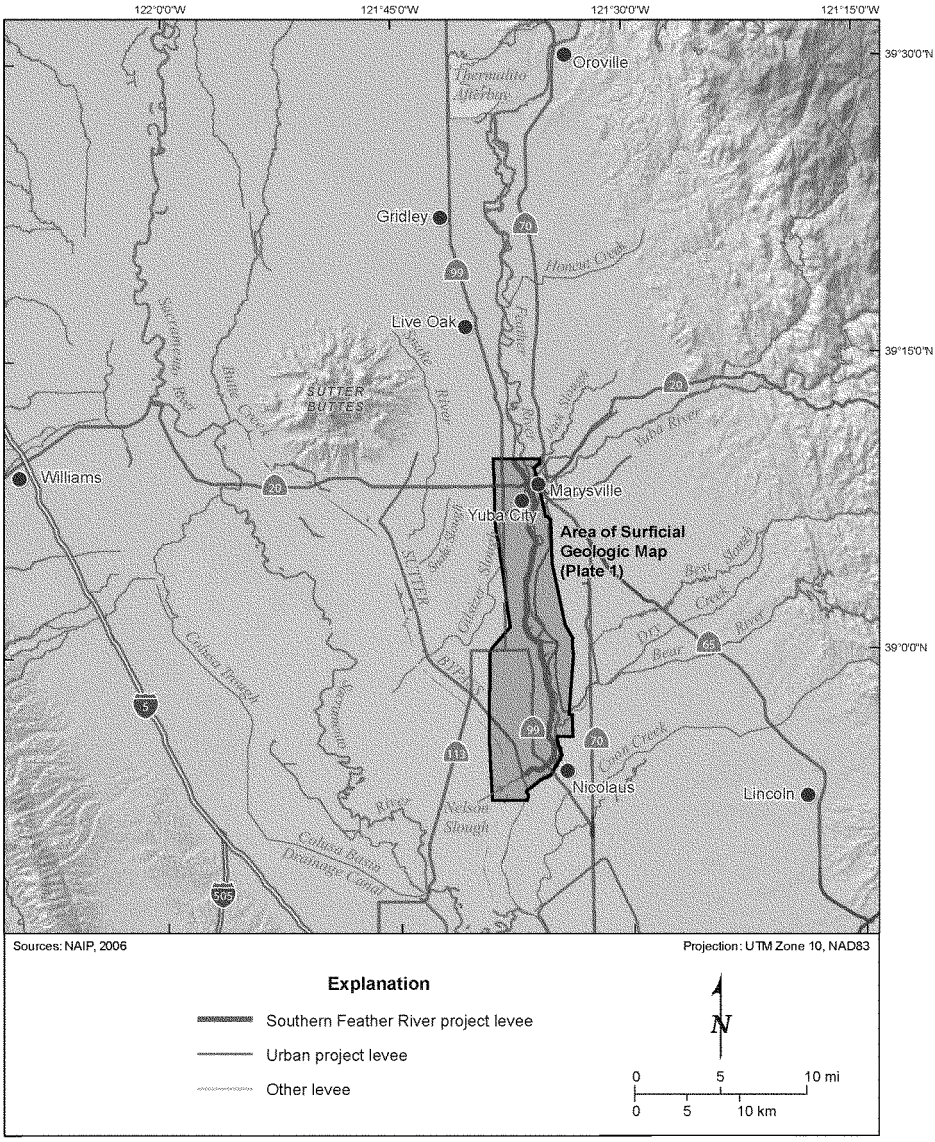
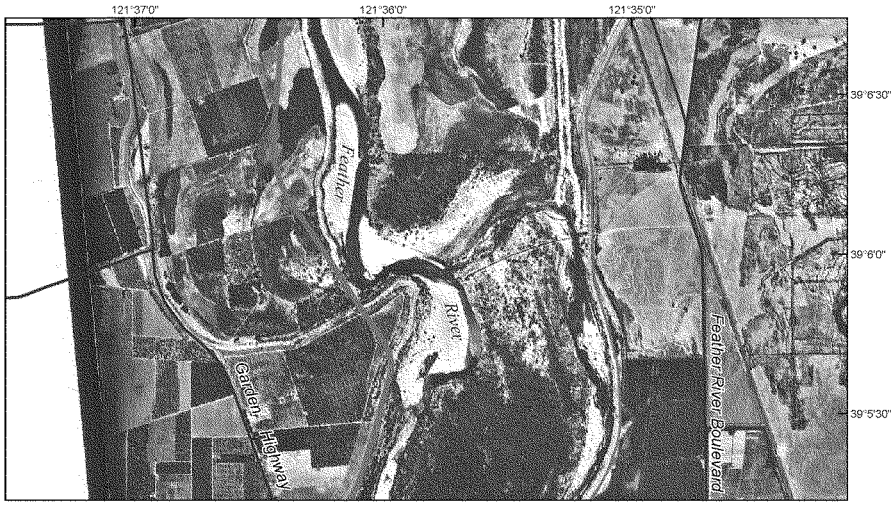
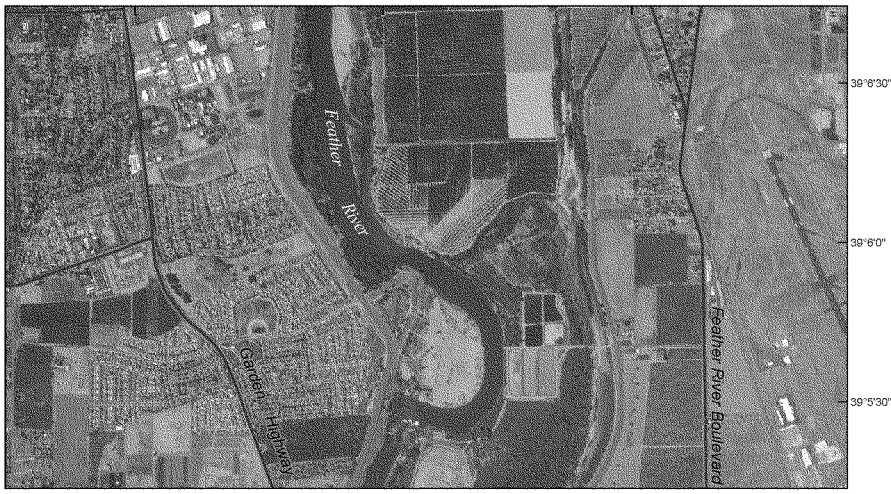


WLA **Map of Central Valley near Sutter Buttes, California** DWR URBAN LEVEE PROJECT Figure 1

1881 South Feather River Modified 09.03.09



A. 1937 USDA Air Photo



B. 2006 NAIP Ortho Imagery

Explanation

- Southern Feather River project levee
- Urban project levee
- Major road

N

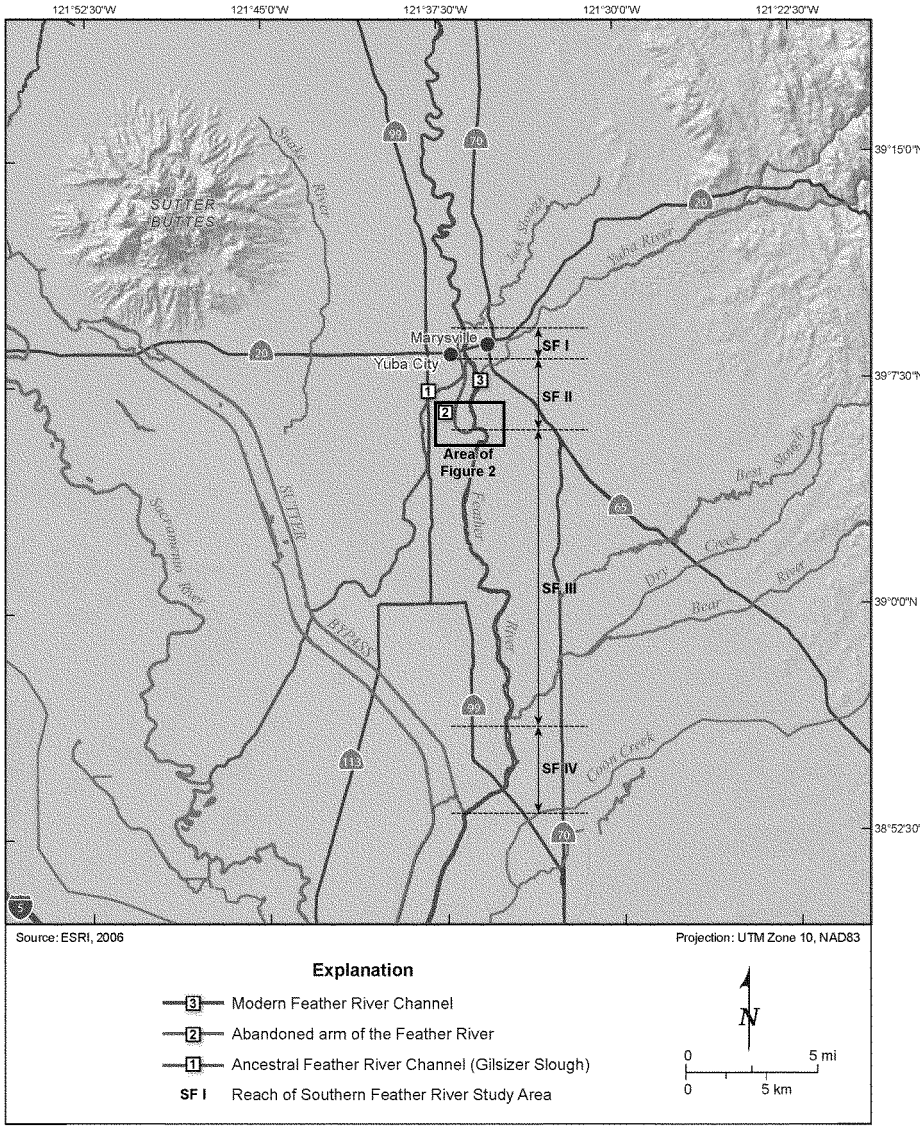
0 5 10 mi

0 5 10 km

WLA **Aerial Imagery of the Feather River at Shanghai Bend** DWR URBAN LEVEE PROJECT

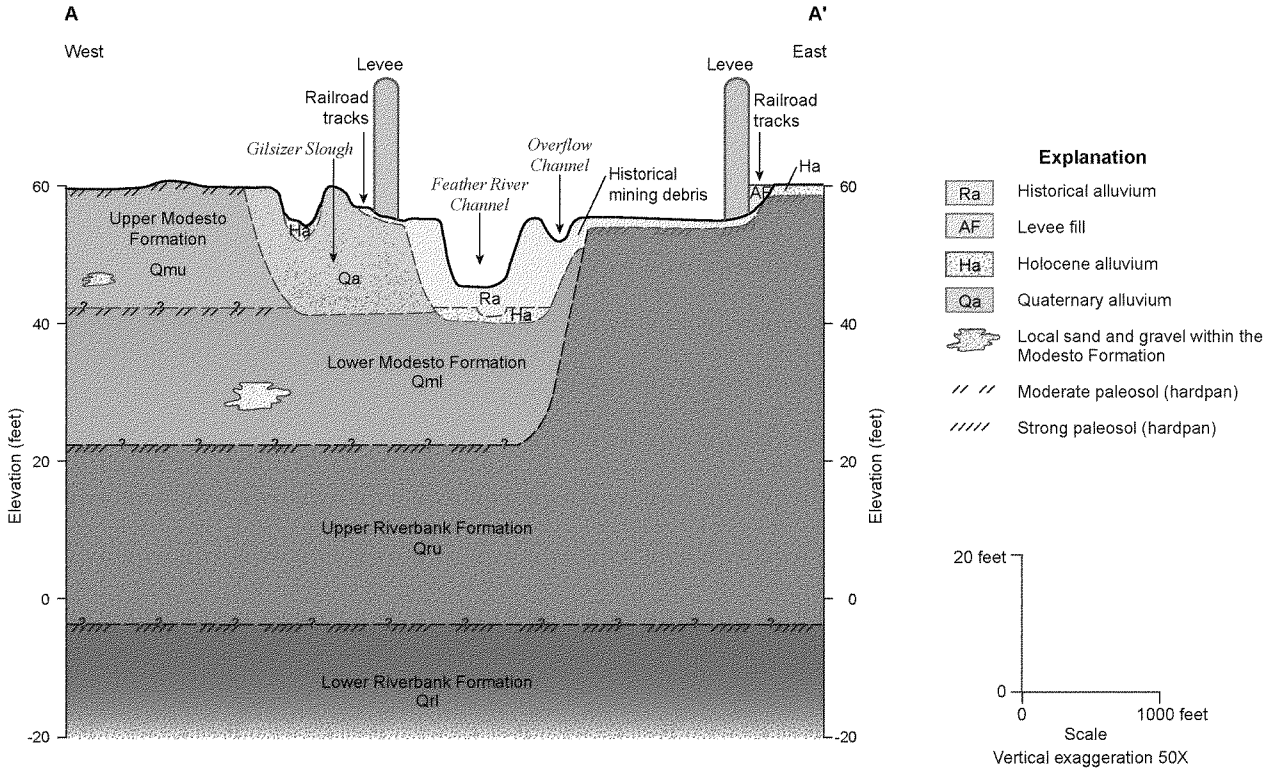
Figure 2

1881 South Feather River Modified 09.03.09



WLA **Map Showing the Eastern Migration of the Feather River** DWR URBAN LEVEE PROJECT Figure 3

1881 South Feather River Modified 09.03.09



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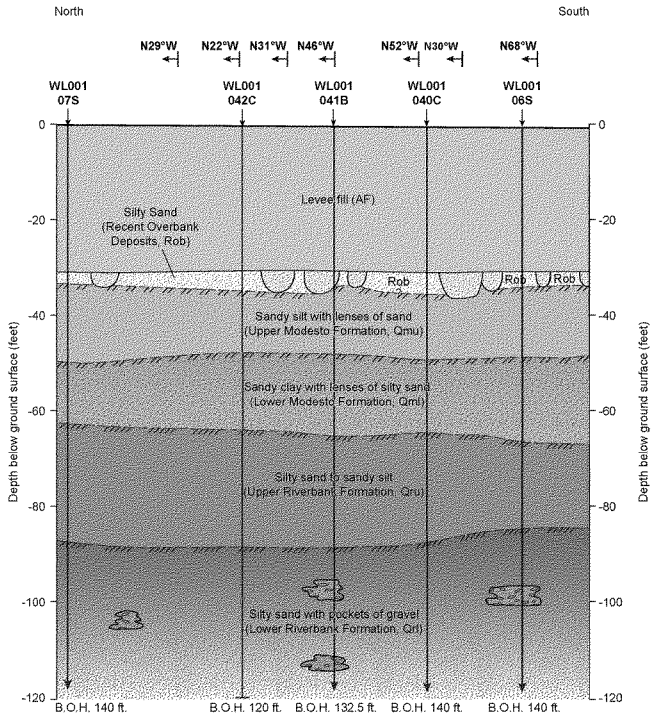
Conceptual Subsurface Diagram across the Feather River at Yuba City

DWR URBAN LEVEE PROJECT

Figure 4

1881 South Feather River

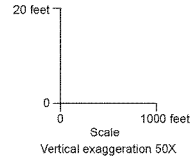
Modified 09.03.09



Explanation

- Recent crevasse splay, surficial geologic map unit Rcs
- Local sand and gravel within the Riverbank Formation
- // // Moderate paleosol (hardpan)
- ///// Strong paleosol (hardpan)
- N46°W Bend in Section

Notes:
1. See Plate 1 for location of cross section.
2. Surficial geologic units and contacts from this study and Helley and Harwood (1985).
3. Bottom of hole (BOH) values shown as total depth below ground surface.
4. Borehole names and horizontal distance shown above from draft URS logs and location maps. Geologic relations could change if borehole locations revised
5. Drilling method indicated as last letter in borehole names:
   S = Sonic Vibracore;
   C = Cone Penetrometer Test;
   B = Mud Rotary with SPT



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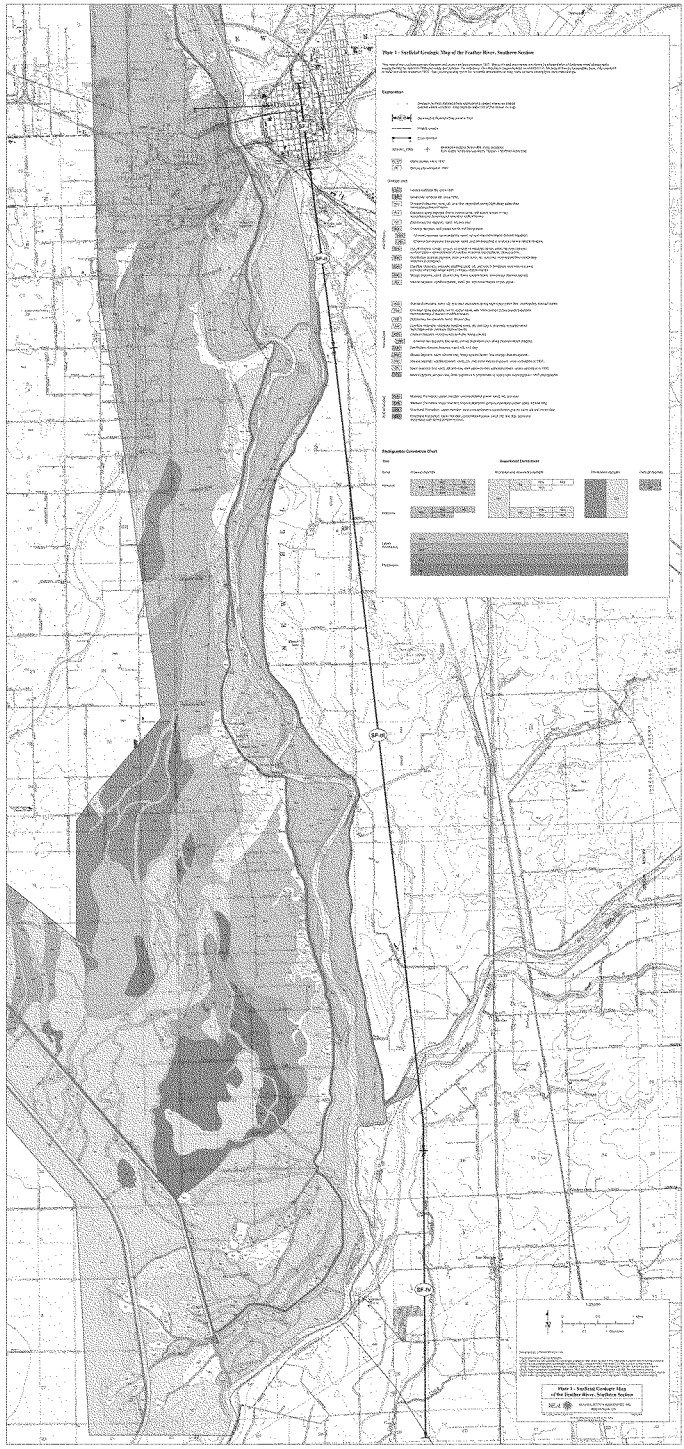
Plate 1 - Surficial Geologic Map of the Feather River, Southern Section
Explanation
Geologic Unit
Holocene
Pleistocene
Pre-Quaternary
Stratigraphic Correlation Chart
Sites
Quaternary Deposits
Pre-Quaternary Rocks
Holocene
Pleistocene
Late Pleistocene
Pre-Cenozoic
Plate 1 - Surficial Geologic Map
of the Feather River, Southern Section
SP-1A
SP-1N

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September 8, 2009

Mr. Juan Vargas
URS Corporation
2870 Gateway Oaks Drive, Suite 150
Sacramento, CA 95833

RE: Surficial geologic mapping and geomorphic assessment, California Department of Water Resources Urban Levees Project, Northern Feather River, Sutter County, California

Dear Mr. Vargas:

This letter presents the surficial geologic mapping and preliminary geomorphic assessment of the northern Feather River study area, for the California Department of Water Resources (DWR) Urban Levees Project geotechnical characterization. The goal of this mapping and geomorphic assessment is to provide information on the type and distribution of surface and shallow subsurface deposits that likely underlie the project levees along the western bank of the Feather River between Thermalito Afterbay and Yuba City. The purpose of this study is to develop spatially continuous geologic map data and a conceptual model for stratigraphic interpretations between shallow boreholes. A primary goal is to provide a geologic framework for the geotechnical assessment of potential levee underseepage. This letter presents the technical approach, surficial geologic map, conceptual geomorphic model, and initial results based on map analysis and preliminary review of available Phase 1 geotechnical data.

We appreciated the opportunity to provide these geomorphic and geologic data and preliminary interpretations of the shallow stratigraphic conditions in the northern Feather River study area. Please do not hesitate to call any of the undersigned if there are any questions or comments.

Respectfully,

WILLIAM LETTIS & ASSOCIATES, INC.

Justin Pearce, C.E.G. 2421
Senior Geologist

Ashley Streig
Senior Staff Geologist

Keith Kelson, C.E.G. 1610
Principal Geologist

1.0 Introduction

This technical memorandum presents the results of surficial geologic mapping and geomorphic assessment along the north Feather River between Thermalito Afterbay and Yuba City, for the California Department of Water Resources Urban Levee program. The purpose of this study is to provide detailed information on the type and distribution of surface and shallow subsurface deposits that likely underlie the project levees, with respect to levee underseepage. This study involved integration and analysis of aerial photography, topographic, geologic, and soil maps, other historical documents, and review of readily available geotechnical exploration data. Synthesis of these data allowed us to assess the geomorphic processes responsible for the distribution of surficial deposits within the project area, and construct a preliminary conceptual model for stratigraphic interpretations. This technical memorandum is accompanied by the "Surficial Geologic Map of the Feather River, Northern Section".

1.1 Map and Report Preparation Quality Control

The surficial geologic map data and geomorphic interpretations presented in this memorandum were subject to quality control and quality assurance procedures as required by the Levee Geotechnical Evaluation Project Management Plan (PMP). The surficial geologic map data developed by this study were reviewed for accuracy and completeness through an internal review and an independent technical review by Dr. Janet Sowers of WLA. Results of QA/QC review were documented using PMP Exhibit 2.2-3 (Independent Technical Review Report) and are kept on file according filing control plan. Subsurface data shown on diagrams were provided as draft information, and were not verified for accuracy or completeness by this study.

2.0 Approach

The approach to developing a surficial geologic map of the northern Feather River project area (Figure 1, Plate 1) consisted of analysis of the following data:

- Aerial photography (black and white stereo-pairs taken in 1937, ~1:20,000-scale);
- early USGS topographic maps (i.e., 1911);
- published surficial geologic maps (Bussaca et al., 1989; Helley and Harwood, 1985; Creely, 1965);
- early and modern soil survey maps (Strahorn et al., 1909; Lytle, et al., 1988);
- other maps and documents (Page, 1985).

Synthesis of these data allow for the development of a detailed surficial geologic map that provides an initial understanding of primary geomorphic processes that have acted in the study area during recent and historical geologic time. Through this mapping, primary geomorphic features and associated surficial geologic deposits are identified, such as abandoned paleochannels, channel deposits, splay and overbank deposits and other deposits commonly associated with large active river systems. Knowledge of fluvial processes and the ability to recognize depositional environments in the geologic record are key to identifying locations along levees where underseepage is most likely to occur (Llopis et al., 2007).

The surficial geologic map was developed at the nominal scale of the aerial photography (1:20,000). This scale establishes the resolution of the map (Plate 1), such that display or analysis of the map data at a more detailed scale than 1:20,000 may introduce uncertainties beyond the original resolution of the data. The map unit boundaries shown on the surficial geologic map should be considered approximate, and accurate within 30 feet on either side of the line shown on the map. The 1937 aerial photographs are the primary data set for interpreting the surficial geologic deposits because: (1) they are the oldest high-quality images that pre-date much of the urbanization and landscape alteration within present-day Sutter and Butte Counties and, (2) these data represent a close approximation to the surficial deposits that were likely present at the ground surface prior to the construction of the levees. The 1937 photographs generally were taken in late summer or early autumn (i.e., August). By 1937, the area had experienced moderate cultivation that locally obscures geomorphic conditions. However, integration of data from the 1937 photography, old and recent topographic maps, geologic maps, soil surveys and historical documents provides sufficient information to delineate many of the pre-historical and historical surficial deposits in detail. Taken together, these data provide key insights to the characteristics of shallow deposits beneath the levees, as well as the geomorphic processes responsible for their distribution.

Additional floodplain deposition may have occurred after 1937, due to flood overflows, levee overtopping, or localized levee failure. A time series analysis that interprets successive aerial photographs taken after major flood events (i.e., USDA, black and white stereo-pairs taken in 1958, ~1:20,000-scale) or known local levee failures (i.e., 1986) may reveal additional information on surficial deposits in the northern Feather River area. Such analyses are beyond the scope of this study. The data and interpretations presented herein address the primary goal of characterizing the type and distribution of deposits likely present directly beneath the project levees that may be conducive to underseepage.

3.0 Geologic Setting

The northern Feather River study area lies in the central Sacramento Valley, between the Coast Ranges to the west and the Sierra Nevada foothills to the east. The Feather River drains the western slope of the Sierra Nevada, and emerges from the mountains south of Thermalito Afterbay (Figure 1). The river flows southward from Thermalito Afterbay, over middle –to late Pleistocene alluvium derived from the Sierra Nevada. The regional land surface is nearly flat, with a gentle west-southwest slope that flattens south of the Sutter Butte. The Feather River is entrenched into middle-to-late Pleistocene semi-consolidated sediments (i.e. Modesto Formation). Historical alluvium deposited by the Feather River is present between the modern levees, inset to the older geologic formations, and is present on the western floodplain as subdued natural levees that mantle the older geologic formations. In this study reach, west-flowing Honcut Creek is the only drainage tributary to the northern Feather River, with a confluence east of the town of Live Oak (Figure 1).

A primary influence on the historical processes in the river system was the hydraulic mining that began in the 1850's. Mining continued through the early 1900's in the Feather, Yuba and

Bear River watersheds, and abruptly introduced large quantities of sediment and drastically changed the geomorphic characteristics of these river systems (DWR, 2004; Ellis, 1939). Aggradation within the stream channels was a primary response to the introduction of substantial mining debris (James, 1999); consequently, post-1850 alluvial deposits are common throughout the study area.

4.0 Surficial Geologic Mapping

Previous geologic mapping along the northern Feather River and surrounding areas generalize the surficial deposits as: Quaternary alluvium (Qa) and Quaternary stream channel deposits (Qsc) are mapped within and proximal to the modern Feather River channel, (Bussaca et al., 1989; Helley and Harwood, 1985; Creely, 1965). These map units are considered Holocene in age (less than 11,000 years old). Late Pleistocene Modesto Formation (Qmu, Qml) is present as an escarpment along the western margin of the floodplain. These map units were delineated by Helley and Harwood (1985) at a regional scale (i.e., 1:62,500). The current analysis of the northern Feather River uses this geologic framework as a basis for more detailed mapping of Quaternary deposits and geomorphic features (Plate 1). The surficial geologic map units within the northern Feather River study area are described below, in order from oldest to youngest. Surficial geologic mapping for this study subdivides these general map units and delineates individual deposits based on relative age and depositional process or environment. The map units depicted on Plate 1 are primarily based on analysis of 1937 aerial photography, and thus the map essentially is a "snapshot" of geologic conditions at this time.

The oldest unit exposed along the Feather River is the lower member of the Riverbank Formation (Qrl) of Helley and Harwood (1985). The Riverbank Formation is a semi-consolidated, highly-dissected alluvial surface with textures of weathered gravel, sand and silt, and is associated with the presence of a well-developed hardpan (or, duripan) layer. This hardpan layer is a product of soil-forming processes over substantial geologic time, and reflects an ancient land surface that locally is buried by younger deposits. The Riverbank Formation is late to middle Pleistocene in age, and is estimated to be 130,000 to 450,000 yrs old (Helley and Harwood, 1985). The upper member (map unit Qru; Plate 1) is poorly consolidated dark brown to red alluvium consisting of gravel, sand, silt and minor clay (Busacca et al., 1989, Helley and Harwood, 1985). West of the Feather River, the Riverbank Formation is present near the town of East Biggs (Plate 1). Soils developed on the Riverbank formation are the Gridley clay loam and the Redding gravelly sandy loam (Carpenter et al., 1926).

The latest Pleistocene Modesto Formation is informally divided into two members: a lower (older) unit that is (about 29,000 to 49,000 years old), and consists of unconsolidated slightly weathered gravel, sand, silt and clay; and an upper member, a younger unit, that is about 12,000 to 26,000 years old (Helley and Harwood, 1985). The upper Modesto (map unit Qmu) consists of sand, silt, and some gravel, and is associated with a moderate amount of secondary (pedogenic) clay accumulation. This clay-rich horizon may form laterally continuous zones of low hydraulic conductivity, and may extend across boundaries between coarse and fine-grained strata within the latest Pleistocene alluvium. Soils developed on the Modesto Formation

include the Gridley loam of Strahorn et al. (1909) and the Conejo complex of Lytle et al. (1988), both of which are associated with a shallow "siltstone" horizon, or duripan (hardpan).

Latest Holocene deposits overlie or are inset into the Modesto Formation, and are categorized as channel, floodplain, and basin deposits (stratigraphic correlation chart; Plate 1). Channel deposits include Holocene channels (Hch), sloughs (Hsl), in-stream or lateral bars (Hb), and meander scrolls (Hms). These deposits likely consist of fine to coarse sand, silty sand, and clayey sand, with trace fine gravel. Holocene channel deposits (Hch) present along the western map area as secondary channels, contain fining-upward sequences of sand, silt and clay. These sloughs (map unit Hsl) are former channels associated with Live Oak and Morrison Sloughs (Plate 1), and are likely filled with a fining upward sequence of silt and clay.

Holocene floodplain deposits include crevasse splays (Hcs), and overbank deposits (Hob) and are typically deposited by non-channelized flow. Crevasse splays (Hcs) are from breaching of river banks or natural levees and are usually sand rich. Overbank deposits form by localized overtopping of river banks or natural levees, and subsequent deposition from shallow sheet flow or standing water.

Undifferentiated Holocene and Quaternary alluvium (Ha and Qa, respectively) usually occur proximal to or within the river channel, (Plate 1). The undifferentiated map unit is used in areas where geomorphic features are obscured or obliterated by historical (1937-era) agriculture. The deposits within these agriculturally modified areas are assigned a relative age (Ha or Qa) based on overlapping and cross cutting relationships with the surrounding deposits as follows: Ha if the agriculture-modified area is mapped within or shown overlying Holocene deposits; Qa where it is difficult to evaluate the age based on the relationship with nearby deposits. Soils associated with these undifferentiated units (Qa) are the Sacramento silt loam and Sacramento fine sandy loam, (Strahorn et al., 1909), and the Columbia fine sandy loam of Lyle et al. (1988), which are poorly-developed soils commonly associated with relatively young deposits (i.e. Shlemon, 1967).

Historical deposits mapped in the Northern Feather Study area include channel and floodplain deposits, as well as artificial fill deposits (Plate 1). Historical deposits are estimated to be less than about 150 years old, dating from approximately 1800 to 1937. Historical stream channels (Rch), and overflow channels (Rofc) transport high stage water flow across the ground surface outboard of the levees. These channel deposits likely consist of silt and sand with traces of gravel. The upper few feet of these deposits probably are filled with debris derived from upstream hydraulic mining activities. Lateral bar deposits (Rb) and meander scrolls (Rms) are located adjacent to the present-day Feather River, and are generally present inboard (waterside) of the present-day Feather River levees. In the northern part of the study area, directly south of Thermalito, are multiple anastomosing chutes (map unit Rcu; Plate 1). These chutes are similar to overflow channels in that they transport water flow during high river stage across the ground surface outboard of the levees. These chutes are entrenched into fluvially deposited hydraulic mining debris, and likely have filled with re-worked mining debris. Historical sloughs transport water collected from sheet flow and overland flow west of the Feather River southerly toward the Sutter Basin (i.e., Live Oak and Morrison Slough). Slough deposits (Rsl) likely consist of fining-upward silt and clay. Historical flood plain deposits include crevasse

splay (Rcs), and overbank (Rob) deposits, which generally consist of a gradational or abrupt fining upward sequence of sand, silt, and clay. Historical overbank (Rob) deposits are slightly finer grained sand, silt, and clay deposited via sheet flow. These historical deposits are differentiated from older deposits based on cross-cutting and superposition relationships relative to cultural features visible on the 1937 photographs.

Historical alluvial deposits (Ra), generally located between the Feather River channel levees, and on the land side of the levees in the area directly south of the Thermalito Afterbay, consist of undifferentiated sand, silt, and minor lenses of gravel. Soils associated with this sandy alluvium are the Columbia very fine sandy loam and Columbia loam, as shown on the Soil Survey Map of the Oroville Area (Carpenter et al., 1926). This series of soils has been correlated with Holocene age deposits by Shlemon (1967). Historical artificial fills are culturally-emplaced heterogeneous deposits, with varying amounts of clay, silt, sand, and gravel from local sources. These deposits include levee structures and canal levee systems (map unit L; Plate 1) and dredge tailings (map unit DT).

The distribution of historical and Holocene deposits shown on Plate 1 generally is consistent with early, less-detailed soil survey mapping along the western banks of the Feather River as areas of Marcuse clay loam, Gridley loam, Sacramento Series fine sand, sandy loam and silt loam and the Columbia very fine sandy loam soils (Strahorn et al., 1909; Carpenter et al., 1926). The Gridley loam occurs along the northern Feather River from the Thermalito Afterbay south to the confluence with the Bear River, and closely corresponds to the Modesto Formation of Helley and Harwood (1985). The relationship between the mapped surficial geologic units and the potential for underseepage is summarized below.

5.0 Geomorphic Conceptual Model

This section provides a preliminary geomorphic conceptual model based on general relationships among surface and subsurface geologic deposits along the western side of the Feather River, as described above and shown on Plate 1. This conceptual model provides a consistent basis for understanding the type and distribution surficial geologic deposits, primary geomorphic processes, and shallow subsurface stratigraphy in the study reach. This conceptual model does not address planform or gradient changes of the Feather River itself, nor the susceptibility of stream banks to erosion. Future studies of these changes would be valuable in understanding process response of the Feather River, and provide key data for estimating rates of channel changes (i.e. lateral migration). However, these analyses are not directly relevant to evaluating the possibility of underseepage with respect to levee stability.

Published geologic maps of the project area show a complex series of westward aggrading alluvial fans and terraces derived from erosion of the Sierra Nevada, identified as the Riverbank and Modesto Formations (Bussaca et al., 1989; Helley and Harwood, 1985; Creely, 1965). The Riverbank Formation and Modesto Formation in general are semi-consolidated to unconsolidated deposits characterized by intraformational paleochannels and lateral and vertical stratigraphic complexity related to past fluvial processes and buried paleo-topography. The oldest map unit, the Riverbank Formation unconformably overlies the Pliocene-Pleistocene

age Laguna Formation, which consists of interbedded alluvial gravel, sand and silt (Busacca et al., 1989; Helley and Harwood, 1985). The overlying Pleistocene Riverbank Formation consists of very dense gravel deposits that are, in turn, overlain by a medium dense sand and gravelly sand package of the latest Pleistocene Modesto Formation (Busacca et al., 1989). The upper member of the Modesto Formation is exposed at the ground surface adjacent to the western bank of the Feather River. The Modesto Formation is locally mantled by unconsolidated, sand rich Holocene deposits (Plate 1). East of the Feather River the older stratigraphic units are uplifted and dissected and younger deposits are inset into them with older deposits buried beneath younger deposits. West of the Feather River, the stratigraphic units are found in typical succession. This is the result of overall westward tilting and uplift of the Sierra Nevada, incision along the tributary drainages (i.e. Honcut creek), and progradational fan deposition west of the river.

Surficial geologic mapping (Plate 1) shows differences in deposit type and distribution from north to south along the northern Feather River study area, which are primarily associated with proximity to the Sierra Nevada mountain front near Thermalito Afterbay. These differences illustrate the diversity of past geomorphic processes along the river and, as a consequence, the type of geologic deposits at and near the ground surface. The surficial geologic map allows the delineation of reaches along the river within which geomorphic processes and their associated deposits appear to be relatively consistent.

The northern Feather River project area is divided into three reaches based on characteristic deposit types and distributions. The levee reaches are numbered Northern Feather one through three (NF-I through NF-III), sequentially from north to south (Figure 2, Plate 1). This section describes the surficial geologic characteristics of Reach NF-I, NF-II, and NF-III of the Feather River between Thermalito Afterbay and Yuba City.

5.1 Reach NF-I

Reach NF-I extends from the Thermalito Afterbay to Reimer Road and is about 11.1 levee miles long (Plate 1). Widespread deposits of historical alluvium (map unit Ra) blanket the area adjacent to the Feather River along the length of this reach where the river flows in the Sacramento Valley. Much of this unconsolidated historical alluvium contains clasts from many source lithologies and is derived from hydraulic mining debris (James, 1999). A complex pattern of anastomosing chutes or cut-off channels (map unit Rcu) eroded the historical alluvium by 1937 (Ra). These chutes underlie the project levees along the length of this reach (Plate 1). Project levees were built after 1937 along NF-I, from Thermalito Afterbay south to Ord Ranch Road.

Hardpan horizons were not identified in subsurface data along this reach, suggesting a substantial thickness of unconsolidated alluvial deposits unconformably overlying the Modesto Formation. Three alluvial units were identified in subsurface data overlying a semi-consolidated alluvial unit that we identified as the lower member of the Modesto Formation. Boreholes revealed an approximately 20-foot-thick package of young, unconsolidated silty sands and sandy clays, above a 10 to 16 foot thick silty sand, and 15-to 20-foot-thick gravel bed (Figure 3).

Hydraulic mining debris was dredged for its gold content along the northern half of the river banks along this reach, from Lapkin Road at Thermalito Afterbay to the area just south of Almond Avenue (Plate 1). Some dredge tailing spoils were apparent in 1937 aerial photography, though the majority of dredge tailing spoils post-date these air photos. The full extent of dredging tailing is apparent in modern USGS topographic maps (i.e. USGS, Biggs topographic quadrangle, 1:24,000 scale, 1970) and is shown on this surficial geologic map (map unit DT). Chutes (map unit Rcu) present in 1937 aerial images, though now obliterated by dredge operations are shown as dotted contacts in the Surficial Geologic Map (Plate 1). In this area project levees either overlie or bound the western edge of the Dredge Tailings (map unit DT). South of the dredged areas, the levee along Ord Ranch Road overlies deposits that fill an abandoned channel meander, map unit Hch (Plate 1). This abandoned meander matches the present river geometry and possibly reflects a southward migration of this meander within the active channel.

5.2 Reach NF-II

The second reach of the north Feather River project area, NF-II, extends from Reimer Road to Sanders Road, and has a length of about 9.4 levee miles. In this reach the project levee is typically perched at the top of a 5- to 15-foot-high east-facing escarpment cut into the Modesto Formation. The active meander belt of the Feather River with its flood plain, meander scrolls, and channel deposits, lies to the east of the levee at the base of the escarpment. West of the escarpment, historical overbank (Rob) and crevasse splay (Rcd) deposits locally overlie the Modesto. They represent locations where flooding of the Feather River overtopped the escarpment in the past and are assumed to pre-date the construction of the levee. An extensive continuous Holocene natural levee deposit has not built up along reach II, in contrast to reach I. The river may be incised too deeply below the surface of the Modesto Formation for floods to regularly overtop the escarpment.

Most of the Reach II levee sits directly on Modesto Formation with about 3.5 of the 9.4 miles of the levee sitting on the above-mentioned Holocene overbank and crevasse splay deposits that overlie Modesto Formation. Borehole WL0009_004S (Plate 1), located in the southern portion of this reach, shows project levee fill directly above the hard, consolidated Modesto Formation.

5.3 Reach NF-III

Levee reach NF-III extends from Sanders Road at the north to Yuba City at the south, and is about 4 miles in length (Plate 1). Along this reach the project levee almost entirely overlies Historical alluvial deposits that mantle, or crosscut the Modesto Formation. Crevasse splay (Rcs), overflow channels (Rofc), historical alluvium (Ra), channel deposits (Rch), and overbank deposits (Rob) are present along this reach. Crevasse splay deposits are present at the northern end of NF-III (Sanders Road, Plate 1), directly adjacent to a westerly bend of the Feather River. Aerial photography from 1937 shows multiple generations of crevasse splay deposits at this location. The levee appears to be constructed overtop these deposits. A pump station is noted on the 1970's topographic map, suggesting this location may have had seepage problems.

Immediately south of Sanders Road, an overflow channel (map unit Rofc) diverges from the Feather River, transporting flow outboard of the levees, and flowing back into the river about 1.5 miles south at Rednall Road (Plate 1). The overflow channel likely consists of a fining upward sequence of sand, silt, clay and some gravel, and could be slightly incised into the Modesto Formation. Undifferentiated historical alluvium (map unit Ra) underlies the levees within the area directly east of these overflow channels. This alluvium was laid down over the surface of the Modesto Formation by unchannelized flow of the Feather River (Plate 1). Historical channel deposits (map unit Rch) from the Feather River underlie about 0.7 miles of the levees north of Rednall Road (Plate 1). Overbank deposits are present near Pease Road (Plate 1) and continue along the levee for about 0.5 miles. Historical crevasse splay and overbank deposits likely consist of a massive to fining upward sequence of sand and silt derived from upstream hydraulic mining activities.

6.0 Applications to the Urban Levee Project

Based on an initial analysis of surface and subsurface geologic and geomorphic data, the levee bordering the western side of the Feather River from the Thermalito Afterbay to Yuba City, overlies three different types of deposits, Reach NF-I overlies a thick package of historical alluvium, NF-II directly overlies the Modesto Formation with local areas of historical alluvium, and Reach NF-III directly overlies a continuous blanket of sediment derived from historical crevasse splay (Rcs), overflow channel (Rofc), alluvium (Ra), channel (Rch) and overbank (Rob) deposits, above the Modesto Formation. The preliminary conceptual surface and subsurface geologic relationships as they relate to levee structures and potential underseepage along each reach of the river are described below. This study does not account for any existing seepage mitigation structures (i.e. cutoff walls) that may be present.

Along Reach NF-I the levees are underlain by a package of young coarse-grained fluvial sediment, most likely of mining debris origin, and chutes filled with coarse grained fining upward sequences of sediment also derived from hydraulic mining debris (Figure 3). This material is laterally extensive and poorly consolidated, with localized chute deposits (map unit Rcu). The chutes extend beneath the levee with an orientation that is roughly orthogonal to the levee crest, and may provide relatively high conductivity pathways for levee underseepage within the already very permeable fluvial sediments. The sediments along the northern half of reach NF-I were dredged for gold during the first half of the 20th century, well-graded dredge tailings remain in these areas. Dredge tailings are unconsolidated and consist of silt, sand, and gravel. At the north near Vance Avenue the project levees appear to overlie these highly permeable tailings, and everywhere else bound the western edge of the tailing spoils. Levees along this entire reach are judged to be highly susceptible to underseepage.

Levee reach NF-II is likely underlain by a combination of coarse grained, semi-consolidated alluvium of the Modesto Formation and localized areas of historical, poorly consolidated coarse-grained avulsion deposits (overbank and crevasse splay deposits) overlying the Modesto Formation. These avulsion deposits likely are permeable and may provide localized areas susceptible to underseepage. Project levees underlain by the Modesto Formation likely are less

susceptible to underseepage problems, however the natural variability within the Modesto may also provide local pathways for underseepage.

Levee reach NF-III generally consists of westward aggrading avulsion deposits overlying the Modesto Formation. The levee is underlain by coarse-grained, poorly consolidated silt, sand and gravel, blanketing the consolidated Modesto Formation and in some places incised into the Modesto Formation. These deposits likely are permeable and susceptible to underseepage.

In summary, lateral and vertical variabilities in the shallow subsurface deposits have resulted from past fluvial geomorphic processes. Surficial geologic mapping along the north Feather River allows reach classifications within which conditions may be relatively similar. The conceptual geomorphic framework suggests that stratigraphic relationships may promote localized levee underseepage, given certain hydraulic conditions throughout the Northern Feather River Study area, particularly along reach NF-I. Areas where levees may overlie historical or Holocene-age coarse grained deposits are of special concern. Further spatial analyses of the surficial geologic mapping and subsurface geotechnical exploration data are needed to better constrain and characterize areas that are most susceptible to underseepage in the study area. We anticipate that this conceptual model will be revised and updated as new information becomes available.

7.0 Limitations

This geomorphic assessment and associated data interpretation have been performed in accordance with the standard of care commonly used as the state-of-practice in the geologic engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this geographic area performing the same services under similar circumstances during the same time period.

Discussions of surface and subsurface conditions summarized in this technical memorandum are based on geologic interpretations of subsurface soil data at limited exploration locations available to this assessment through September of 2007. Variations in subsurface conditions may exist between exploration locations, and the project team may not be able to identify all adverse conditions in the levee and its foundation. This memorandum is for the use and benefit of DWR. Use by any other party is at their own discretion and risk.

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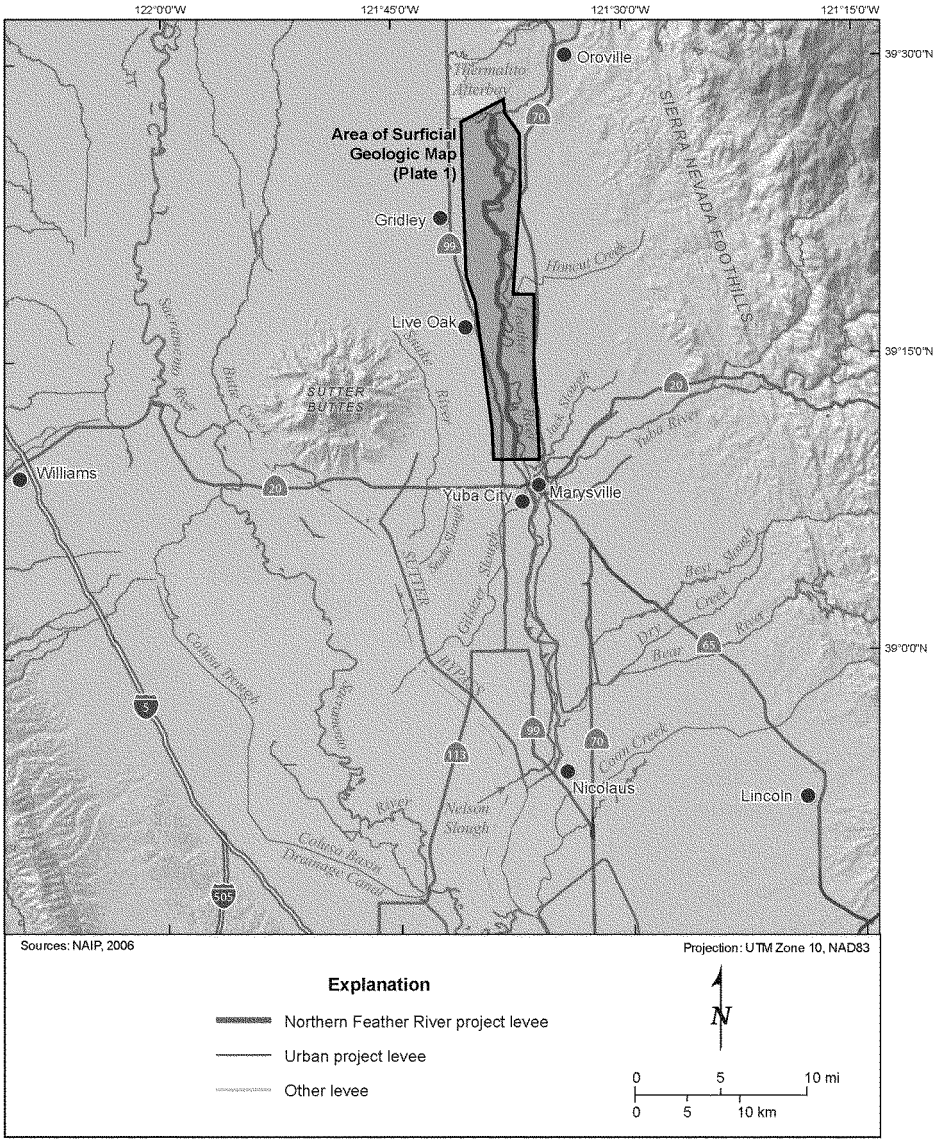
USGS, Palermo topographic quadrangle published 1952, remapped 1970; map scale 1:24,000, five foot contour interval.

USGS, Sutter topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.

USGS, Yuba City topographic quadrangle, published 1952, photo revised 1973; map scale 1:24,000, five foot contour interval.

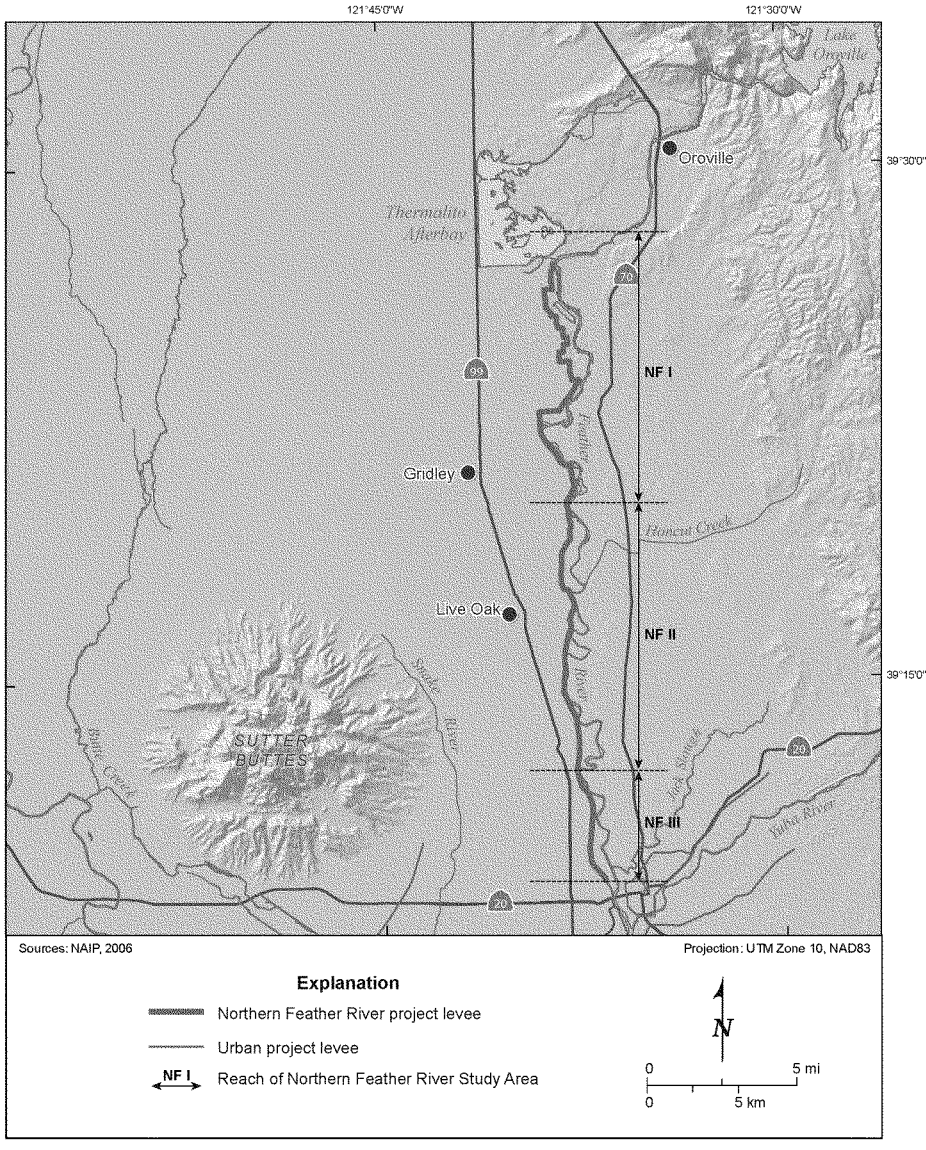


WLA **Map of Central Valley near Sutter Buttes, California**

DWR URBAN LEVEE PROJECT
Figure 1

1881 North Feather River

Modified 09.03.09



WLA

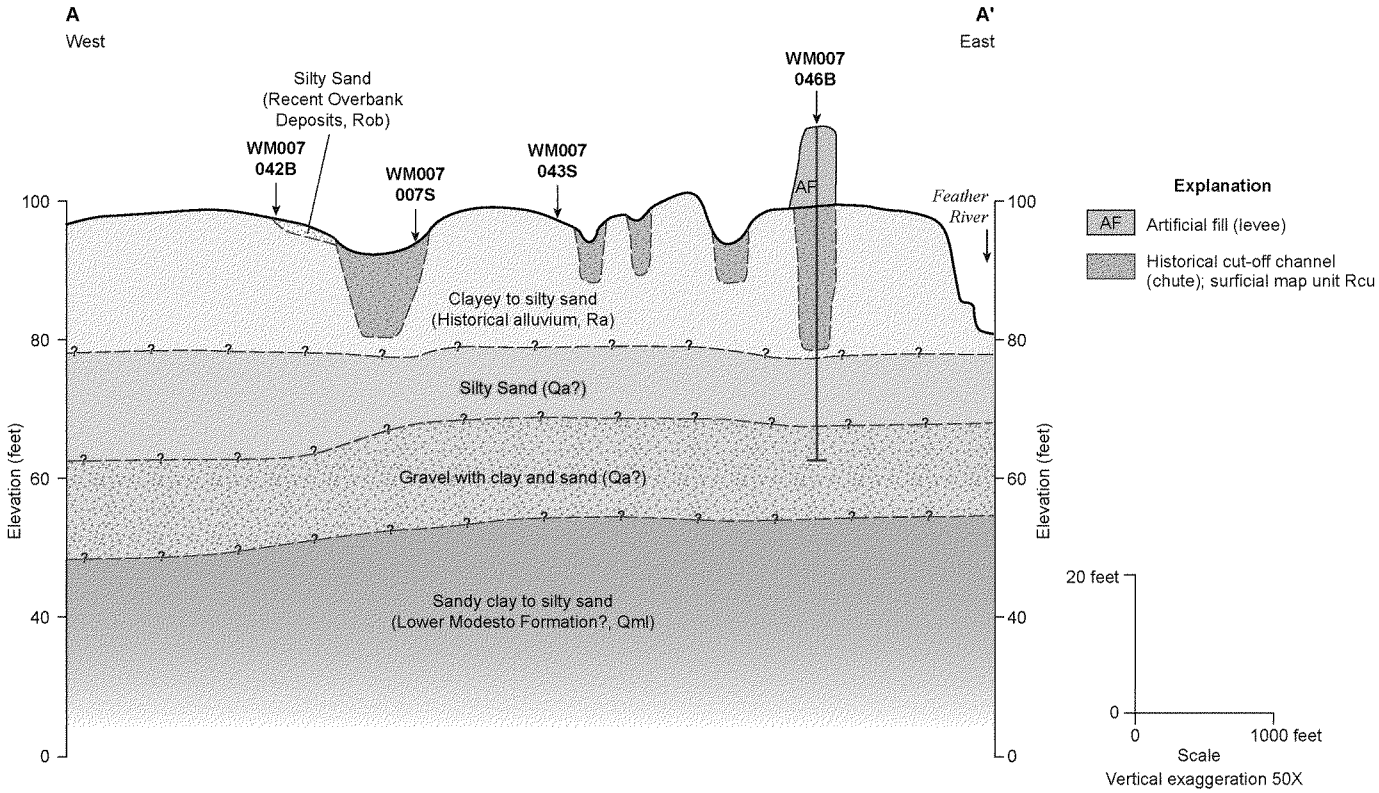
Map of the Reaches Identified along the Northern Feather River Study Area

DWR URBAN LEVEE PROJECT

Figure 2

1881 North Feather River

Modified 09.03.09



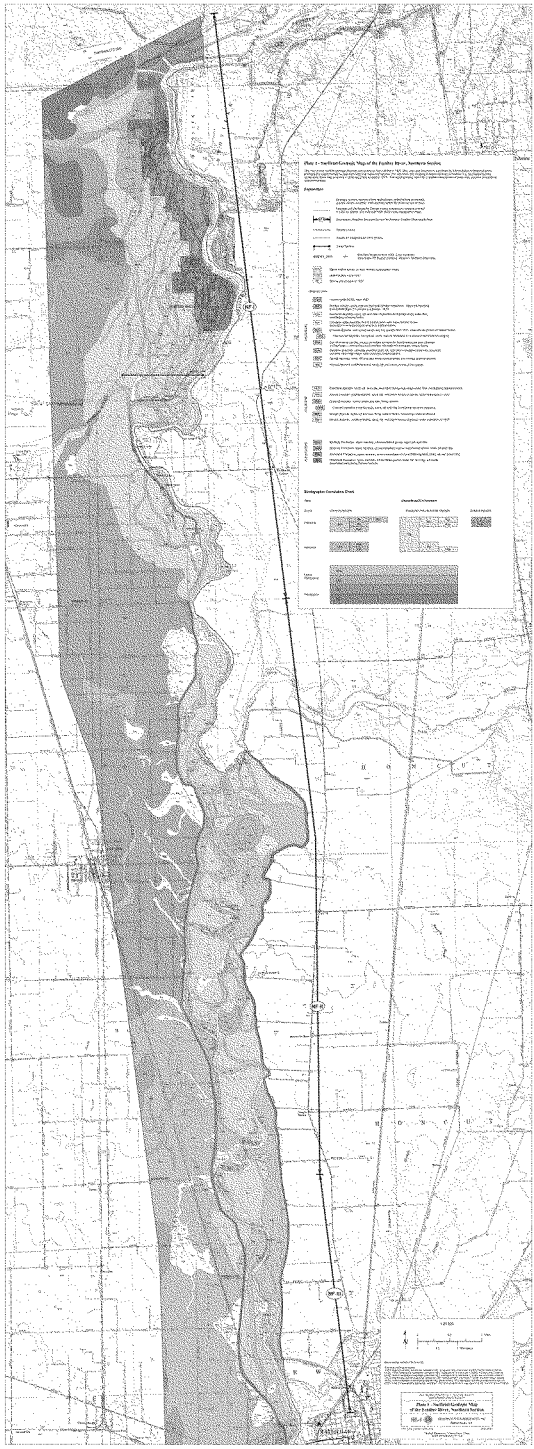
WLA

Conceptual Subsurface Diagram across the Northern Feather River, A-A'

DWR URBAN LEVEE PROJECT
Figure 3

1881 North Feather River

Modified 09.03.09



ENCLOSURE E

SEMI-PROBABALISTIC LEVEE STAGE-PERFORMANCE FUNCTIONS

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Wadsworth Canal
Basin and Reach: East Levee

Levee Mile: 0.83
Coordinates: 2170954.86 N, 6629916.3 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WSEWWC_010C	7					8					CL	0.0071	SM	2.8	394				
WSEWWC_001B	8.5					7					CL	0.0071	SM	2.8	394				
WSEWWC_009C	7					7					Cl	0.0071	SM	2.8	394				
WSEWWC_008C	6					5					CL	0.0071	SM	2.8	394				
WSEWWC_007C	3					9					CL	0.0071	SM	2.8	394				
WSEWWC_006C	8	7	2	13	29	2	7	3	14	43	CL	0.0071	SM	2.8	394	493	455	204287	92
WSEWWC_001A	10.5					11					CL, CH	0.0071	SM/SP-SM	11.14	1569				
WSEWWC_029B	4					7					CL	0.28	SP-SM	2.8	10				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WSEWWC_010C	CL	7	0.0071				7	SM	8	2.8							2.8
WSEWWC_001B	CL	8.5	0.0071				8.5	SM	7	2.8							2.8
WSEWWC_009C	Cl	7	0.0071				7	SM	7	2.8							2.8
WSEWWC_008C	CL	6	0.0071				6	SM	5	2.8							2.8
WSEWWC_007C	CL	3	0.0071				3	SM	9	2.8							2.8
WSEWWC_006C	CL	8	0.0071				8	SM	2	2.8							2.8
WSEWWC_001A	CL, CH	10.5	0.0071				10.5	SM	2.5	1.4	SP-SM	8.5	14				11.14
WSEWWC_029B	CL	4	0.28				4	SP-SM	7	2.8							2.8

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Wadsworth Canal
River Section: East Levee

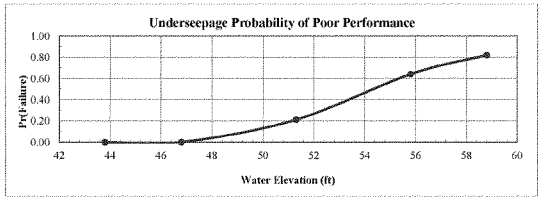
Levee Mile: 0.83
River Mile: 2170954.86 N; 6629916.3 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permeability Ratio	493	455	92
Blanket Thickness (z)	7	2	29
Aquifer Thickness (d)	7	3	43

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	10	101	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.80	0.0000
Toe+3ft	3.00	46.80	0.0011
Half Height	7.50	51.30	0.2121
Crest-3ft	12.00	55.80	0.6407
Crest	15.00	58.80	0.8199

Crest	Rh
Head = 15.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	493	7.00	7.00	9.99	155.43	0.0263	8.75	1.25		
2	948	7.00	7.00	9.99	215.53	0.0214	9.90	1.41	0.164025	60.43
3	38	7.00	7.00	9.82	43.15	0.0455	4.20	0.60		
4	493	9.00	7.00	9.99	176.24	0.0244	9.20	1.02	0.093025	34.27
5	493	5.00	7.00	9.98	131.36	0.0289	8.13	1.63		
6	493	7.00	10.00	9.99	185.77	0.0337	9.39	1.34	0.014400	5.30
7	493	7.00	4.00	9.98	117.49	0.0175	7.71	1.10		
								Total	0.271450	100.00

E[I] = 1.250000
Var[I] = 0.271450
σ[I] = 0.521009
V(I) = 0.416807

E[ln I] = 0.143051
σ [ln I] = 0.400231

Ic= 0.80
ln(I crit) = -0.223144

β = 0.357421
F(z) = 0.180107
Pr(f) % = 81.989307

Crest-3ft	Rh
Head = 12.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	493	7.00	7.00	9.99	155.43	0.0263	7.00	1.00		
2	948	7.00	7.00	9.99	215.53	0.0214	7.92	1.13	0.105625	61.32
3	38	7.00	7.00	9.82	43.15	0.0455	3.36	0.48		
4	493	9.00	7.00	9.99	176.24	0.0244	7.36	0.82	0.057600	33.44
5	493	5.00	7.00	9.98	131.36	0.0289	6.50	1.30		
6	493	7.00	10.00	9.99	185.77	0.0337	7.51	1.07	0.009025	5.24
7	493	7.00	4.00	9.98	117.49	0.0175	6.17	0.88		
								Total	0.172250	100.00

E[I] = 1.000000
Var[I] = 0.172250
σ[I] = 0.415030
V(I) = 0.415030

E[ln I] = -0.079462
σ [ln I] = 0.398654

Ic= 0.80
ln(I crit) = -0.223144

β = -0.199327
F(z) = 0.359268
Pr(f) % = 64.073178

Half Height	Rh
Head = 7.50	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	493	7.00	7.00	9.99	155.43	0.0263	4.38	0.63		
2	948	7.00	7.00	9.99	215.53	0.0214	4.95	0.71	0.042025	61.69
3	38	7.00	7.00	9.82	43.15	0.0455	2.10	0.30		
4	493	9.00	7.00	9.99	176.24	0.0244	4.60	0.51	0.022500	33.03
5	493	5.00	7.00	9.98	131.36	0.0289	4.07	0.81		
6	493	7.00	10.00	9.99	185.77	0.0337	4.69	0.67	0.003600	5.28
7	493	7.00	4.00	9.98	117.49	0.0175	3.86	0.55		
								Total	0.068125	100.00

E[I] = 0.630000
Var[I] = 0.068125
σ[I] = 0.261008
V(I) = 0.414298

E[ln I] = -0.541239
σ [ln I] = 0.398004

Ic= 0.80
ln(I crit) = -0.223144

β = -1.359885
F(z) = 0.787921
Pr(f) % = 21.207929

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	493	7.00	7.00	9.99	155.43	0.0263	1.75	0.25		
2	948	7.00	7.00	9.99	215.53	0.0214	1.98	0.28	0.006400	56.89
3	38	7.00	7.00	9.82	43.15	0.0455	0.84	0.12		
4	493	9.00	7.00	9.99	176.24	0.0244	1.84	0.20	0.004225	37.56
5	493	5.00	7.00	9.98	131.36	0.0289	1.63	0.33		
6	493	7.00	10.00	9.99	185.77	0.0337	1.88	0.27	0.000625	5.56
7	493	7.00	4.00	9.98	117.49	0.0175	1.54	0.22		
								Total	0.011250	100.00

E[I] = 0.250000
Var[I] = 0.011250
σ[I] = 0.106066
V(I) = 0.424264

E[ln I] = -1.469052
σ [ln I] = 0.406835

Ic= 0.80
ln(I crit) = -0.223144

β = -3.610930
F(z) = 0.998902
Pr(f) % = 0.109769

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Wadsworth Canal
River Section: East Levee

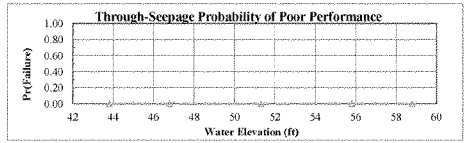
Levee Mile: 0.83
River Mile: 2170954.86 N; 6629916.3 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.80	0.0000
Toe+3ft	3.00	46.80	0.000000
Half Height	7.50	51.30	0.000000
Crest-3ft	12.00	55.80	0.000000
Crest	15.00	58.80	0.000000

Crest	Head =	15.00	Horizontal Gradient (Ix) =	

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Crest-3ft	Head =	12.00	Horizontal Gradient (Ix) =	

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	7.50	Horizontal Gradient (Ix) =	

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Horizontal Gradient (Ix) =	

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

1196

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

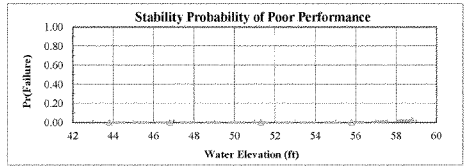
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal
River Section: East Levee

Levee Mile: 0.83
River Mile: 2170954.86 N; 6629916.3 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee φ'	31	4	12.00
Levee γ	125	6	5.00
Foundation c'	150	50	33.00
Foundation γ	115	6	5.00
Foundation φ'	28	3	12.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.80	0.0000
Toe+3ft	3.00	46.80	0.000000
Half Height	7.50	51.30	0.000000
Crest-3ft	12.00	55.80	0.000322
Crest	15.00	58.80	0.021343

Crest	Head =	15.00	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.50		
2	27	125	150	115	28	1.48	0.001225	1.44
3	35	125	150	115	28	1.55		
4	31	119	150	115	28	1.52	0.000169	0.20
5	31	131	150	115	28	1.50		
6	31	125	100	115	28	1.11	0.074529	87.51
7	31	125	200	115	28	1.66		
8	31	125	150	109	28	1.44	0.005402	6.34
9	31	125	150	121	28	1.58		
10	31	125	150	115	25	1.45	0.003844	4.51
11	31	125	150	115	31	1.57		

E[FS] =	1.504000	E[ln FS] =	0.389648	Total	0.085169 100.00
Var[FS] =	0.085169				
σ[FS] =	0.291838	σ[ln FS] =	0.192251	β =	2.026769
V(FS) =	0.194041	ln(FS req'd) =	0.000000	F(z) =	0.021343
FS req'd =	1.00			Pr(f) % =	2.134304

Crest-3ft	Head =	12.00	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.80		
2	27	125	150	115	28	1.75	0.001936	2.11
3	35	125	150	115	28	1.84		
4	31	119	150	115	28	1.83	0.000812	0.88
5	31	131	150	115	28	1.77		
6	31	125	100	115	28	1.38	0.078400	85.41
7	31	125	200	115	28	1.94		
8	31	125	150	109	28	1.73	0.004556	4.96
9	31	125	150	121	28	1.86		
10	31	125	150	115	25	1.72	0.006084	6.63
11	31	125	150	115	31	1.87		

E[FS] =	1.796000	E[ln FS] =	0.571533	Total	0.091789 100.00
Var[FS] =	0.091789				
σ[FS] =	0.302966	σ[ln FS] =	0.167507	β =	3.411982
V(FS) =	0.168689	ln(FS req'd) =	0.000000	F(z) =	0.000322
FS req'd =	1.00			Pr(f) % =	0.032246

Half Height	Head =	7.50	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

1197

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

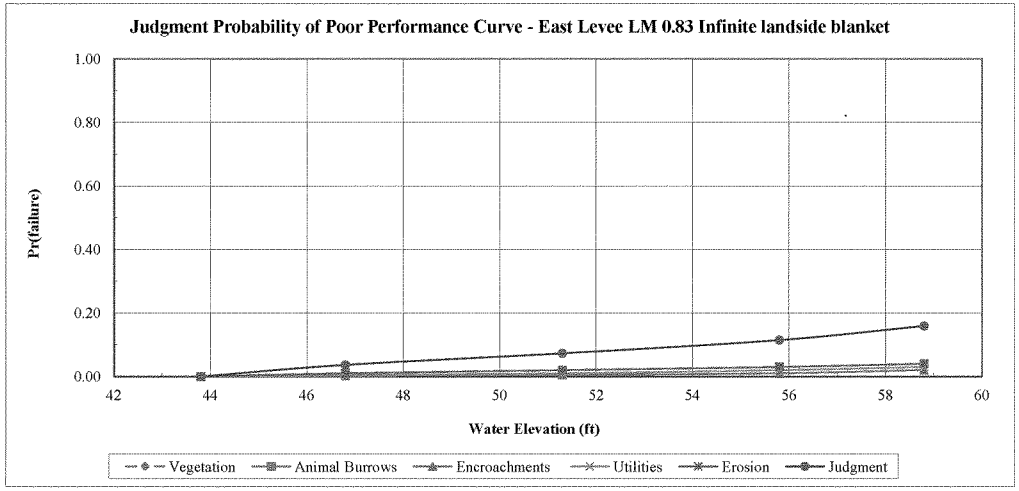
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal
River Section: East Levee

Levee Mile: 0.83
River Mile: 2170954.86 N
Analysis Case: Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 9/13/

Water Surface	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.80	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.80	0.0100	0.9900	0.0100	0.9900	0.0020	0.9980	0.0050	0.9950	0.0100	0.9900	0.0365	0.9635
51.30	0.0200	0.9800	0.0200	0.9800	0.0050	0.9950	0.0100	0.9900	0.0200	0.9800	0.0729	0.9271
55.80	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.0300	0.9700	0.1145	0.8855
58.80	0.0400	0.9600	0.0400	0.9600	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.1590	0.8410



1198

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

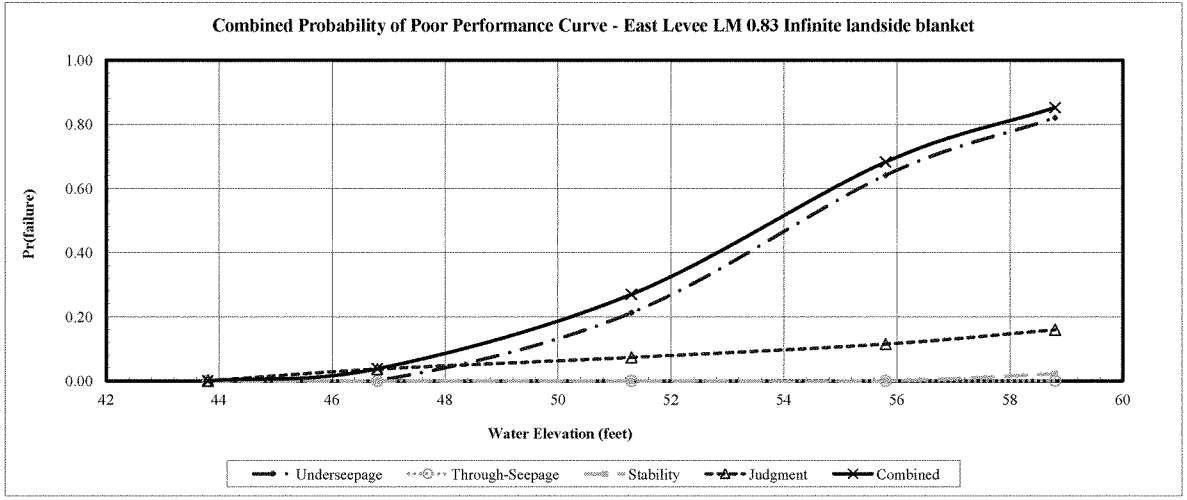
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal
River Section: East Levee

Levee Mile: 0.83
River Mile: 2170954.86 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/13/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.80	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.80	0.0011	0.9989	0.0000	1.0000	0.0000	1.0000	0.0365	0.9635	0.0375	0.9625
51.30	0.2121	0.7879	0.0000	1.0000	0.0000	1.0000	0.0729	0.9271	0.2695	0.7305
55.80	0.6407	0.3593	0.0000	1.0000	0.0003	0.9997	0.1145	0.8855	0.6820	0.3180
58.80	0.8199	0.1801	0.0000	1.0000	0.0213	0.9787	0.1590	0.8410	0.8518	0.1482



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Sutter Bypass
Basin and Reach: East Levee

Levee Mile: 6.20
Coordinates: 2158855 N, 6631970 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: 9/13/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Varables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WSESBP 011B	14					9					sCL/CH	0.007	SP-SM	10	1429				
WSESBP 015B	9					16.5					CLs,CL,ML	0.1	SM	3	30				
WSESBP 016B	10.5					9					SM/CL	0.007	SP-SM	10	1429				
WSESBP 017B	8	10	4	25	40	2	10	6	43	60	CL,SM	0.3	SP-SM	10	33	725	650	427548	90
WSESBP 018B	14					8					CL,SM/CL	0.007	SP-SM,ML,sML	3	429				
WSESBP 019B	4.8					17.5					CL/ML	0.01	SP-SM	10	1000				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	(kf)
WSESBP 011B	sCL	6	0.007	CH	8	0.007	14	SP-SM	9	10							10
WSESBP 015B	CLs,CL,ML	9	0.1				9	SM	16.5	3							3
WSESBP 016B	SM	2	0.007	CL	8.5	0.007	10.5	SP-SM	9	10							10
WSESBP 017B	CL,SM	8	0.3				8	SP-SM	2	10							10
WSESBP 018B	CL,SM	2.5	0.007	CL	11.5	0.007	14	SP-SM,ML,sML	8	3							3
WSESBP 019B	CL	4.5	0.01	ML	3	0.1	4.8	SP-SM	17.5	10							10

1200

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

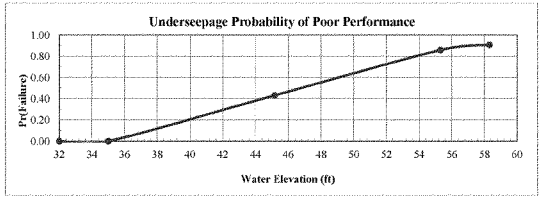
Levee Mile: 6.20
River Mile: 2158855 N; 6631970 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: 9/13/2012

Random Variables			
Parameter	Expected Value	Standard Devintion	Coefficient of Variation, %
Permeability Ratio	725	650	90
Blanket Thickness (z)	10	4	40
Aquifer Thickness (d)	10	6	60

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	15	150	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.00	0.0000
Toe+3ft	3.00	35.00	0.0004
Half Height	13.15	45.15	0.4311
Crest-3ft	23.30	55.30	0.8583
Crest	26.30	58.30	0.9076

Crest	Rh
Head = 26.30	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	16.31	1.63		
2	1375	10.00	10.00	14.99	370.81	0.0187	18.20	1.82	0.207025	33.43
3	75	10.00	10.00	14.85	86.60	0.0398	9.06	0.91		
4	725	14.00	10.00	14.99	318.59	0.0207	17.33	1.24	0.366025	59.11
5	725	6.00	10.00	14.97	208.57	0.0268	14.68	2.45		
6	725	10.00	16.00	14.99	340.59	0.0316	17.72	1.77	0.046225	7.46
7	725	10.00	4.00	14.96	170.29	0.0119	13.36	1.34		
								Total	0.619275	100.00

E[I] = 1.630000
Var[I]= 0.619275
σ[I]= 0.786940
V(I) = 0.482785

E[ln I] = 0.383822
σ [ln I] = 0.457730

Ic= 0.80
ln(I crit) = -0.223144

β = 0.838533
F(z) = 0.092414
Pr(f) % = 90.758579

Crest-3ft	Rh
Head = 23.30	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	14.45	1.45		
2	1375	10.00	10.00	14.99	370.81	0.0187	16.13	1.61	0.164025	33.59
3	75	10.00	10.00	14.85	86.60	0.0398	8.02	0.80		
4	725	14.00	10.00	14.99	318.59	0.0207	15.35	1.10	0.286225	58.62
5	725	6.00	10.00	14.97	208.57	0.0268	13.01	2.17		
6	725	10.00	16.00	14.99	340.59	0.0316	15.70	1.57	0.038025	7.79
7	725	10.00	4.00	14.96	170.29	0.0119	11.84	1.18		
								Total	0.488275	100.00

E[I] = 1.450000
Var[I]= 0.488275
σ[I]= 0.698767
V(I) = 0.481908

E[ln I] = 0.267149
σ [ln I] = 0.456979

Ic= 0.80
ln(I crit) = -0.223144

β = 0.584597
F(z) = 0.141658
Pr(f) % = 85.834162

Half Height	Rh
Head = 13.15	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	8.15	0.82		
2	1375	10.00	10.00	14.99	370.81	0.0187	9.10	0.91	0.052900	34.13
3	75	10.00	10.00	14.85	86.60	0.0398	4.53	0.45		
4	725	14.00	10.00	14.99	318.59	0.0207	8.66	0.62	0.090000	58.06
5	725	6.00	10.00	14.97	208.57	0.0268	7.34	1.22		
6	725	10.00	16.00	14.99	340.59	0.0316	8.86	0.89	0.012100	7.81
7	725	10.00	4.00	14.96	170.29	0.0119	6.68	0.67		
								Total	0.155000	100.00

E[I] = 0.820000
Var[I]= 0.155000
σ[I]= 0.393700
V(I) = 0.480122

E[ln I] = -0.302168
σ [ln I] = 0.455450

Ic= 0.80
ln(I crit) = -0.223144

β = -0.663450
F(z) = 0.568874
Pr(f) % = 43.112558

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	1.86	0.19		
2	1375	10.00	10.00	14.99	370.81	0.0187	2.08	0.21	0.003025	35.38
3	75	10.00	10.00	14.85	86.60	0.0398	1.03	0.10		
4	725	14.00	10.00	14.99	318.59	0.0207	1.98	0.14	0.004900	57.31
5	725	6.00	10.00	14.97	208.57	0.0268	1.68	0.28		
6	725	10.00	16.00	14.99	340.59	0.0316	2.02	0.20	0.000625	7.31
7	725	10.00	4.00	14.96	170.29	0.0119	1.52	0.15		
								Total	0.008550	100.00

E[I] = 0.190000
Var[I]= 0.008550
σ[I]= 0.092466
V(I) = 0.486664

E[ln I] = -1.767012
σ [ln I] = 0.461044

Ic= 0.80
ln(I crit) = -0.223144

β = -3.832633
F(z) = 0.999594
Pr(f) % = 0.040605

1201

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

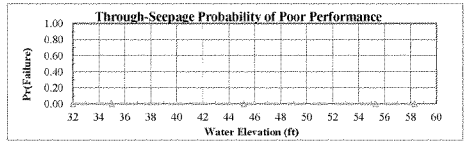
Levee Mile: 6.20
River Mile: 2158855 N; 6631970 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: 9/13/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.00	0.0000
Toe+3ft	3.00	35.00	0.000000
Half Height	13.15	45.15	0.000000
Crest-3ft	23.30	55.30	0.000000
Crest	26.30	58.30	0.000000

Crest — Head = 26.30 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft — Head = 23.30 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Half Height — Head = 13.15 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft — Head = 3.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

1202

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

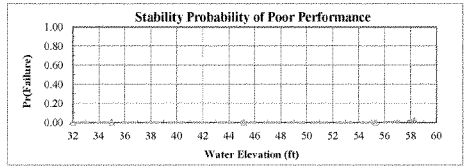
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 6.20
River Mile: 2158855 N; 6631970 E
Analysis Case Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: 9/13/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee φ'	31	4	12.00
Levee γ	125	6	5.00
Foundation c'	150	50	33.00
Foundation γ	115	6	5.00
Foundation φ'	28	3	12.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.00	0.0000
Toe+3ft	3.00	35.00	0.000000
Half Height	13.15	45.15	0.000000
Crest-3ft	23.30	55.30	0.000322
Crest	26.30	58.30	0.021343

Crest | Head = 26.30 | Pr(f)=0 | NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.50		
2	27	125	150	115	28	1.48	0.001225	1.44
3	35	125	150	115	28	1.55		
4	31	119	150	115	28	1.52	0.000169	0.20
5	31	131	150	115	28	1.50		
6	31	125	100	115	28	1.11	0.074529	87.51
7	31	125	200	115	28	1.66		
8	31	125	150	109	28	1.44	0.005402	6.34
9	31	125	150	121	28	1.58		
10	31	125	150	115	25	1.45	0.003844	4.51
11	31	125	150	115	31	1.57		

E[FS] = 1.504000 | E[ln FS] = 0.389648 | Total 0.085169 | 100.00
Var[FS] = 0.085169
σ[FS] = 0.291838 | σ[ln FS] = 0.192251 | β = 2.026769
V(FS) = 0.194041 | F(z) = 0.021343
FS req'd = 1.00 | ln(FS req'd) = 0.000000 | Pr(f) % = 2.134304

Crest-3ft | Head = 23.30 | Pr(f)=0 | NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.80		
2	27	125	150	115	28	1.75	0.001936	2.11
3	35	125	150	115	28	1.84		
4	31	119	150	115	28	1.83	0.000812	0.88
5	31	131	150	115	28	1.77		
6	31	125	100	115	28	1.38	0.078400	85.41
7	31	125	200	115	28	1.94		
8	31	125	150	109	28	1.73	0.004556	4.96
9	31	125	150	121	28	1.86		
10	31	125	150	115	25	1.72	0.006084	6.63
11	31	125	150	115	31	1.87		

E[FS] = 1.796000 | E[ln FS] = 0.571533 | Total 0.091789 | 100.00
Var[FS] = 0.091789
σ[FS] = 0.302966 | σ[ln FS] = 0.167507 | β = 3.411982
V(FS) = 0.168689 | F(z) = 0.000322
FS req'd = 1.00 | ln(FS req'd) = 0.000000 | Pr(f) % = 0.032246

Half Height | Head = 13.15 | Pr(f)=0 | YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] = | β =
V(FS) = | F(z) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000 | Pr(f) % = 0.000000

Toe+3ft | Head = 3.00 | Pr(f)=0 | YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] = | β =
V(FS) = | F(z) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000 | Pr(f) % = 0.000000

1203

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

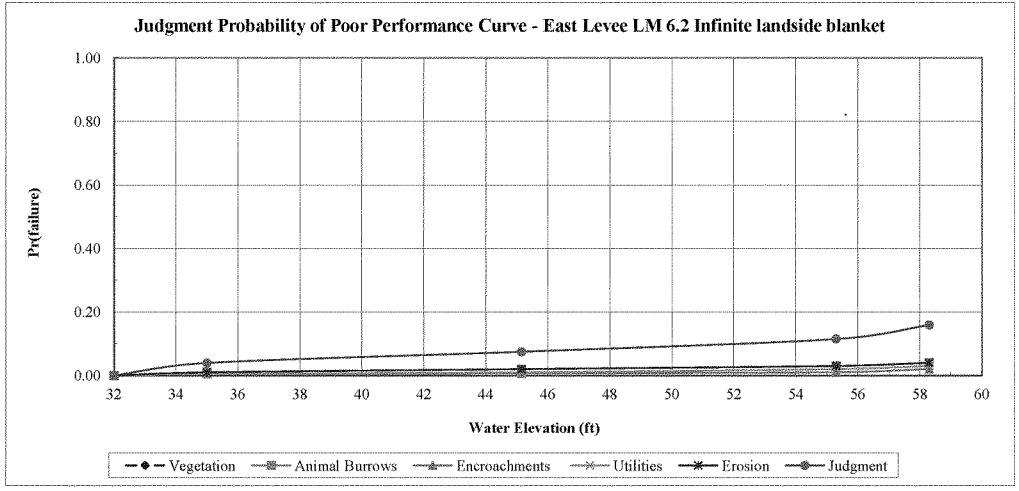
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 6.20
River Mile: 2158855 N; 6
Analysis Case: Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: 9/13/2012

Water Surface	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.00	0.0100	0.9900	0.0100	0.9900	0.0050	0.9950	0.0050	0.9950	0.0100	0.9900	0.0394	0.9606
45.15	0.0200	0.9800	0.0200	0.9800	0.0070	0.9930	0.0100	0.9900	0.0200	0.9800	0.0747	0.9253
55.30	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.0300	0.9700	0.1145	0.8855
58.30	0.0400	0.9600	0.0400	0.9600	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.1590	0.8410



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

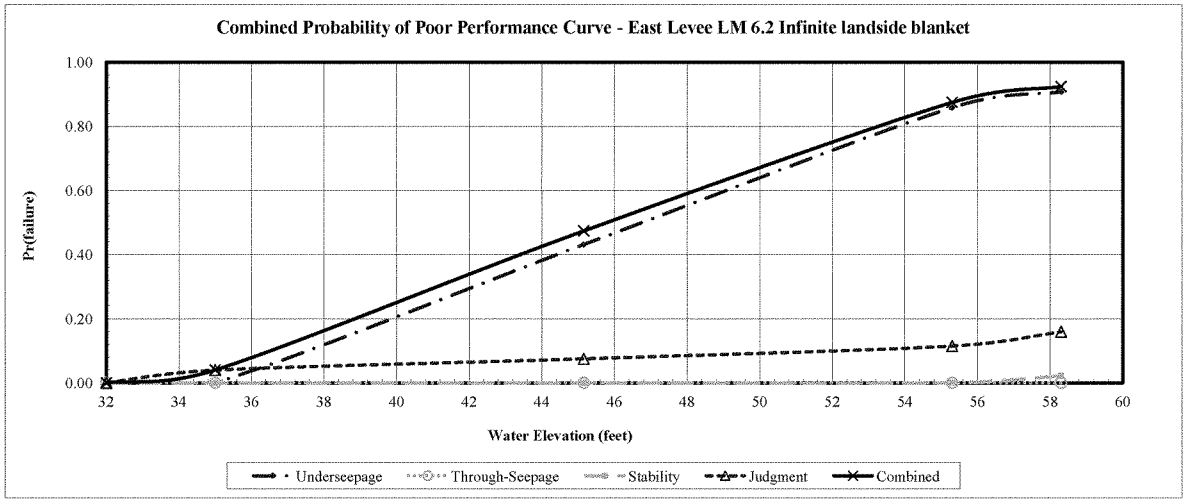
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 6.20
River Mile: 2158855 N; 663
Analysis Case: Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: 9/13/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.00	0.0004	0.9996	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0398	0.9602
45.15	0.4311	0.5689	0.0000	1.0000	0.0000	1.0000	0.0747	0.9253	0.4736	0.5264
55.30	0.8583	0.1417	0.0000	1.0000	0.0003	0.9997	0.1145	0.8855	0.8746	0.1254
58.30	0.9076	0.0924	0.0000	1.0000	0.0213	0.9787	0.1590	0.8410	0.9239	0.0761



1205

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Sutter Bypass
Basin and Reach: East Levee

Levee Mile: 17.30
Coordinates: 2113476.9763 N; 6955398.0817 E
Analysis Case Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 13 August 2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WSESBP 001B	4					4					CH,sML	0.14	SM	3	21				
WSESBP 002B	26.23					10.5					sCL,SC/ML	0.007	SM	3	429				
WSESBP 003B	11					2					sCL,CH	0.007	SM	3	429				
WSESBP 004B	27	15	10	111	67	31	13	13	164	98	sML, CL,SC	0.1	SM/SP-SM	8.4	84	1117	1398	1830429	98
WSESBP 005B	7.65					31.5					sCL/CH, sML	0.007	SP-SM/SW-SM	10	1429				
WSESBP 008B	23					7					sCL, CH	0.007	SP-SM/SW-SM	10	1429				
WSESBP 009B	8.25					3					CLs/ML	0.007	SP	28	4000				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	(Kf)
WSESBP 001B	CH,sML	4	0.14				4	SM	4	3							3
WSESBP 002B	sCL,SC	26	0.007	ML	4.5	0.14	26.23	SM	10.5	3							3
WSESBP 003B	sCL,CH	11	0.007				11	SM	2	3							3
WSESBP 004B	sML, CL,SC	27	0.1				27	SM	7.1	3	SP-SM	23.9	10				8.4
WSESBP 005B	sCL	7.25	0.007	CH, sML	5.75	0.1	7.65	SP-SM	13	10	SW-SM	18.5	10				10
WSESBP 008B	sCL, CH	23	0.007				23	SP-SM	5	10	SW-SM	2	10				10
WSESBP 009B	CLs	8	0.007	ML	5	0.14	8.25	SP	3	28							28

1206

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

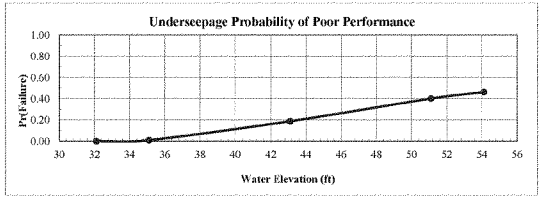
Levee Mile: 17.30
River Mile: 2113476.9763 N; 6655398.0817 E
Analysis Case Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 13 August 2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permeability Ratio	1117	1095	98
Blanket Thickness (z)	15	10	67
Aquifer Thickness (d)	13	13	98

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	15	150	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.10	0.0000
Toe+3ft	3.00	35.10	0.0094
Half Height	11.00	43.10	0.1876
Crest-3ft	19.00	51.10	0.4011
Crest	22.00	54.10	0.4623

Crest	Rh
Head = 22.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1117	15.00	13.00	14.99	466.71	0.0206	16.25	1.08		
2	2212	15.00	13.00	15.00	656.71	0.0158	17.58	1.17	0.140625	10.48
3	22	15.00	13.00	14.75	66.00	0.0563	6.29	0.42		
4	1117	25.05	13.00	15.00	603.12	0.0169	17.27	0.69	1.060900	79.04
5	1117	4.95	13.00	14.98	268.10	0.0300	13.62	2.75		
6	1117	15.00	25.74	15.00	656.71	0.0313	17.58	1.17	0.140625	10.48
7	1117	15.00	0.26	14.75	66.00	0.0011	6.29	0.42		
								Total	1.342150	100.00

E[I] = 1.080000
Var[I]= 1.342150
σ[I]= 1.158512
V(I) = 1.072696

E[ln I] = -0.305930
σ [ln I] = 0.875090

Ic= 0.80
ln(I crit) = -0.223144

β = -0.349599
F(z) = 0.537685
Pr(f) % = 46.231478

Crest-3ft	Rh
Head = 19.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1117	15.00	13.00	14.99	466.71	0.0206	14.04	0.94		
2	2212	15.00	13.00	15.00	656.71	0.0158	15.18	1.01	0.105625	10.53
3	22	15.00	13.00	14.75	66.00	0.0563	5.43	0.36		
4	1117	25.05	13.00	15.00	603.12	0.0169	14.92	0.60	0.792100	78.95
5	1117	4.95	13.00	14.98	268.10	0.0300	11.76	2.38		
6	1117	15.00	25.74	15.00	656.71	0.0313	15.18	1.01	0.105625	10.53
7	1117	15.00	0.26	14.75	66.00	0.0011	5.43	0.36		
								Total	1.003350	100.00

E[I] = 0.940000
Var[I]= 1.003350
σ[I]= 1.001674
V(I) = 1.065610

E[ln I] = -0.441232
σ [ln I] = 0.871041

Ic= 0.80
ln(I crit) = -0.223144

β = -0.506557
F(z) = 0.598852
Pr(f) % = 40.114814

Half Height	Rh
Head = 11.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1117	15.00	13.00	14.99	466.71	0.0206	8.13	0.54		
2	2212	15.00	13.00	15.00	656.71	0.0158	8.79	0.59	0.036100	10.54
3	22	15.00	13.00	14.75	66.00	0.0563	3.15	0.21		
4	1117	25.05	13.00	15.00	603.12	0.0169	8.64	0.34	0.270400	78.93
5	1117	4.95	13.00	14.98	268.10	0.0300	6.81	1.38		
6	1117	15.00	25.74	15.00	656.71	0.0313	8.79	0.59	0.036100	10.54
7	1117	15.00	0.26	14.75	66.00	0.0011	3.15	0.21		
								Total	0.342600	100.00

E[I] = 0.540000
Var[I]= 0.342600
σ[I]= 0.585320
V(I) = 1.083927

E[ln I] = -1.004677
σ [ln I] = 0.881465

Ic= 0.80
ln(I crit) = -0.223144

β = -1.139780
F(z) = 0.812361
Pr(f) % = 18.763921

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1117	15.00	13.00	14.99	466.71	0.0206	2.22	0.15		
2	2212	15.00	13.00	15.00	656.71	0.0158	2.40	0.16	0.002500	9.61
3	22	15.00	13.00	14.75	66.00	0.0563	0.86	0.06		
4	1117	25.05	13.00	15.00	603.12	0.0169	2.36	0.09	0.021025	80.79
5	1117	4.95	13.00	14.98	268.10	0.0300	1.86	0.38		
6	1117	15.00	25.74	15.00	656.71	0.0313	2.40	0.16	0.002500	9.61
7	1117	15.00	0.26	14.75	66.00	0.0011	0.86	0.06		
								Total	0.026025	100.00

E[I] = 0.150000
Var[I]= 0.026025
σ[I]= 0.161323
V(I) = 1.075484

E[ln I] = -2.281402
σ [ln I] = 0.876678

Ic= 0.80
ln(I crit) = -0.223144

β = -2.602327
F(z) = 0.990558
Pr(f) % = 0.944249

1207

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

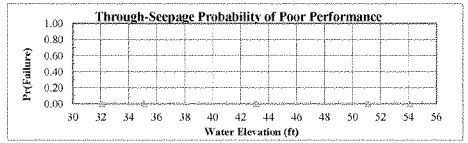
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 17.30
River Mile: 2113476.9763 N; 6655398.0817 E
Analysis Case Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 13 August 2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	15	1.5	10.00
Initial Porosity (n)	45	4.50	10.00
Initial Permeability (Ko)	1.00E-10	3.00E-11	30.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.10	0.0000
Toe+3ft	3.00	35.10	0.000000
Half Height	11.00	43.10	0.000000
Crest-3ft	19.00	51.10	0.000000
Crest	22.00	54.10	0.000000

Pr(f)=0
YES

Crest — Head = 22.00 — Horizontal Gradient (Ix) = 0.297

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] =
V(FS) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft — Head = 19.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] =
V(FS) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Half Height — Head = 11.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] =
V(FS) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft — Head = 3.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] =
V(FS) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

1208

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

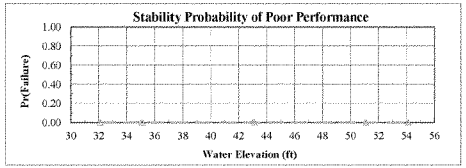
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 17.30
River Mile: 2113476.9763 N; 6655398.0817 E
Analysis Case Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 13 August 2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee φ'	31	4	12.00
Levee γ	125	6	5.00
Foundation c'	150	50	33.00
Foundation γ	115	6	5.00
Foundation φ'	28	3	12.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.10	0.0000
Toe+3ft	3.00	35.10	0.000000
Half Height	11.00	43.10	0.000000
Crest-3ft	19.00	51.10	0.000000
Crest	22.00	54.10	0.000076

Crest — Head = 22.00 — Pr(f)=0: NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.44		
2	27	125	150	115	28	1.43	0.000020	0.11
3	35	125	150	115	28	1.44		
4	31	119	150	115	28	1.45	0.000090	0.48
5	31	131	150	115	28	1.43		
6	31	125	100	115	28	1.41	0.014520	77.49
7	31	125	200	115	28	1.65		
8	31	125	150	109	28	1.50	0.000012	0.07
9	31	125	150	121	28	1.51		
10	31	125	150	115	25	1.37	0.004096	21.86
11	31	125	150	115	31	1.50		

E[FS] = 1.439000 — E[ln FS] = 0.359444 — Total 0.018739 — 100.00
Var[FS] = 0.018739
σ[FS] = 0.136890 — σ[ln FS] = 0.094915 — β = 3.787021
V(FS) = 0.095129 — F(z) = 0.000076
FS req'd = 1.00 — ln(FS req'd) = 0.000000 — Pr(f) % = 0.007623

Crest-3ft — Head = 19.00 — Pr(f)=0: YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = — E[ln FS] = — Total
Var[FS] =
σ[FS] = — σ[ln FS] = — β =
V(FS) = — F(z) =
FS req'd = 1.00 — ln(FS req'd) = 0.000000 — Pr(f) % = 0.000000

Half Height — Head = 11.00 — Pr(f)=0: YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = — E[ln FS] = — Total
Var[FS] =
σ[FS] = — σ[ln FS] = — β =
V(FS) = — F(z) =
FS req'd = 1.00 — ln(FS req'd) = 0.000000 — Pr(f) % = 0.000000

Toe+3ft — Head = 3.00 — Pr(f)=0: YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] = — E[ln FS] = — Total
Var[FS] =
σ[FS] = — σ[ln FS] = — β =
V(FS) = — F(z) =
FS req'd = 1.00 — ln(FS req'd) = 0.000000 — Pr(f) % = 0.000000

1209

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

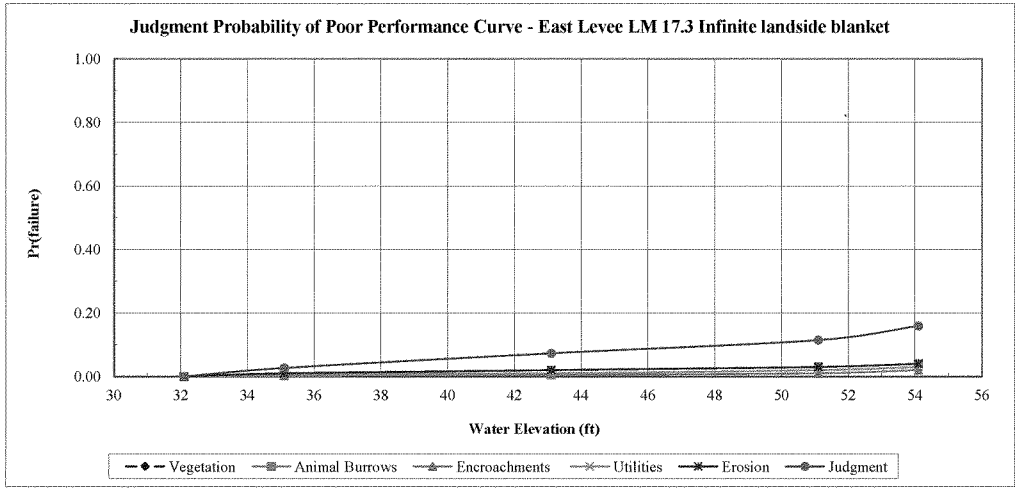
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 17.30
River Mile: 2113476.9763
Analysis Case: Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 13 A

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.10	0.0050	0.9950	0.0050	0.9950	0.0020	0.9980	0.0050	0.9950	0.0100	0.9900	0.0267	0.9733
43.10	0.0200	0.9800	0.0200	0.9800	0.0050	0.9950	0.0100	0.9900	0.0200	0.9800	0.0729	0.9271
51.10	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.0300	0.9700	0.1145	0.8855
54.10	0.0400	0.9600	0.0400	0.9600	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.1590	0.8410



1210

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

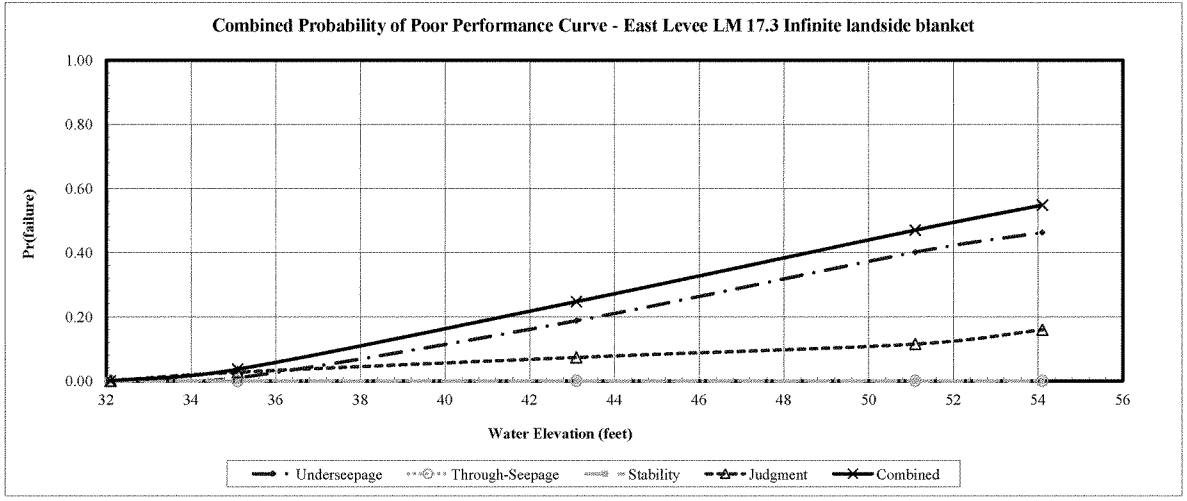
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 17.30
River Mile: 2113476.9763 N
Analysis Case: Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 13 Augu

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.10	0.0094	0.9906	0.0000	1.0000	0.0000	1.0000	0.0267	0.9733	0.0359	0.9641
43.10	0.1876	0.8124	0.0000	1.0000	0.0000	1.0000	0.0729	0.9271	0.2468	0.7532
51.10	0.4011	0.5989	0.0000	1.0000	0.0000	1.0000	0.1145	0.8855	0.4697	0.5303
54.10	0.4623	0.5377	0.0000	1.0000	0.0001	0.9999	0.1590	0.8410	0.5478	0.4522



1211

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River South
Basin and Reach: MA 3

Levee Mile: 4.92
Coordinates: 2106963.58 N; 6679261.24E
Analysis Case Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 09/12/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WM0003 012B	16					75					SC-SM/CL,CLs	0.007	SM,GP-GM,SP	10	1429				
WM0003 016B	18.5					17.5					MLS	0.14	SM-SPg	1.12	8				
WM0003 004S	25					88					MLs	0.14	M, SPg,GW-GF	3	21				
WM0003 020B	22.6					78					CLs/sML,CL	0.007	SMSW-SM,GW	30	4286				
WM0003 022B	24					89.5					CLs	0.007	M, SPM-SM,SF	30	4286				
WL0001 020B	30					89.5					CLs,CL	0.01	SMg,SP-SC,GF	30	3000				
WL0001 025B	14																		
WL0001 031B	25.75																		
		22	5	133	23		73	28	1849	38						2172	1974	3422159	91

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WM0003 012B	SC-SM	1	0.007	CL,CLs	15	0.007	16	SM,GP-GM,SP	75	10							10
WM0003 016B	MLS	18.5	0.14				18.5	SM-SPg	17.5	1.12							1.12
WM0003 004S	MLs	25	0.14				25	M, SPg,GW-GF	88	3							3
WM0003 020B	CLs	22	0.007	sML,CL	12	0.14	22.6	SMSW-SM,GW	78	30							30
WM0003 022B	CLs	24	0.007				24	M, SPM-SM,SF	89.5	30							30
WL0001 020B	CLs,CL	30	0.01				30	SMg,SP-SC,GF	89.5	30							30
WL0001 025B	sCL, SM, CL	14	0.01				14	SP-SC, SP-SM	4	3							3

1212

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

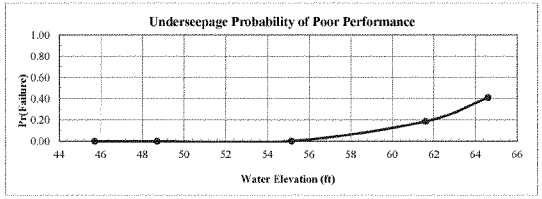
Levee Mile: 4.92
River Mile: 2106963.58 N; 6679261.24E
Analysis Case Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 09/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permeability Ratio	2172	1977	91
Blanket Thickness (z)	22	5	23
Aquifer Thickness (d)	73	28	38

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	50	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	45.70	0.0000
Toe+3ft	3.00	48.70	0.0000
Half Height	9.45	55.15	0.0011
Crest-3ft	15.89	61.59	0.1867
Crest	18.89	64.59	0.4106

Crest	Rh
Head = 18.89	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	2172	22.00	73.00	49.99	1867.68	0.0357	17.23	0.78		
2	4149	22.00	73.00	49.99	2581.19	0.0264	17.66	0.80	0.005625	14.75
3	195	22.00	73.00	49.87	560.30	0.0986	14.30	0.65		
4	2172	27.06	73.00	49.99	2071.36	0.0324	17.38	0.64	0.032400	84.98
5	2172	16.94	73.00	49.98	1638.88	0.0401	17.02	1.00		
6	2172	22.00	100.74	49.99	2194.03	0.0424	17.46	0.79	0.000100	0.26
7	2172	22.00	45.26	49.98	1470.61	0.0274	16.83	0.77		
								Total	0.038125	100.00

E[I] = 0.780000
Var[I] = 0.038125
σ[I] = 0.195256
V(I) = 0.250329

E[ln I] = -0.278851
σ [ln I] = 0.246535

Ic = 0.80
ln(I crit) = -0.223144

β = -1.131083
F(z) = 0.589385
Pr(f) % = 41.061547

Crest-3ft	Rh
Head = 15.89	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	2172	22.00	73.00	49.99	1867.68	0.0357	14.49	0.66		
2	4149	22.00	73.00	49.99	2581.19	0.0264	14.85	0.68	0.004225	14.84
3	195	22.00	73.00	49.87	560.30	0.0986	12.03	0.55		
4	2172	27.06	73.00	49.99	2071.36	0.0324	14.62	0.54	0.024025	84.37
5	2172	16.94	73.00	49.98	1638.88	0.0401	14.32	0.85		
6	2172	22.00	100.74	49.99	2194.03	0.0424	14.69	0.67	0.000225	0.79
7	2172	22.00	45.26	49.98	1470.61	0.0274	14.16	0.64		
								Total	0.028475	100.00

E[I] = 0.660000
Var[I] = 0.028475
σ[I] = 0.168745
V(I) = 0.255675

E[ln I] = -0.447176
σ [ln I] = 0.251638

Ic = 0.80
ln(I crit) = -0.223144

β = -1.777061
F(z) = 0.813347
Pr(f) % = 18.665317

Half Height	Rh
Head = 9.45	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	2172	22.00	73.00	49.99	1867.68	0.0357	8.61	0.39		
2	4149	22.00	73.00	49.99	2581.19	0.0264	8.83	0.40	0.001225	13.00
3	195	22.00	73.00	49.87	560.30	0.0986	7.15	0.33		
4	2172	27.06	73.00	49.99	2071.36	0.0324	8.69	0.32	0.008100	85.94
5	2172	16.94	73.00	49.98	1638.88	0.0401	8.51	0.50		
6	2172	22.00	100.74	49.99	2194.03	0.0424	8.73	0.40	0.000100	1.06
7	2172	22.00	45.26	49.98	1470.61	0.0274	8.42	0.38		
								Total	0.009425	100.00

E[I] = 0.390000
Var[I] = 0.009425
σ[I] = 0.097082
V(I) = 0.248929

E[ln I] = -0.971669
σ [ln I] = 0.245197

Ic = 0.80
ln(I crit) = -0.223144

β = -3.962806
F(z) = 0.998866
Pr(f) % = 0.113378

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	2172	22.00	73.00	49.99	1867.68	0.0357	2.74	0.12		
2	4149	22.00	73.00	49.99	2581.19	0.0264	2.80	0.13	0.000225	19.57
3	195	22.00	73.00	49.87	560.30	0.0986	2.27	0.10		
4	2172	27.06	73.00	49.99	2071.36	0.0324	2.76	0.10	0.000900	78.26
5	2172	16.94	73.00	49.98	1638.88	0.0401	2.70	0.16		
6	2172	22.00	100.74	49.99	2194.03	0.0424	2.77	0.13	0.000025	2.17
7	2172	22.00	45.26	49.98	1470.61	0.0274	2.67	0.12		
								Total	0.001150	100.00

E[I] = 0.120000
Var[I] = 0.001150
σ[I] = 0.033912
V(I) = 0.282597

E[ln I] = -2.158680
σ [ln I] = 0.277187

Ic = 0.80
ln(I crit) = -0.223144

β = -7.787820
F(z) = 1.000000
Pr(f) % = 0.000000

1213

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

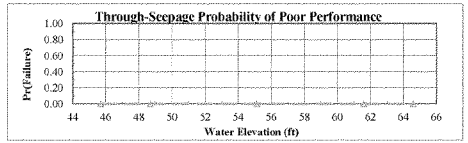
Levee Mile: 4.92
River Mile: 2106963.58 N; 6679261.24E
Analysis Case Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 09/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	45.70	0.0000
Toe+3ft	3.00	48.70	0.000000
Half Height	9.45	55.15	0.000000
Crest-3ft	15.89	61.59	0.000000
Crest	18.89	64.59	0.000000

Crest | Head = 18.89 | Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] =
V(FS) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | Head = 15.89 | Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] =
V(FS) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Half Height | Head = 9.45 | Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] =
V(FS) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | Head = 3.00 | Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] =
V(FS) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

1214

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

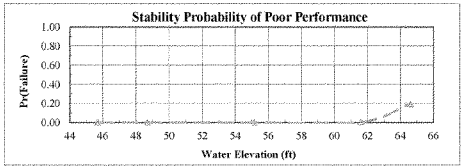
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

Levee Mile: 4.92
River Mile: 2106963.58 N; 6679261.24E
Analysis Case Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 09/12/2012

Random Variables				
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %	
Levee ϕ'	29	1	5.00	
Levee γ	120	6	5.00	
Foundation c'	150	17	11.50	
Foundation γ	120	6	5.00	
Foundation ϕ'	31	4	11.50	



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	45.70	0.0000
Toe+3ft	3.00	48.70	0.000000
Half Height	9.45	55.15	0.000000
Crest-3ft	15.89	61.59	0.003757
Crest	18.89	64.59	0.193409

Crest	Head =	18.89	Pr(f)=0	NO

Run	Levee ϕ'	Levee γ	Foundation c'	Foundation γ	Foundation ϕ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.09		
2	28	120	150	120	31	1.20	0.010816	93.19
3	30	120	150	120	31	0.99		
4	29	114	150	120	31	1.07	0.000306	2.64
5	29	126	150	120	31	1.11		
6	29	120	133	120	31	1.09	0.000484	4.17
7	29	120	167	120	31	1.05		
8	29	120	150	114	31	1.09	0.000000	0.00
9	29	120	150	126	31	1.09		
10	29	120	150	120	27	1.09	0.000000	0.00
11	29	120	150	120	35	1.09		
E[FS] =	1.094000			E[ln FS] =	0.085015	Total	0.011606	100.00
Var[FS] =	0.011606							
σ[FS] =	0.107732			σ[ln FS] =	0.098238		β =	0.865401
V(FS) =	0.098476						F(z) =	0.193409
FS req'd =	1.00			ln(FS req'd) =	0.000000		Pr(f) % =	19.340941

Crest-3ft	Head =	15.89	Pr(f)=0	NO

Run	Levee ϕ'	Levee γ	Foundation c'	Foundation γ	Foundation ϕ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.25		
2	28	120	150	120	31	1.35	0.009604	90.64
3	30	120	150	120	31	1.16		
4	29	114	150	120	31	1.24	0.000144	1.36
5	29	126	150	120	31	1.26		
6	29	120	133	120	31	1.25	0.000784	7.40
7	29	120	167	120	31	1.19		
8	29	120	150	114	31	1.25	0.000064	0.60
9	29	120	150	126	31	1.23		
10	29	120	150	120	27	1.25	0.000000	0.00
11	29	120	150	120	35	1.25		
E[FS] =	1.250000			E[ln FS] =	0.219764	Total	0.010596	100.00
Var[FS] =	0.010596							
σ[FS] =	0.102937			σ[ln FS] =	0.082210		β =	2.673193
V(FS) =	0.082349						F(z) =	0.003757
FS req'd =	1.00			ln(FS req'd) =	0.000000		Pr(f) % =	0.375665

Half Height	Head =	9.45	Pr(f)=0	YES

Run	Levee ϕ'	Levee γ	Foundation c'	Foundation γ	Foundation ϕ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			
E[FS] =				E[ln FS] =		Total		
Var[FS] =								
σ[FS] =				σ[ln FS] =			β =	
V(FS) =							F(z) =	
FS req'd =	1.00			ln(FS req'd) =	0.000000		Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee ϕ'	Levee γ	Foundation c'	Foundation γ	Foundation ϕ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			
E[FS] =				E[ln FS] =		Total		
Var[FS] =								
σ[FS] =				σ[ln FS] =			β =	
V(FS) =							F(z) =	
FS req'd =	1.00			ln(FS req'd) =	0.000000		Pr(f) % =	0.000000

1215

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

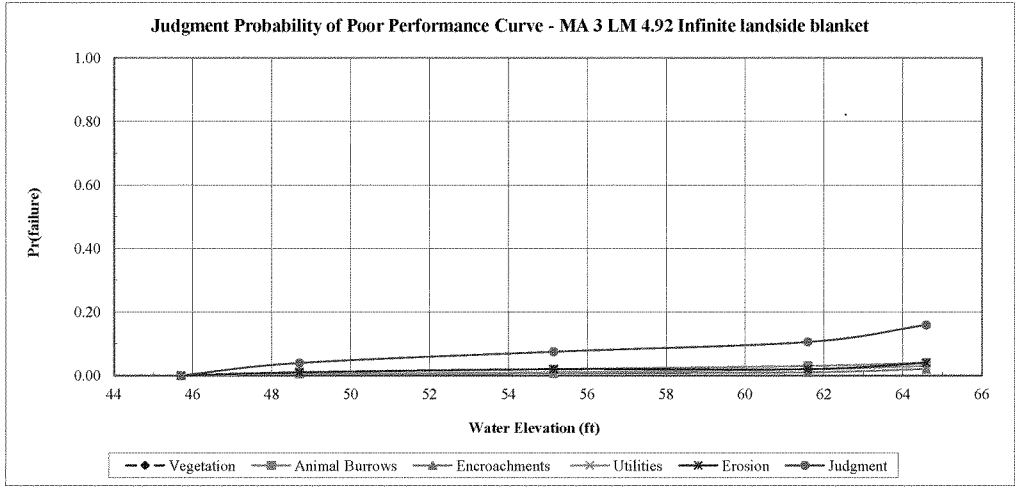
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

Levee Mile: 4.92
River Mile: 2106963.58 N
Analysis Case: Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 09/12

Water Surface	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
45.70	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
48.70	0.0100	0.9900	0.0100	0.9900	0.0050	0.9950	0.0050	0.9950	0.0100	0.9900	0.0394	0.9606
55.15	0.0200	0.9800	0.0200	0.9800	0.0070	0.9930	0.0100	0.9900	0.0200	0.9800	0.0747	0.9253
61.59	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.0200	0.9800	0.1054	0.8946
64.59	0.0400	0.9600	0.0400	0.9600	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.1590	0.8410



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

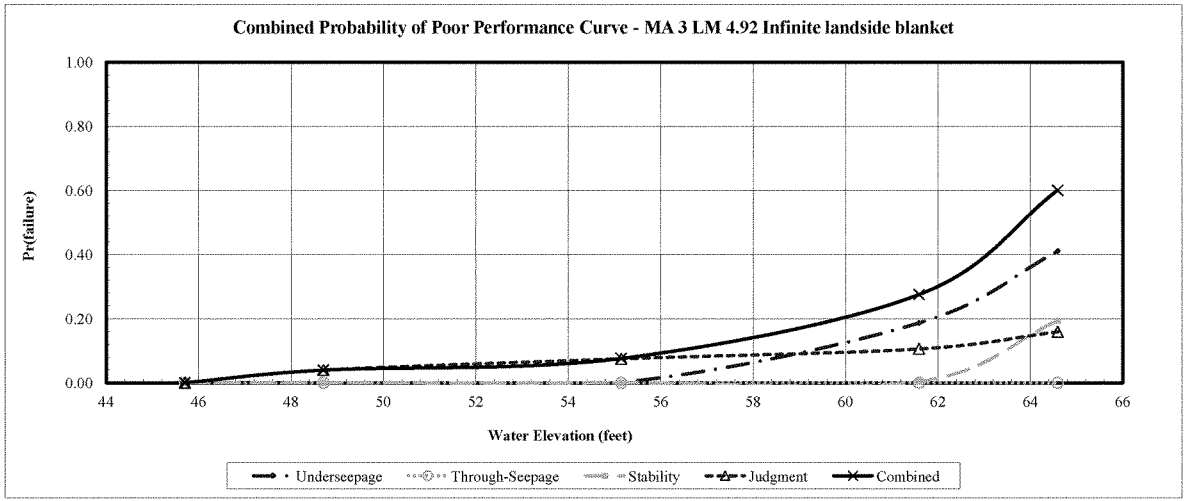
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

Levee Mile: 4.92
River Mile: 2106963.58 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 09/12/2(

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
45.70	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
48.70	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0394	0.9606
55.15	0.0011	0.9989	0.0000	1.0000	0.0000	1.0000	0.0747	0.9253	0.0758	0.9242
61.59	0.1867	0.8133	0.0000	1.0000	0.0038	0.9962	0.1054	0.8946	0.2751	0.7249
64.59	0.4106	0.5894	0.0000	1.0000	0.1934	0.8066	0.1590	0.8410	0.6002	0.3998



1217

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River South
Basin and Reach: LD 1

Levee Mile: 3.99
Coordinates: 2127081.8143 N; 6676331.1294E
Analysis Case Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 09/26/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WL0001 033B	5.29					3					CH/SM	0.01	SM	2.8	280				
WL0001 005S	10.35					97					CL,CLs/sML	0.007	M,SW,SP-SM, S	10	1429				
WL0001 039B	24.04					35.5					CL, sCL, CH/	0.001	M,SW,SW-SM	70	70000				
WL0001 006S	6.2					28					CL/SC/ML	0.007	M, SW, GW,GW	70	10000				
2F-97-1	13					11					CL, CLs	0.01	SC, SM, SP-SM	1	100				
WL0001 041B	11					5					CL,sMH	0.01	SM	1.2	120				
WL0001 007S	25.5					11					CLs,CL, CLs	0.007	SM, SP-SM	14	2000				
WL0001 046B	25.18					16					sCLs,sML,MH	0.01	SP-SM	2.8	280				
		14	9	84	66		26	31	767	98						10526	24260	244824623	98

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (Kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WL0001 033B	CH	5	0.01	SM	4	0.14	5.29	SM	3	2.8							2.8
WL0001 005S	CL,CLs	10	0.007	sML	7	0.14	10.35	M,SW,SP-SM, S	97	10							10
WL0001 039B	Ls, CL, sCL, C	24	0.001	sML	4	0.1	24.04	M,SW,SW-SM	35.5	70							70
WL0001 006S	CL	6	0.007	SC/ML	4	0.14	6.2	M, SW, GW,GW	28	70							70
2F-97-1	CL, CLs	13	0.01				13	SC, SM, SP-SM	11	1							1
WL0001 041B	CL,sMH	11	0.01				11	SM	5	1.2							1.2
WL0001 007S	CLs,CL, CLs	25.5	0.007				25.5	SM, SP-SM	11	14							14

1218

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

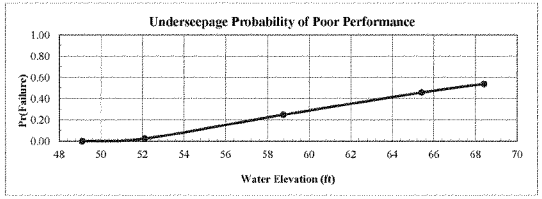
Levee Mile: 3.99
River Mile: 2127081.8143 N; 6676331.1294E
Analysis Case Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 09/26/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permeability Ratio	10526	10315	98
Blanket Thickness (z)	14	9	66
Aquifer Thickness (d)	26	25	98

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	50	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	49.10	0.0000
Toe+3ft	3.00	52.10	0.0240
Half Height	9.65	58.75	0.2485
Crest-3ft	16.30	65.40	0.4584
Crest	19.30	68.40	0.5390

Crest	Rh
Head = 19.30	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
I (Mean)	10526	13.63	26.00	49.99	1931.07	0.0123	17.65	1.30		
2	20841	13.63	26.00	49.99	2717.26	0.0090	18.10	1.33	0.055225	2.69
3	211	13.63	26.00	49.45	273.09	0.0575	11.65	0.86		
4	10526	22.62	26.00	49.99	2488.01	0.0097	18.00	0.80	1.946025	94.63
5	10526	4.63	26.00	49.97	1126.00	0.0199	16.64	3.59		
6	10526	13.63	51.48	49.99	2717.26	0.0178	18.10	1.33	0.055225	2.69
7	10526	13.63	0.52	49.45	273.09	0.0011	11.65	0.86		
								Total	2.056475	100.00

E[I] = 1.300000
Var[I]= 2.056475
σ[I]= 1.434041
V(I) = 1.103109

E[ln I] = -0.135679
σ [ln I] = 0.892237

Ic= 0.80
ln(I crit) = -0.223144

β = -0.152066
F(z) = 0.460955
Pr(f) % = 53.904505

Crest-3ft	Rh
Head = 16.30	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
I (Mean)	10526	13.63	26.00	49.99	1931.07	0.0123	14.91	1.09		
2	20841	13.63	26.00	49.99	2717.26	0.0090	15.29	1.12	0.040000	2.72
3	211	13.63	26.00	49.45	273.09	0.0575	9.84	0.72		
4	10526	22.62	26.00	49.99	2488.01	0.0097	15.20	0.67	1.392400	94.57
5	10526	4.63	26.00	49.97	1126.00	0.0199	14.05	3.03		
6	10526	13.63	51.48	49.99	2717.26	0.0178	15.29	1.12	0.040000	2.72
7	10526	13.63	0.52	49.45	273.09	0.0011	9.84	0.72		
								Total	1.472400	100.00

E[I] = 1.090000
Var[I]= 1.472400
σ[I]= 1.213425
V(I) = 1.113234

E[ln I] = -0.316902
σ [ln I] = 0.897863

Ic= 0.80
ln(I crit) = -0.223144

β = -0.352951
F(z) = 0.541583
Pr(f) % = 45.841661

Half Height	Rh
Head = 9.65	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
I (Mean)	10526	13.63	26.00	49.99	1931.07	0.0123	8.83	0.65		
2	20841	13.63	26.00	49.99	2717.26	0.0090	9.05	0.66	0.013225	2.56
3	211	13.63	26.00	49.45	273.09	0.0575	5.82	0.43		
4	10526	22.62	26.00	49.99	2488.01	0.0097	9.00	0.40	0.490000	94.88
5	10526	4.63	26.00	49.97	1126.00	0.0199	8.32	1.80		
6	10526	13.63	51.48	49.99	2717.26	0.0178	9.05	0.66	0.013225	2.56
7	10526	13.63	0.52	49.45	273.09	0.0011	5.82	0.43		
								Total	0.516450	100.00

E[I] = 0.650000
Var[I]= 0.516450
σ[I]= 0.718645
V(I) = 1.105607

E[ln I] = -0.830069
σ [ln I] = 0.893629

Ic= 0.80
ln(I crit) = -0.223144

β = -0.928875
F(z) = 0.751483
Pr(f) % = 24.851517

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
I (Mean)	10526	13.63	26.00	49.99	1931.07	0.0123	2.74	0.20		
2	20841	13.63	26.00	49.99	2717.26	0.0090	2.81	0.21	0.001600	3.10
3	211	13.63	26.00	49.45	273.09	0.0575	1.81	0.13		
4	10526	22.62	26.00	49.99	2488.01	0.0097	2.80	0.12	0.048400	93.80
5	10526	4.63	26.00	49.97	1126.00	0.0199	2.59	0.56		
6	10526	13.63	51.48	49.99	2717.26	0.0178	2.81	0.21	0.001600	3.10
7	10526	13.63	0.52	49.45	273.09	0.0011	1.81	0.13		
								Total	0.051600	100.00

E[I] = 0.200000
Var[I]= 0.051600
σ[I]= 0.227156
V(I) = 1.135782

E[ln I] = -2.023714
σ [ln I] = 0.910248

Ic= 0.80
ln(I crit) = -0.223144

β = -2.223255
F(z) = 0.976042
Pr(f) % = 2.395820

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

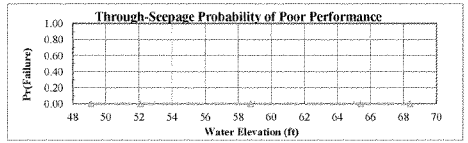
Levee Mile: 3.99
River Mile: 2127081.8143 N; 6676331.1294E
Analysis Case Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James\J.M. Bolton
Date: Updated 09/26/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	49.10	0.0000
Toe+3ft	3.00	52.10	0.000000
Half Height	9.65	58.75	0.000000
Crest-3ft	16.30	65.40	0.000000
Crest	19.30	68.40	0.000000

Crest — Head = 19.30 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
T (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(c) =
Pr(f) % = 0.000000

Crest-3ft — Head = 16.30 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
T (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(c) =
Pr(f) % = 0.000000

Half Height — Head = 9.65 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
T (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(c) =
Pr(f) % = 0.000000

Toe+3ft — Head = 3.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
T (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(c) =
Pr(f) % = 0.000000

1220

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

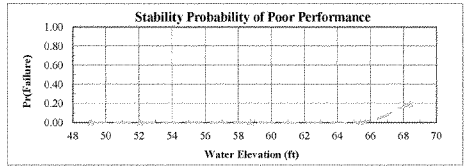
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 3.99
River Mile: 2127081.8143 N; 6676331.1294E
Analysis Case Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 09/26/2012

Random Variables				
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %	
Levee φ'	29	1	5.00	
Levee γ	120	6	5.00	
Foundation c'	150	17	11.50	
Foundation γ	120	6	5.00	
Foundation φ'	31	4	11.50	



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	49.10	0.0000
Toe+3ft	3.00	52.10	0.000000
Half Height	9.65	58.75	0.000000
Crest-3ft	16.30	65.40	0.003757
Crest	19.30	68.40	0.193409

Crest	Head =	19.30	Pr(f)=0 =	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.09		
2	28	120	150	120	31	1.20	0.010816	93.19
3	30	120	150	120	31	0.99		
4	29	114	150	120	31	1.07	0.000306	2.64
5	29	126	150	120	31	1.11		
6	29	120	133	120	31	1.09	0.000484	4.17
7	29	120	167	120	31	1.05		
8	29	120	150	114	31	1.09	0.000000	0.00
9	29	120	150	126	31	1.09		
10	29	120	150	120	27	1.09	0.000000	0.00
11	29	120	150	120	35	1.09		

E[FS] =	1.094000	E[ln FS] =	0.085015	Total	0.011606	100.00
Var[FS] =	0.011606				
σ[FS] =	0.107732	σ[ln FS] =	0.098238	β =	0.865401
V(FS) =	0.098476			F(z) =	0.193409
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	19.340941

Crest-3ft	Head =	16.30	Pr(f)=0 =	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.25		
2	28	120	150	120	31	1.35	0.009604	90.64
3	30	120	150	120	31	1.16		
4	29	114	150	120	31	1.24	0.000144	1.36
5	29	126	150	120	31	1.26		
6	29	120	133	120	31	1.25	0.000784	7.40
7	29	120	167	120	31	1.19		
8	29	120	150	114	31	1.25	0.000064	0.60
9	29	120	150	126	31	1.23		
10	29	120	150	120	27	1.25	0.000000	0.00
11	29	120	150	120	35	1.25		

E[FS] =	1.250000	E[ln FS] =	0.219764	Total	0.010596	100.00
Var[FS] =	0.010596				
σ[FS] =	0.102937	σ[ln FS] =	0.082210	β =	2.673193
V(FS) =	0.082349			F(z) =	0.003757
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.375665

Half Height	Head =	9.65	Pr(f)=0 =	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0 =	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

1221

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

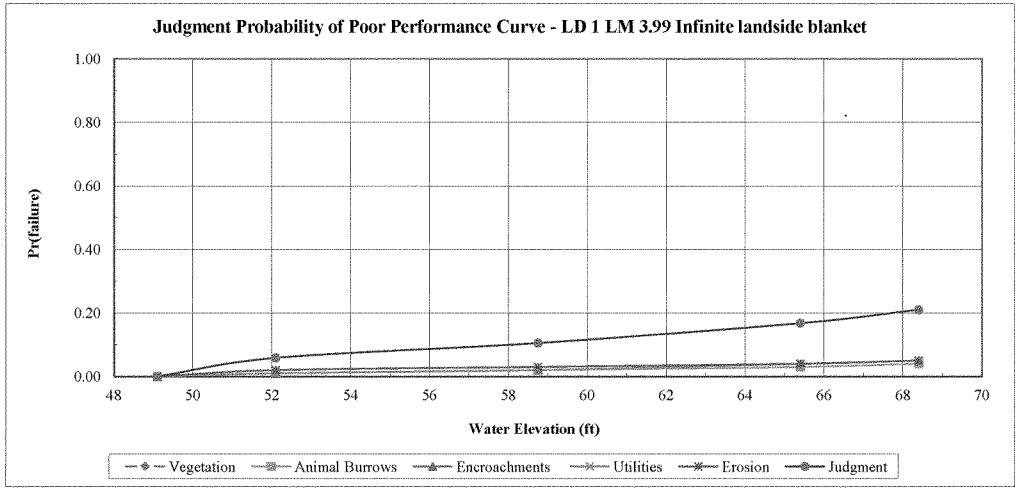
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 3.99
River Mile: 2127081.8143
Analysis Case: Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James\J.I
Date: Updated 09/26

Water Surface	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
49.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
52.10	0.0100	0.9900	0.0100	0.9900	0.0100	0.9900	0.0100	0.9900	0.0200	0.9800	0.0586	0.9414
58.75	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0300	0.9700	0.1053	0.8947
65.40	0.0300	0.9700	0.0300	0.9700	0.0400	0.9600	0.0400	0.9600	0.0400	0.9600	0.1676	0.8324
68.40	0.0400	0.9600	0.0400	0.9600	0.0500	0.9500	0.0500	0.9500	0.0500	0.9500	0.2098	0.7902



1222

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

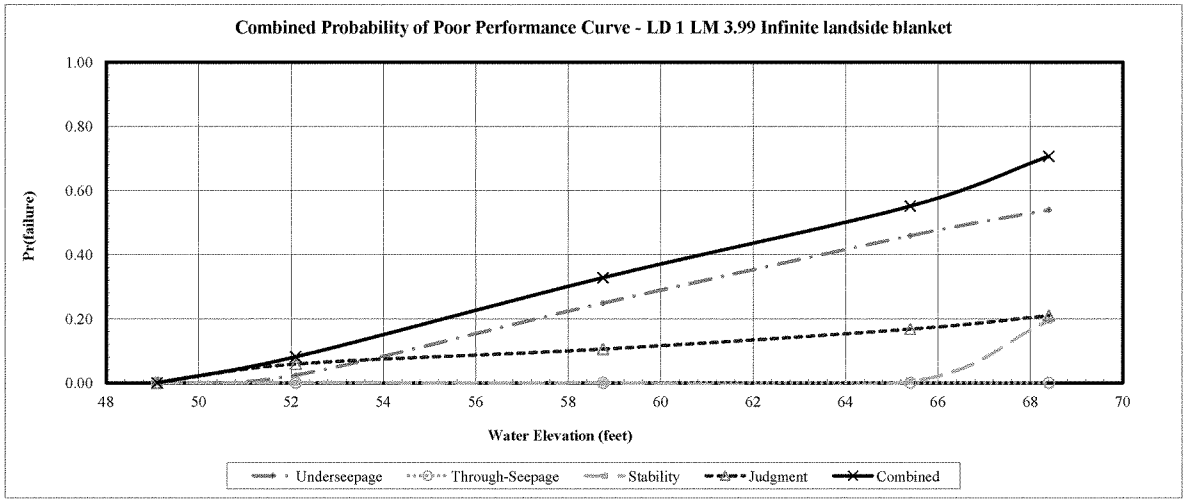
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 3.99
River Mile: 2127081.8143 N
Analysis Case: Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James\J.M.
Date: Updated 09/26/2

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
49.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
52.10	0.0240	0.9760	0.0000	1.0000	0.0000	1.0000	0.0586	0.9414	0.0812	0.9188
58.75	0.2485	0.7515	0.0000	1.0000	0.0000	1.0000	0.1053	0.8947	0.3276	0.6724
65.40	0.4584	0.5416	0.0000	1.0000	0.0038	0.9962	0.1676	0.8324	0.5509	0.4491
68.40	0.5390	0.4610	0.0000	1.0000	0.1934	0.8066	0.2098	0.7902	0.7062	0.2938



1223

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River South
Basin and Reach: LD 1

Levee Mile: 9.31
Coordinates: 2156078.18 N; 6673804.98 E
Analysis Case Infinite landside blanket

Crest Elev.: 78.50
L/S Toe Elev.: 51.40
W/S Toe Elev.: 53.70

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)							
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
SL0001 001B	20					14					CL, ML	0.007	SP-SM	14	2000				
WL0001 059B	25					14.9					CL, CH, sML	0.01	SM	1.2	120				
WL0001 012S	31					16.5					CL, sML	0.01	GW-GM, GP-(	5.73	573				
2F-07-05	8.5					2.5					sML	0.14	SM	1.2	9				
2F-07-06	12					5					sML	0.14	SM	1.2	9				
2F-07-01	10					40					CL, ML	0.01	SW-SM, GM S	13	1300				
WL0001 064B	12										ML, CL	0.01	SP-SM	14	1400				
		17	9	92	53		15	13	162	87						773	797	343652	98

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
SL0001 001B	CL, ML	20	0.007				20	SP-SM	14	14							14
WL0001 059B	CL, CH, sML	25	0.01				25	SM	14.9	1.2							1.2
WL0001 012S	CL, sML	31	0.01				31	SM	8	1.2	GW-GM, GP-G	8.5	10				5.73
2F-07-05	sML	8.5	0.14				8.5	SM	2.5	1.2							1.2
2F-07-06	sML	12	0.14				12	SM	5	1.2							1.2
2F-07-01	CL, ML	10	0.01				10	SP	30	14	SW-SM, GM SW	10	10				13
WL0001 064B	ML, CL	12	0.01				12	SP-SM	9	14							14

1224

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

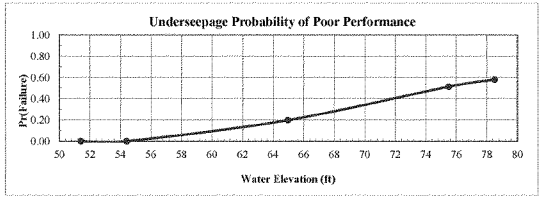
Levee Mile: 9.31
River Mile: 2156078.18 N: 6673804.98 E
Analysis Case Infinite landside blanket

Crest Elev.: 78.50
L/S Toe Elev.: 51.40
W/S Toe Elev.: 53.70

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permeability Ratio	773	758	98
Blanket Thickness (z)	17	9	53
Aquifer Thickness (d)	15	13	87

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	50	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	51.40	0.0000
Toe+3ft	3.00	54.40	0.0008
Half Height	13.55	64.95	0.1986
Crest-3ft	24.10	75.50	0.5140
Crest	27.10	78.50	0.5805

Crest	Rh
Head = 27.10	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	773	17.00	15.00	49.79	443.98	0.0240	19.29	1.13		
2	1531	17.00	15.00	49.89	624.73	0.0186	21.04	1.24	0.164025	24.22
3	15	17.00	15.00	41.56	62.79	0.0640	7.26	0.43		
4	773	26.01	15.00	49.86	549.17	0.0206	20.41	0.78	0.455625	67.28
5	773	7.99	15.00	49.56	304.37	0.0310	17.04	2.13		
6	773	17.00	28.05	49.89	607.13	0.0356	20.91	1.23	0.057600	8.50
7	773	17.00	1.95	48.44	160.08	0.0058	12.82	0.75		
								Total	0.677250	100.00

E[I] = 1.130000
Var[I]= 0.677250
σ[I]= 0.822952
V(I) = 0.728276

E[ln I] = -0.090542
σ [ln I] = 0.652319

Ic= 0.80
ln(I crit) = -0.223144

β = -0.138801
F(z) = 0.419459
Pr(f) % = 58.054056

Crest-3ft	Rh
Head = 24.10	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	773	17.00	15.00	49.79	443.98	0.0240	17.15	1.01		
2	1531	17.00	15.00	49.89	624.73	0.0186	18.71	1.10	0.129600	24.28
3	15	17.00	15.00	41.56	62.79	0.0640	6.46	0.38		
4	773	26.01	15.00	49.86	549.17	0.0206	18.15	0.70	0.360000	67.45
5	773	7.99	15.00	49.56	304.37	0.0310	15.16	1.90		
6	773	17.00	28.05	49.89	607.13	0.0356	18.59	1.09	0.044100	8.26
7	773	17.00	1.95	48.44	160.08	0.0058	11.40	0.67		
								Total	0.533700	100.00

E[I] = 1.010000
Var[I]= 0.533700
σ[I]= 0.730548
V(I) = 0.723315

E[ln I] = -0.200451
σ [ln I] = 0.648693

Ic= 0.80
ln(I crit) = -0.223144

β = -0.309008
F(z) = 0.486047
Pr(f) % = 51.395286

Half Height	Rh
Head = 13.55	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	773	17.00	15.00	49.79	443.98	0.0240	9.64	0.57		
2	1531	17.00	15.00	49.89	624.73	0.0186	10.52	0.62	0.042025	24.60
3	15	17.00	15.00	41.56	62.79	0.0640	3.63	0.21		
4	773	26.01	15.00	49.86	549.17	0.0206	10.21	0.39	0.115600	67.66
5	773	7.99	15.00	49.56	304.37	0.0310	8.52	1.07		
6	773	17.00	28.05	49.89	607.13	0.0356	10.45	0.61	0.013225	7.74
7	773	17.00	1.95	48.44	160.08	0.0058	6.41	0.38		
								Total	0.170850	100.00

E[I] = 0.570000
Var[I]= 0.170850
σ[I]= 0.413340
V(I) = 0.725158

E[ln I] = -0.773396
σ [ln I] = 0.650042

Ic= 0.80
ln(I crit) = -0.223144

β = -1.189764
F(z) = 0.801360
Pr(f) % = 19.864030

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	773	17.00	15.00	49.79	443.98	0.0240	2.14	0.13		
2	1531	17.00	15.00	49.89	624.73	0.0186	2.33	0.14	0.002025	23.68
3	15	17.00	15.00	41.56	62.79	0.0640	0.80	0.05		
4	773	26.01	15.00	49.86	549.17	0.0206	2.26	0.09	0.005625	65.79
5	773	7.99	15.00	49.56	304.37	0.0310	1.89	0.24		
6	773	17.00	28.05	49.89	607.13	0.0356	2.31	0.14	0.000900	10.53
7	773	17.00	1.95	48.44	160.08	0.0058	1.42	0.08		
								Total	0.008550	100.00

E[I] = 0.130000
Var[I]= 0.008550
σ[I]= 0.092466
V(I) = 0.711279

E[ln I] = -2.244922
σ [ln I] = 0.639845

Ic= 0.80
ln(I crit) = -0.223144

β = -3.508538
F(z) = 0.999211
Pr(f) % = 0.078941

1225

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

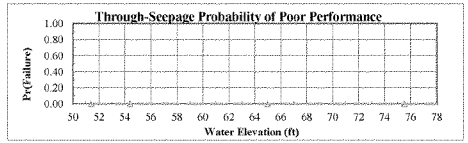
Levee Mile: 9.31
River Mile: 2156078.18 N; 6673804.98 E
Analysis Case Infinite landside blanket

Crest Elev.: 78.50
L/S Toe Elev.: 51.40
W/S Toe Elev.: 53.70

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	51.40	0.0000
Toe+3ft	3.00	54.40	0.000000
Half Height	13.55	64.95	0.000000
Crest-3ft	24.10	75.50	0.000000
Crest	27.10	78.50	0.000000

Crest — Head = 27.10 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Crest-3ft — Head = 24.10 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height — Head = 13.55 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft — Head = 3.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

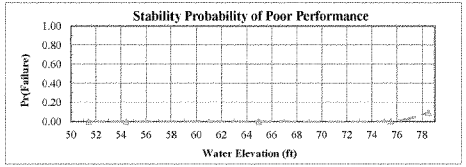
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 9.31
River Mile: 2156078.18 N; 6673804.98 E
Analysis Case Infinite landside blanket

Crest Elev.: 78.50
L/S Toe Elev.: 51.40
W/S Toe Elev.: 53.70

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Random Variables				
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %	
Levee φ'	29	1	5.00	
Levee γ	120	6	5.00	
Foundation c'	150	17	11.50	
Foundation γ	120	6	5.00	
Foundation φ'	31	4	11.50	



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	51.40	0.0000
Toe+3ft	3.00	54.40	0.000000
Half Height	13.55	64.95	0.000000
Crest-3ft	24.10	75.50	0.003757
Crest	27.10	78.50	0.091721

Crest	Head =	27.10	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.50		
2	28	120	150	120	31	1.69	0.024806	13.98
3	30	120	150	120	31	1.37		
4	29	114	150	120	31	1.46	0.001560	0.88
5	29	126	150	120	31	1.54		
6	29	120	133	120	31	1.70	0.136530	76.92
7	29	120	167	120	31	0.96		
8	29	120	150	114	31	1.53	0.003782	2.13
9	29	120	150	126	31	1.41		
10	29	120	150	120	27	1.58	0.010816	6.09
11	29	120	150	120	35	1.37		

E[FS] =	1.499000	E[ln FS] =	0.366785	Total	0.177495	100.00
Var[FS] =	0.177495				
σ[FS] =	0.421302	σ[ln FS] =	0.275730	β =	1.330229
V(FS) =	0.281055			F(z) =	0.091721
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	9.172136

Crest-3ft	Head =	24.10	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.25		
2	28	120	150	120	31	1.35	0.009604	90.64
3	30	120	150	120	31	1.16		
4	29	114	150	120	31	1.24	0.000144	1.36
5	29	126	150	120	31	1.26		
6	29	120	133	120	31	1.25	0.000784	7.40
7	29	120	167	120	31	1.19		
8	29	120	150	114	31	1.25	0.000064	0.60
9	29	120	150	126	31	1.23		
10	29	120	150	120	27	1.25	0.000000	0.00
11	29	120	150	120	35	1.25		

E[FS] =	1.250000	E[ln FS] =	0.219764	Total	0.010596	100.00
Var[FS] =	0.010596				
σ[FS] =	0.102937	σ[ln FS] =	0.082210	β =	2.673193
V(FS) =	0.082349			F(z) =	0.003757
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.375665

Half Height	Head =	13.55	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

1227

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

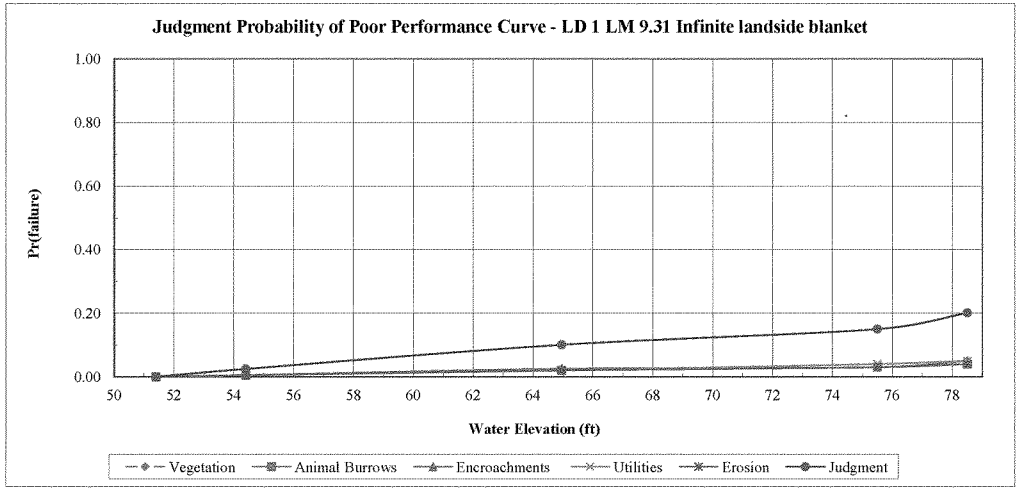
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 9.31
River Mile: 2156078.18 N
Analysis Case: Infinite landside blanket

Crest Elev.: 78.50
L/S Toe Elev.: 51.40
W/S Toe Elev.: 53.70

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 2/21/

Water Surface	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
51.40	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
54.40	0.0050	0.9950	0.0050	0.9950	0.0050	0.9950	0.0050	0.9950	0.0050	0.9950	0.0248	0.9752
64.95	0.0200	0.9800	0.0200	0.9800	0.0250	0.9750	0.0200	0.9800	0.0200	0.9800	0.1007	0.8993
75.50	0.0300	0.9700	0.0300	0.9700	0.0300	0.9700	0.0400	0.9600	0.0300	0.9700	0.1501	0.8499
78.50	0.0400	0.9600	0.0400	0.9600	0.0500	0.9500	0.0500	0.9500	0.0400	0.9600	0.2015	0.7985



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

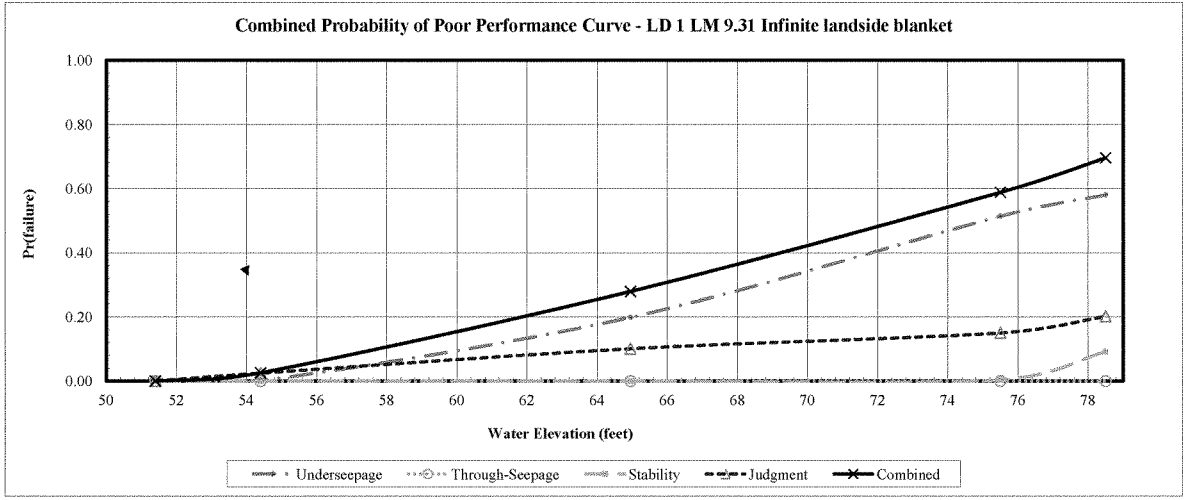
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 9.31
River Mile: 2156078.18 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 78.50
L/S Toe Elev.: 51.40
W/S Toe Elev.: 53.70

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 2/21/20

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
51.40	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
54.40	0.0008	0.9992	0.0000	1.0000	0.0000	1.0000	0.0248	0.9752	0.0255	0.9745
64.95	0.1986	0.8014	0.0000	1.0000	0.0000	1.0000	0.1007	0.8993	0.2793	0.7207
75.50	0.5140	0.4860	0.0000	1.0000	0.0038	0.9962	0.1501	0.8499	0.5885	0.4115
78.50	0.5805	0.4195	0.0000	1.0000	0.0917	0.9083	0.2015	0.7985	0.6958	0.3042



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River South
Basin and Reach: LD 9

Levee Mile: 0.52
Coordinates: 2188213.88 N; 6668679.41 E
Analysis Case Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WL0009 001S	19.5					52.5					CL	0.007	SP-SM/SP-SC	14	2000				
WL0009 007A	10					50.8					CL, CLs	0.007	SM, SP, SM/SW	17.94	2563				
WL0009 007A	7.5					27.5					CL, ML	0.007	SP-SM, SP-SC	14	2000				
WL0009 12B	13					10.8					CL-ML	0.007	SP-SM/SW	23.46	3351				
2F-07-7	10	13	5	55	38	17.5	28	17	383	61	ML	0.14	SW/SP-SM	26	186	1730	1217	1685521	70
SL0009 001B	10					24					SC, CL, ML	1.4	SP-SM/SP-SC	14	10				
WL0009 009B	20					11					ML, CL	0.007	SM, SP-SM	14	2000				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (Kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WL0009 001S	CL	19.5	0.007				19.5	SP-SM	47	14	SP-SC	5.5	14				14
WL0009 007A	CL, CLs	10	0.007				10	SP-SM, SP, SM	36.5	14	SW-SM	14.3	28				17.94
WL0009 007A	CL, ML	7.5	0.007				7.5	SP-SM, SP-SC	27.5	14							14
WL0009 12B	CL-ML	13	0.007				13	SP-SM	3.5	14	SW	7.3	28				23.46
2F-07-7	ML	10	0.14				10	SW	15	28	SP-SM	2.5	14				26
SL0009 001B	SC, CL, ML	10	1.4				10	SP-SM	12	14	SP-SC	12	14				14
WL0009 009B	ML, CL	20	0.007				20	SM, SP-SM	11	14							14

1230

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibtlity Study
Study Area: Feather River South
River Section: LD 9

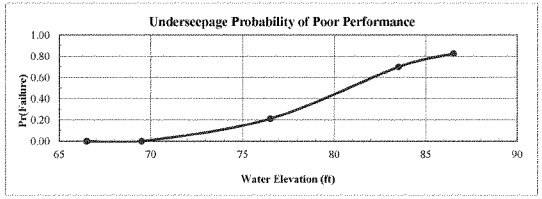
Levee Mile: 0.52
River Mile: 2188213.88 N; 6668679.41 E
Analysis Case Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaeability Ratio	1730	1217	70
Blanket Thickness (z)	13	5	38
Aquifer Thickness (d)	28	17	61

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	50	130	∞	112



Analysis Case	Head	Elevation	Pr(f) Stability
Toe	0.00	66.50	0.0000
Toe+3ft	3.00	69.50	0.0001
Half Height	10.01	76.51	0.2117
Crest-3ft	17.02	83.52	0.6995
Crest	20.02	86.52	0.8254

Crest	Rh
Head = 20.02	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1730	13.00	28.00	49.93	793.55	0.0288	16.32	1.26		
2	2947	13.00	28.00	49.96	1035.72	0.0230	17.06	1.31	0.012100	4.40
3	513	13.00	28.00	49.78	432.12	0.0458	14.14	1.09		
4	1730	18.00	28.00	49.95	933.77	0.0251	16.79	0.93	0.255025	92.66
5	1730	8.00	28.00	49.89	622.51	0.0349	15.53	1.94		
6	1730	13.00	45.00	49.96	1006.01	0.0379	16.98	1.31	0.008100	2.94
7	1730	13.00	11.00	49.83	497.38	0.0162	14.70	1.13		
								Total	0.275225	100.00

E[I] = 1.260000
Var[I]= 0.275225
σ[I]= 0.524619
V(I) = 0.416364

E[ln I] = 0.151176
σ [ln I] = 0.399838

Ic= 0.80
ln(I crit) = -0.223144

β = 0.378094
F(z) = 0.174591
Pr(f) % = 82.540925

Crest-3ft	Rh
Head = 17.02	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1730	13.00	28.00	49.93	793.55	0.0288	13.87	1.07		
2	2947	13.00	28.00	49.96	1035.72	0.0230	14.50	1.12	0.010000	4.99
3	513	13.00	28.00	49.78	432.12	0.0458	12.02	0.92		
4	1730	18.00	28.00	49.95	933.77	0.0251	14.27	0.79	0.184900	92.21
5	1730	8.00	28.00	49.89	622.51	0.0349	13.20	1.65		
6	1730	13.00	45.00	49.96	1006.01	0.0379	14.44	1.11	0.005625	2.81
7	1730	13.00	11.00	49.83	497.38	0.0162	12.50	0.96		
								Total	0.200525	100.00

E[I] = 1.070000
Var[I]= 0.200525
σ[I]= 0.447800
V(I) = 0.418505

E[ln I] = -0.013038
σ [ln I] = 0.401737

Ic= 0.80
ln(I crit) = -0.223144

β = -0.032453
F(z) = 0.300489
Pr(f) % = 69.951062

Half Height	Rh
Head = 10.01	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1730	13.00	28.00	49.93	793.55	0.0288	8.16	0.63		
2	2947	13.00	28.00	49.96	1035.72	0.0230	8.53	0.66	0.003600	5.32
3	513	13.00	28.00	49.78	432.12	0.0458	7.07	0.54		
4	1730	18.00	28.00	49.95	933.77	0.0251	8.39	0.47	0.062500	92.32
5	1730	8.00	28.00	49.89	622.51	0.0349	7.77	0.97		
6	1730	13.00	45.00	49.96	1006.01	0.0379	8.49	0.65	0.001600	2.36
7	1730	13.00	11.00	49.83	497.38	0.0162	7.35	0.57		
								Total	0.067700	100.00

E[I] = 0.630000
Var[I]= 0.067700
σ[I]= 0.260192
V(I) = 0.413004

E[ln I] = -0.540782
σ [ln I] = 0.396853

Ic= 0.80
ln(I crit) = -0.223144

β = -1.362674
F(z) = 0.788258
Pr(f) % = 21.174185

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1730	13.00	28.00	49.93	793.55	0.0288	2.45	0.19		
2	2947	13.00	28.00	49.96	1035.72	0.0230	2.56	0.20	0.000400	6.40
3	513	13.00	28.00	49.78	432.12	0.0458	2.12	0.16		
4	1730	18.00	28.00	49.95	933.77	0.0251	2.52	0.14	0.005625	90.00
5	1730	8.00	28.00	49.89	622.51	0.0349	2.33	0.29		
6	1730	13.00	45.00	49.96	1006.01	0.0379	2.54	0.20	0.000225	3.60
7	1730	13.00	11.00	49.83	497.38	0.0162	2.20	0.17		
								Total	0.006250	100.00

E[I] = 0.190000
Var[I]= 0.006250
σ[I]= 0.079057
V(I) = 0.416089

E[ln I] = -1.740569
σ [ln I] = 0.399594

Ic= 0.80
ln(I crit) = -0.223144

β = -4.355841
F(z) = 0.999927
Pr(f) % = 0.007311

1231

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 9

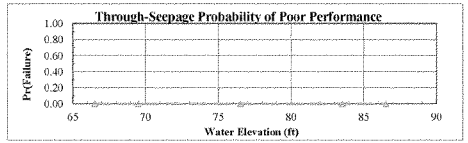
Levee Mile: 0.52
River Mile: 2188213.88 N; 6668679.41 E
Analysis Case Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f) Stability
Toe	0.00	66.50	0.0000
Toe+3ft	3.00	69.50	0.000000
Half Height	10.01	76.51	0.000000
Crest-3ft	17.02	83.52	0.000000
Crest	20.02	86.52	0.000000

Crest — Head = 20.02 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft — Head = 17.02 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Half Height — Head = 10.01 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft — Head = 3.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

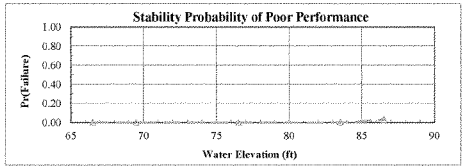
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 9

Levee Mile: 0.52
River Mile: 2188213.88 N; 6668679.41 E
Analysis Case Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee Φ	29	4	13.00
Levee γ	120	48	40.00
Foundation Cohesion	150	11	7.00
Foundation γ	120	16	13.00
Foundation Φ	31	12	40.00



Analysis Case	Head	Elevation	Pr(f) Stability
Toe	0.00	66.50	0.0000
Toe+3ft	3.00	69.50	0.000000
Half Height	10.01	76.51	0.000000
Crest-3ft	17.02	83.52	0.000000
Crest	20.02	86.52	0.029687

Crest	Head =	20.02	Pr(f)=0 =	NO

Run	Levee Φ	Levee γ	Foundation Cohesion	Foundation γ	Foundation Φ	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.29		
2	25	120	150	120	31	1.22	0.000576	2.01
3	33	120	150	120	31	1.27		
4	29	72	150	120	31	1.30	0.003025	10.58
5	29	168	150	120	31	1.19		
6	29	120	139	120	31	1.23	0.000110	0.39
7	29	120	161	120	31	1.21		
8	29	120	150	104	31	1.33	0.013225	46.24
9	29	120	150	136	31	1.10		
10	29	120	150	120	19	1.36	0.011664	40.78
11	29	120	150	120	43	1.14		

E[FS] =	1.290000	E[ln FS] =	0.246122	Total	0.028600	100.00
Var[FS] =	0.028600				
σ[FS] =	0.169116	σ[ln FS] =	0.130540	β =	1.883419
V(FS) =	0.131098			F(z) =	0.029687
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	2.968665

Crest-3ft	Head =	17.02	Pr(f)=0 =	YES

Run	Levee Φ	Levee γ	Foundation Cohesion	Foundation γ	Foundation Φ	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.25		
2	25	120	150	120	31	1.35	0.009604	90.64
3	33	120	150	120	31	1.16		
4	29	72	150	120	31	1.24	0.000144	1.36
5	29	168	150	120	31	1.26		
6	29	120	139	120	31	1.25	0.000784	7.40
7	29	120	161	120	31	1.19		
8	29	120	150	104	31	1.25	0.000064	0.60
9	29	120	150	136	31	1.23		
10	29	120	150	120	19	1.25	0.000000	0.00
11	29	120	150	120	43	1.25		

E[FS] =		E[ln FS] =		Total	0.010596	100.00
Var[FS] =	0.010596				
σ[FS] =	0.102937	σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Half Height	Head =	10.01	Pr(f)=0 =	YES

Run	Levee Φ	Levee γ	Foundation Cohesion	Foundation γ	Foundation Φ	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	25	120	150	120	31			
3	33	120	150	120	31			
4	29	72	150	120	31			
5	29	168	150	120	31			
6	29	120	139	120	31			
7	29	120	161	120	31			
8	29	120	150	104	31			
9	29	120	150	136	31			
10	29	120	150	120	19			
11	29	120	150	120	43			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0 =	YES

Run	Levee Φ	Levee γ	Foundation Cohesion	Foundation γ	Foundation Φ	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	25	120	150	120	31			
3	33	120	150	120	31			
4	29	72	150	120	31			
5	29	168	150	120	31			
6	29	120	139	120	31			
7	29	120	161	120	31			
8	29	120	150	104	31			
9	29	120	150	136	31			
10	29	120	150	120	19			
11	29	120	150	120	43			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

1233

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

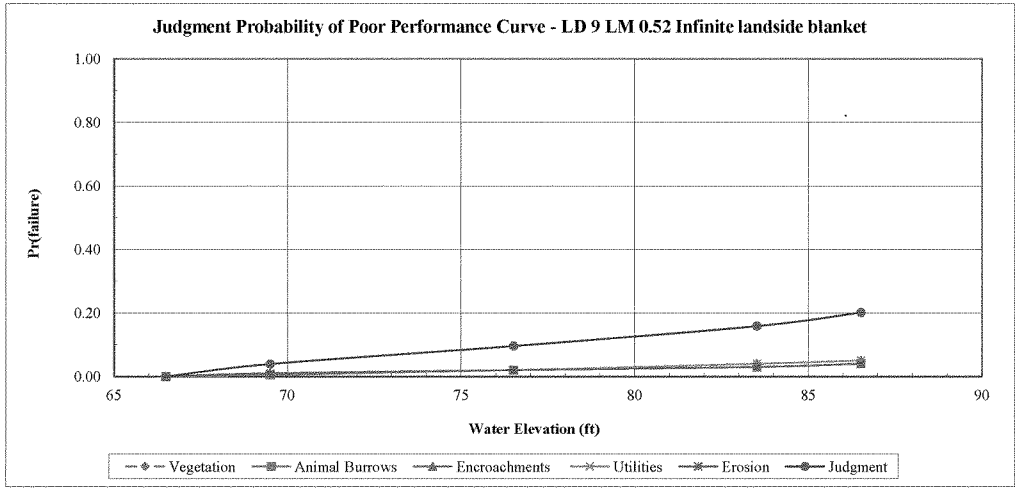
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 9

Levee Mile: 0.52
River Mile: 2188213.88 N
Analysis Case: Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 9/12/

Water Surface	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
66.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
69.50	0.0050	0.9950	0.0050	0.9950	0.0100	0.9900	0.0100	0.9900	0.0100	0.9900	0.0394	0.9606
76.51	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0961	0.9039
83.52	0.0300	0.9700	0.0300	0.9700	0.0400	0.9600	0.0400	0.9600	0.0300	0.9700	0.1589	0.8411
86.52	0.0400	0.9600	0.0400	0.9600	0.0500	0.9500	0.0500	0.9500	0.0400	0.9600	0.2015	0.7985



1234

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

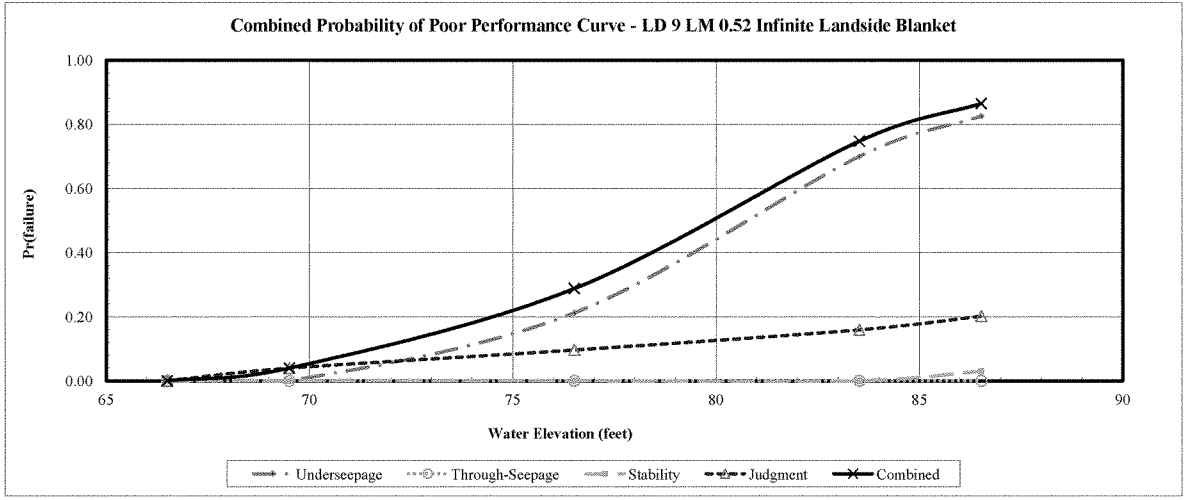
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 9

Levee Mile: 0.52
River Mile: 2188213.88 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/12/20

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
66.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
69.50	0.0001	0.9999	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0394	0.9606
76.51	0.2117	0.7883	0.0000	1.0000	0.0000	1.0000	0.0961	0.9039	0.2875	0.7125
83.52	0.6995	0.3005	0.0000	1.0000	0.0000	1.0000	0.1589	0.8411	0.7473	0.2527
86.52	0.8254	0.1746	0.0000	1.0000	0.0297	0.9703	0.2015	0.7985	0.8647	0.1353



1235

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River North
Basin and Reach: MA 16

Levee Mile: 0.90
Coordinates: 2224154.37 N, 6664999.34 E
Analysis Case Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WM0016 011B	5					9.5					CL-ML	0.007	SP-SM/SP	25.79	3684				
WM0016 010C	15					30					CL-ML	0.007	SP	28	4000				
WM0016 012C	5					10					CL-ML	0.007	SP	28	4000				
WM0016 009C	3					14					CL-ML	0.0284	SP	28	986				
WM0016 001A	4	6	5	24	76	15	16	8	70	53	CL	0.0284	SW-SM	14	493	2633	1742	3033812	66

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WM0016 011B	CL-ML	5	0.007				5	SP-SM	1.5	14	SP	8	28				25.79
WM0016 010C	CL-ML	18	0.007				18	SP	30	28							28
WM0016 012C	CL-ML	5	0.007				5	SP	10	28							28
WM0016 009C	CL-ML	3	0.0284				3	SP	14	28							28
WM0016 001A	CL	4	0.0284				4	SW-SM	15	14							14

1236

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

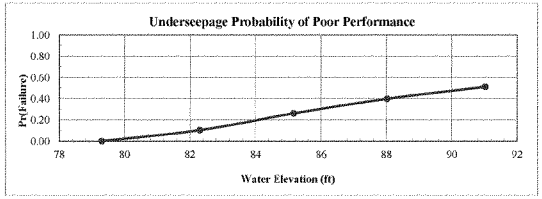
Levee Mile: 0.90
River Mile: 2224154.37 N; 6664999.34 E
Analysis Case Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permeability Ratio	2633	1742	66
Blanket Thickness (z)	6	5	76
Aquifer Thickness (d)	16	8	53

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	15	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	79.30	0.0000
Toe+3ft	3.00	82.30	0.1036
Half Height	5.86	85.16	0.2614
Crest-3ft	8.72	88.02	0.3990
Crest	11.72	91.02	0.5127

Crest	Rh
Head = 11.72	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	2633	6.40	15.70	15.00	514.32	0.0238	9.14	1.43		
2	4374	6.40	15.70	15.00	662.98	0.0194	9.62	1.50	0.018225	0.45
3	891	6.40	15.70	14.99	299.19	0.0353	7.89	1.23		
4	2633	11.28	15.70	15.00	682.76	0.0190	9.67	0.86	4.040100	99.33
5	2633	1.52	15.70	14.98	250.77	0.0397	7.43	4.88		
6	2633	6.40	24.05	15.00	636.55	0.0308	9.55	1.49	0.009025	0.22
7	2633	6.40	7.35	14.99	351.94	0.0148	8.30	1.30		
								Total	4.067350	100.00

E[I] = 1.430000
Var[I]= 4.067350
σ[I]= 2.016767
V(I) = 1.410327

E[ln I] = -0.189799
σ [ln I] = 1.046397

Ic= 0.80
ln(I crit) = -0.223144

β = -0.181383
F(z) = 0.487289
Pr(f) % = 51.271073

Crest-3ft	Rh
Head = 8.72	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	2633	6.40	15.70	15.00	514.32	0.0238	6.80	1.06		
2	4374	6.40	15.70	15.00	662.98	0.0194	7.16	1.12	0.010000	0.44
3	891	6.40	15.70	14.99	299.19	0.0353	5.87	0.92		
4	2633	11.28	15.70	15.00	682.76	0.0190	7.19	0.64	2.235025	99.34
5	2633	1.52	15.70	14.98	250.77	0.0397	5.53	3.63		
6	2633	6.40	24.05	15.00	636.55	0.0308	7.10	1.11	0.004900	0.22
7	2633	6.40	7.35	14.99	351.94	0.0148	6.18	0.97		
								Total	2.249925	100.00

E[I] = 1.060000
Var[I]= 2.249925
σ[I]= 1.499975
V(I) = 1.415071

E[ln I] = -0.491441
σ [ln I] = 1.048532

Ic= 0.80
ln(I crit) = -0.223144

β = -0.468694
F(z) = 0.600978
Pr(f) % = 39.902203

Half Height	Rh
Head = 5.86	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	2633	6.40	15.70	15.00	514.32	0.0238	4.57	0.71		
2	4374	6.40	15.70	15.00	662.98	0.0194	4.81	0.75	0.004225	0.42
3	891	6.40	15.70	14.99	299.19	0.0353	3.95	0.62		
4	2633	11.28	15.70	15.00	682.76	0.0190	4.83	0.43	1.010025	99.34
5	2633	1.52	15.70	14.98	250.77	0.0397	3.71	2.44		
6	2633	6.40	24.05	15.00	636.55	0.0308	4.77	0.75	0.002500	0.25
7	2633	6.40	7.35	14.99	351.94	0.0148	4.15	0.65		
								Total	1.016750	100.00

E[I] = 0.710000
Var[I]= 1.016750
σ[I]= 1.008340
V(I) = 1.420197

E[ln I] = -0.894615
σ [ln I] = 1.050833

Ic= 0.80
ln(I crit) = -0.223144

β = -0.851339
F(z) = 0.738585
Pr(f) % = 26.141473

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	2633	6.40	15.70	15.00	514.32	0.0238	2.34	0.37		
2	4374	6.40	15.70	15.00	662.98	0.0194	2.46	0.38	0.000900	0.34
3	891	6.40	15.70	14.99	299.19	0.0353	2.02	0.32		
4	2633	11.28	15.70	15.00	682.76	0.0190	2.47	0.22	0.265225	99.43
5	2633	1.52	15.70	14.98	250.77	0.0397	1.90	1.25		
6	2633	6.40	24.05	15.00	636.55	0.0308	2.44	0.38	0.000625	0.23
7	2633	6.40	7.35	14.99	351.94	0.0148	2.12	0.33		
								Total	0.266750	100.00

E[I] = 0.370000
Var[I]= 0.266750
σ[I]= 0.516478
V(I) = 1.395888

E[ln I] = -1.534901
σ [ln I] = 1.039855

Ic= 0.80
ln(I crit) = -0.223144

β = -1.476073
F(z) = 0.896432
Pr(f) % = 10.356768

1237

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

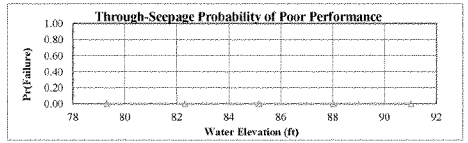
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 0.90
River Mile: 2224154.37 N; 6664959.34 E
Analysis Case Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	15	1.5	10.00
Initial Porosity (n)	45	4.50	10.00
Initial Permeability (Ko)	1.00E-10	3.00E-11	30.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	79.30	0.0000
Toe+3ft	3.00	82.30	0.000000
Half Height	5.86	85.16	0.000000
Crest-3ft	8.72	88.02	0.000000
Crest	11.72	91.02	0.000000

Pr(f)=0
YES

Crest — Head = 11.72 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft — Head = 8.72 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Half Height — Head = 5.86 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Toe-3ft — Head = 3.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	15.00	45.00	1.00E-10	3628.12			
2	13.50	45.00	1.00E-10	3265.31			
3	16.50	45.00	1.00E-10	3990.93			
4	15.00	40.50	1.00E-10	3441.94			
5	15.00	49.50	1.00E-10	3805.21			
6	15.00	45.00	7.00E-11	4336.44			
7	15.00	45.00	1.30E-10	3182.07			

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

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Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

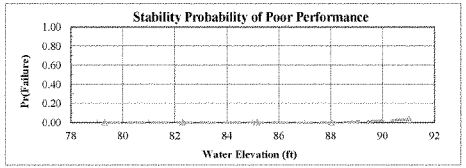
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 0.90
River Mile: 2224154.37 N; 6664999.34 E
Analysis Case Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee φ'	31	4	12.00
Levee γ	125	6	5.00
Foundation c'	150	50	33.00
Foundation γ	115	6	5.00
Foundation φ'	28	3	12.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	79.30	0.0000
Toe+3ft	3.00	82.30	0.000000
Half Height	5.86	85.16	0.000000
Crest-3ft	8.72	88.02	0.000000
Crest	11.72	91.02	0.029687

Crest	Head =	11.72	Pr(f)=0 =	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.29		
2	27	125	150	115	28	1.22	0.000576	2.01
3	35	125	150	115	28	1.27		
4	31	119	150	115	28	1.30	0.003025	10.58
5	31	131	150	115	28	1.19		
6	31	125	100	115	28	1.23	0.000110	0.39
7	31	125	200	115	28	1.21		
8	31	125	150	109	28	1.33	0.013225	46.24
9	31	125	150	121	28	1.10		
10	31	125	150	115	25	1.36	0.011664	40.78
11	31	125	150	115	31	1.14		

E[FS] = 1.290000
Var[FS] = 0.028600
σ[FS] = 0.169116
V(FS) = 0.131098
FS req'd = 1.00

E[ln FS] = 0.246122
σ[ln FS] = 0.130540
ln(FS req'd) = 0.000000

Total 0.028600 100.00

β = 1.885419
F(z) = 0.029687
Pr(f) % = 2.968665

Crest-3ft	Head =	8.72	Pr(f)=0 =	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28	1.25		
2	27	125	150	115	28	1.35	0.009604	90.64
3	35	125	150	115	28	1.16		
4	31	119	150	115	28	1.24	0.000144	1.36
5	31	131	150	115	28	1.26		
6	31	125	100	115	28	1.25	0.000784	7.40
7	31	125	200	115	28	1.19		
8	31	125	150	109	28	1.25	0.000064	0.60
9	31	125	150	121	28	1.23		
10	31	125	150	115	25	1.25	0.000000	0.00
11	31	125	150	115	31	1.25		

E[FS] =
Var[FS] = 0.010596
σ[FS] = 0.102937
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS] =
ln(FS req'd) = 0.000000

Total 0.010596 100.00

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Head =	5.86	Pr(f)=0 =	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] =
Var[FS] =
σ[FS] =
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS] =
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Head =	3.00	Pr(f)=0 =	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	31	125	150	115	28			
2	27	125	150	115	28			
3	35	125	150	115	28			
4	31	119	150	115	28			
5	31	131	150	115	28			
6	31	125	100	115	28			
7	31	125	200	115	28			
8	31	125	150	109	28			
9	31	125	150	121	28			
10	31	125	150	115	25			
11	31	125	150	115	31			

E[FS] =
Var[FS] =
σ[FS] =
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS] =
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

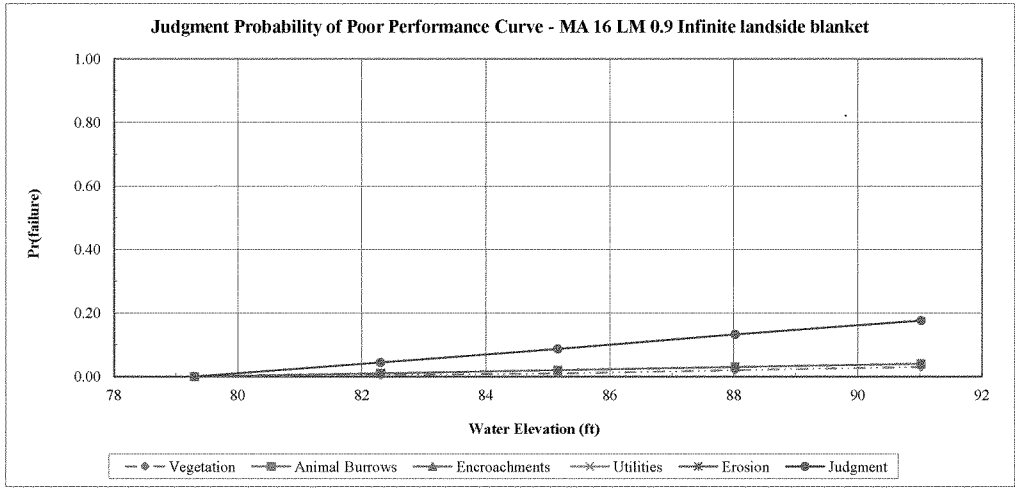
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 0.90
River Mile: 2224154.37 N
Analysis Case: Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 9/12/

Water Surface	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
79.30	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
82.30	0.0050	0.9950	0.0100	0.9900	0.0100	0.9900	0.0100	0.9900	0.0100	0.9900	0.0442	0.9558
85.16	0.0100	0.9900	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0200	0.9800	0.0869	0.9131
88.02	0.0200	0.9800	0.0300	0.9700	0.0300	0.9700	0.0300	0.9700	0.0300	0.9700	0.1324	0.8676
91.02	0.0300	0.9700	0.0400	0.9600	0.0400	0.9600	0.0400	0.9600	0.0400	0.9600	0.1761	0.8239



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

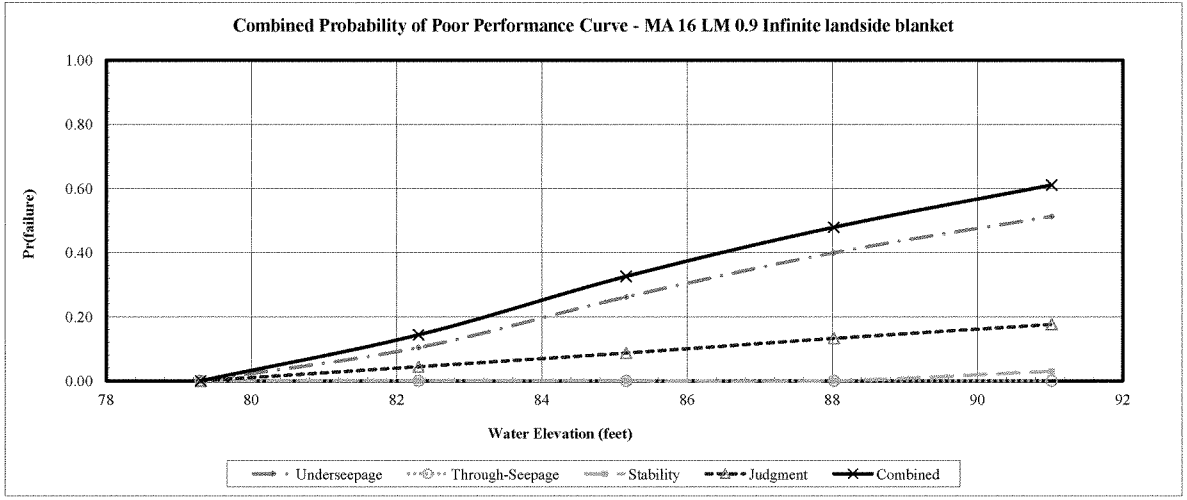
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 0.90
River Mile: 2224154.37 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/12/20

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
79.30	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
82.30	0.1036	0.8964	0.0000	1.0000	0.0000	1.0000	0.0442	0.9558	0.1432	0.8568
85.16	0.2614	0.7386	0.0000	1.0000	0.0000	1.0000	0.0869	0.9131	0.3256	0.6744
88.02	0.3990	0.6010	0.0000	1.0000	0.0000	1.0000	0.1324	0.8676	0.4786	0.5214
91.02	0.5127	0.4873	0.0000	1.0000	0.0297	0.9703	0.1761	0.8239	0.6105	0.3895



1241

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River North
Basin and Reach: MA 16

Levee Mile: 2.90
Coordinates: 2233626.25 N, 6664328.54 E
Analysis Case Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James-J.M. Bolton
Date: Updated 9/12/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WM0016 011B	9					10					CL-ML	0.28	SP	28	100				
WM0016 014B	20					18					CL-ML	0.0071	SW, SM, SC	14	1972				
WM0016 018B	10					12					SC, SM	0.14	SP,SW,SM	28	200				
WM0016 019S	18					18					CL, ML	0.0071	SP	28	3944				
WM0016 020B	10					10					CL, ML	0.28	SW-SM	14	50				
WM0016 022S	8					4					CL	0.28	SP-SM	14	50				
		13	5	26	41		12	5	29	45						1053	1603	2569602	98

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)		Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)			Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WM0016 011B	CL-ML	9	0.28				9	9	SP	10	28							28
WM0016 014B	CL-ML	20	0.0071				20	20	SW, SM, SC	18	14							14
WM0016 018B	SC, SM	10	0.14				10	10	SP,SW,SM	12	28							28
WM0016 019S	CL, ML	18	0.0071				18	18	SP	18	28							28
WM0016 020B	CL, ML	10	0.28				10	10	SW-SM	10	14							14
WM0016 022S	CL	8	0.28				10	10	SP-SM	3	14							14

1242

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

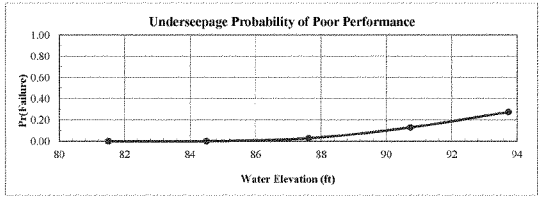
Levee Mile: 2.90
River Mile: 2233626.25 N; 6664328.54 E
Analysis Case Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permeability Ratio	1053	1032	98
Blanket Thickness (z)	13	5	41
Aquifer Thickness (d)	12	5	45

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	50	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	81.50	0.0000
Toe+3ft	3.00	84.50	0.0005
Half Height	6.12	87.62	0.0271
Crest-3ft	9.23	90.73	0.1294
Crest	12.23	93.73	0.2738

Crest	Rh
Head = 12.23	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1053	12.50	12.00	49.74	397.35	0.0208	8.42	0.67		
2	2084	12.50	12.00	49.87	559.12	0.0162	9.25	0.74	0.062500	45.32
3	21	12.50	12.00	39.97	56.19	0.0531	3.04	0.24		
4	1053	17.63	12.00	49.81	471.87	0.0184	8.86	0.50	0.072900	52.86
5	1053	7.37	12.00	49.56	305.14	0.0248	7.70	1.04		
6	1053	12.50	17.37	49.82	478.01	0.0264	8.89	0.71	0.002500	1.81
7	1053	12.50	6.63	49.53	295.43	0.0140	7.61	0.61		
								Total	0.137900	100.00

E[I] = 0.670000
Var[I]= 0.137900
σ[I]= 0.371349
V(I) = 0.554252

E[ln I] = -0.534420
σ [ln I] = 0.517575

Ic= 0.80
ln(I crit) = -0.223144

β = -1.032545
F(z) = 0.726217
Pr(f) % = 27.378272

Crest-3ft	Rh
Head = 9.23	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1053	12.50	12.00	49.74	397.35	0.0208	6.36	0.51		
2	2084	12.50	12.00	49.87	559.12	0.0162	6.98	0.56	0.036100	45.28
3	21	12.50	12.00	39.97	56.19	0.0531	2.29	0.18		
4	1053	17.63	12.00	49.81	471.87	0.0184	6.68	0.38	0.042025	52.71
5	1053	7.37	12.00	49.56	305.14	0.0248	5.81	0.79		
6	1053	12.50	17.37	49.82	478.01	0.0264	6.71	0.54	0.001600	2.01
7	1053	12.50	6.63	49.53	295.43	0.0140	5.74	0.46		
								Total	0.079725	100.00

E[I] = 0.510000
Var[I]= 0.079725
σ[I]= 0.282356
V(I) = 0.553640

E[ln I] = -0.807027
σ [ln I] = 0.517073

Ic= 0.80
ln(I crit) = -0.223144

β = -1.560760
F(z) = 0.870595
Pr(f) % = 12.940497

Half Height	Rh
Head = 6.12	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1053	12.50	12.00	49.74	397.35	0.0208	4.21	0.34		
2	2084	12.50	12.00	49.87	559.12	0.0162	4.63	0.37	0.015625	44.96
3	21	12.50	12.00	39.97	56.19	0.0531	1.52	0.12		
4	1053	17.63	12.00	49.81	471.87	0.0184	4.43	0.25	0.018225	52.45
5	1053	7.37	12.00	49.56	305.14	0.0248	3.85	0.52		
6	1053	12.50	17.37	49.82	478.01	0.0264	4.44	0.36	0.000900	2.59
7	1053	12.50	6.63	49.53	295.43	0.0140	3.80	0.30		
								Total	0.034750	100.00

E[I] = 0.340000
Var[I]= 0.034750
σ[I]= 0.186414
V(I) = 0.548275

E[ln I] = -1.210225
σ [ln I] = 0.512669

Ic= 0.80
ln(I crit) = -0.223144

β = -2.360633
F(z) = 0.972909
Pr(f) % = 2.709121

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1053	12.50	12.00	49.74	397.35	0.0208	2.07	0.17		
2	2084	12.50	12.00	49.87	559.12	0.0162	2.27	0.18	0.003600	41.86
3	21	12.50	12.00	39.97	56.19	0.0531	0.75	0.06		
4	1053	17.63	12.00	49.81	471.87	0.0184	2.17	0.12	0.004900	56.98
5	1053	7.37	12.00	49.56	305.14	0.0248	1.89	0.26		
6	1053	12.50	17.37	49.82	478.01	0.0264	2.18	0.17	0.000100	1.16
7	1053	12.50	6.63	49.53	295.43	0.0140	1.87	0.15		
								Total	0.008600	100.00

E[I] = 0.170000
Var[I]= 0.008600
σ[I]= 0.092736
V(I) = 0.545507

E[ln I] = -1.902207
σ [ln I] = 0.510391

Ic= 0.80
ln(I crit) = -0.223144

β = -3.726957
F(z) = 0.999499
Pr(f) % = 0.050137

1243

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

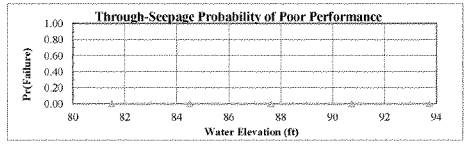
Levee Mile: 2.90
River Mile: 2233626.25 N; 6664328.54 E
Analysis Case Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	81.50	0.0000
Toe+3ft	3.00	84.50	0.000000
Half Height	6.12	87.62	0.000000
Crest-3ft	9.23	90.73	0.000000
Crest	12.23	93.73	0.000000

Crest — Head = 12.23 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] = β =
V(FS) = F(z) =
FS req'd = 1.00 ln(FS req'd) = 0.000000 Pr(f) % = 0.000000

Crest-3ft — Head = 9.23 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] = β =
V(FS) = F(z) =
FS req'd = 1.00 ln(FS req'd) = 0.000000 Pr(f) % = 0.000000

Half Height — Head = 6.12 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] = β =
V(FS) = F(z) =
FS req'd = 1.00 ln(FS req'd) = 0.000000 Pr(f) % = 0.000000

Toe-3ft — Head = 3.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] = β =
V(FS) = F(z) =
FS req'd = 1.00 ln(FS req'd) = 0.000000 Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

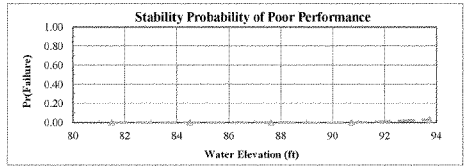
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 2.90
River Mile: 2233626.25 N; 6664328.54 E
Analysis Case Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/12/2012

Random Variables				
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %	
Levee φ'	29	1	5.00	
Levee γ	120	6	5.00	
Foundation c'	150	17	11.50	
Foundation γ	120	6	5.00	
Foundation φ'	31	4	11.50	



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	81.50	0.0000
Toe+3ft	3.00	84.50	0.000000
Half Height	6.12	87.62	0.000000
Crest-3ft	9.23	90.73	0.000000
Crest	12.23	93.73	0.029687

Crest	Head =	12.23	Pr(f)=0 =	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.29		
2	28	120	150	120	31	1.22	0.000576	2.01
3	30	120	150	120	31	1.27		
4	29	114	150	120	31	1.30	0.003025	10.58
5	29	126	150	120	31	1.19		
6	29	120	133	120	31	1.23	0.000110	0.39
7	29	120	167	120	31	1.21		
8	29	120	150	114	31	1.33	0.013225	46.24
9	29	120	150	126	31	1.10		
10	29	120	150	120	27	1.36	0.011664	40.78
11	29	120	150	120	35	1.14		

E[FS] =	1.290000	E[ln FS] =	0.246122	Total	0.028600	100.00
Var[FS] =	0.028600				
σ[FS] =	0.169116	σ[ln FS] =	0.130540	β =	1.885419
V(FS) =	0.131098			F(z) =	0.029687
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	2.968665

Crest-3ft	Head =	9.23	Pr(f)=0 =	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.25		
2	28	120	150	120	31	1.35	0.009604	90.64
3	30	120	150	120	31	1.16		
4	29	114	150	120	31	1.24	0.000144	1.36
5	29	126	150	120	31	1.26		
6	29	120	133	120	31	1.25	0.000784	7.40
7	29	120	167	120	31	1.19		
8	29	120	150	114	31	1.25	0.000064	0.60
9	29	120	150	126	31	1.23		
10	29	120	150	120	27	1.25	0.000000	0.00
11	29	120	150	120	35	1.25		

E[FS] =		E[ln FS] =		Total	0.010596	100.00
Var[FS] =	0.010596				
σ[FS] =	0.102937	σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Half Height	Head =	6.12	Pr(f)=0 =	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0 =	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

1245

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

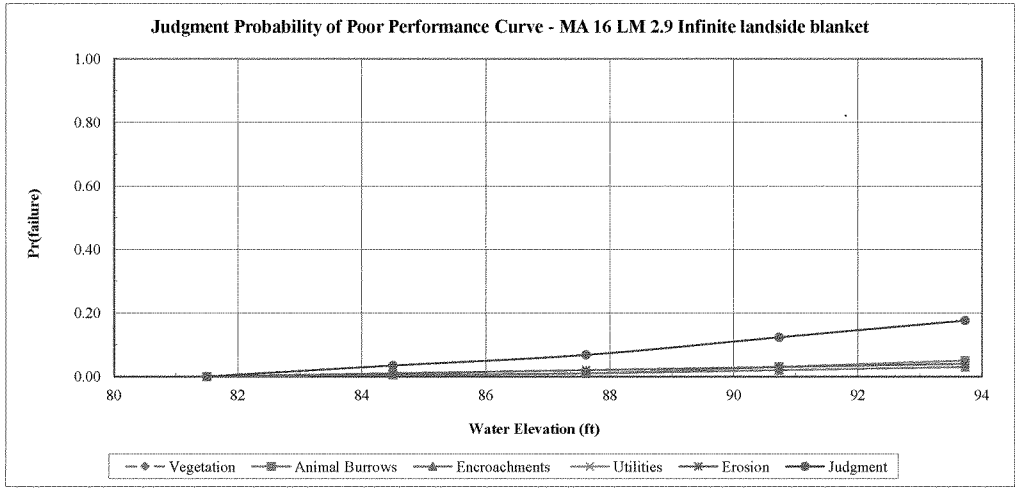
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 2.90
River Mile: 2233626.25 N
Analysis Case: Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 9/12/

Water Surface	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
81.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
84.50	0.0050	0.9950	0.0050	0.9950	0.0050	0.9950	0.0100	0.9900	0.0100	0.9900	0.0345	0.9655
87.62	0.0100	0.9900	0.0100	0.9900	0.0100	0.9900	0.0200	0.9800	0.0200	0.9800	0.0681	0.9319
90.73	0.0200	0.9800	0.0300	0.9700	0.0200	0.9800	0.0300	0.9700	0.0300	0.9700	0.1235	0.8765
93.73	0.0300	0.9700	0.0500	0.9500	0.0300	0.9700	0.0400	0.9600	0.0400	0.9600	0.1762	0.8238



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

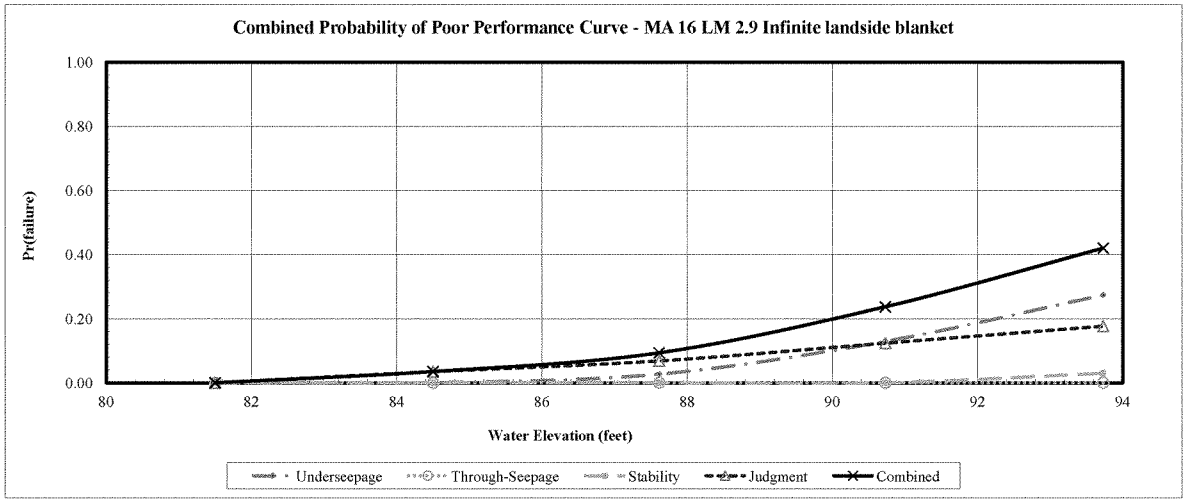
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 2.90
River Mile: 2233626.25 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/12/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
81.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
84.50	0.0005	0.9995	0.0000	1.0000	0.0000	1.0000	0.0345	0.9655	0.0350	0.9650
87.62	0.0271	0.9729	0.0000	1.0000	0.0000	1.0000	0.0681	0.9319	0.0934	0.9066
90.73	0.1294	0.8706	0.0000	1.0000	0.0000	1.0000	0.1235	0.8765	0.2369	0.7631
93.73	0.2738	0.7262	0.0000	1.0000	0.0297	0.9703	0.1762	0.8238	0.4195	0.5805



1247

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Feather River North
Basin and Reach: Hamilton Bend (MA 7)

Levee Mile: 0.51
Coordinates: 2288660.96 N; 6662820.24 E
Analysis Case Infinite landside blanket

Crest Elev.: 136.00
L/S Toe Elev.: 118.00
W/S Toe Elev.: 118.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WM0007 069B	10					31.5					sML	0.14	GP-GM, GP,GV	560	4000				
WM0007 068S	9.02					49					L, CL-MLs/SP-	0.007	M,GW, GP-GM	70	10000				
WM0007 013S	8.71					60.5					CL-ML,sCL/MI	0.01	GW,GP,GC,SM	560	56000				
WM0007 067B/S	15					10					sML/SM	0.14	GP-GM	35	250				
WM0007 66S	16	12	3	10	26	13	30	21	482	70	ML, SC/CL-MI	0.14	SP	14	100	11742	20103	306195806	98
WM0007 65B/S	13.3					15.5					sML/SM	0.14	SW, SP-SM,GP-	14	100				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WM0007 069B	sML	10	0.14				10	GP-GM, GP,GV	31.5	560							560
WM0007 068S	sML, CL-MLs	9	0.007	SP-SM	2	0.7	9.02	M,GW, GP-GM	49	70							70
WM0007 013S	CL-ML,sCL	8.5	0.01	ML	3	0.14	8.71	GW,GP,GC,SM	60.5	560							560
WM0007 067B/S	sML	11	0.14	SM	8	0.28	15	GP-GM	10	35							35
WM0007 66S	sML, SC	9	0.14	CL-ML	7	0.14	16	SP	13	14							14
WM0007 65B/S	sML	12	0.14	SM	6.5	0.7	13.3	SW, SP-SM,GP-	15.5	14							14

1248

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: Hamilton Bend (MA 7)

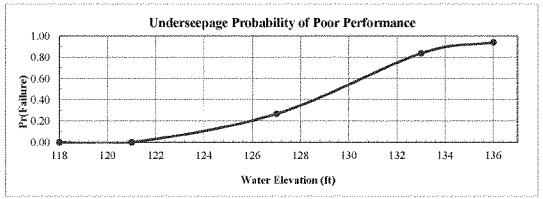
Levee Mile: 0.51
River Mile: 2288660.96 N; 6662820.24 E
Analysis Case Infinite landside blanket

Crest Elev.: 136.00
L/S Toe Elev.: 118.00
W/S Toe Elev.: 118.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permeability Ratio	11742	11507	98
Blanket Thickness (z)	12	3	26
Aquifer Thickness (d)	30	21	70

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	50	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	118.00	0.0000
Toe+3ft	3.00	121.00	0.0000
Half Height	9.00	127.00	0.2678
Crest-3ft	15.00	133.00	0.8376
Crest	18.00	136.00	0.9405

Crest	Rh
Head = 18.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	11742	12.01	29.92	49.99	2053.54	0.0134	16.55	1.38		
2	23249	12.01	29.92	50.00	2889.58	0.0097	16.94	1.41	0.057600	28.54
3	235	12.01	29.92	49.51	290.41	0.0637	11.12	0.93		
4	11742	15.18	29.92	49.99	2309.16	0.0120	16.70	1.10	0.140625	69.68
5	11742	8.83	29.92	49.99	1761.20	0.0154	16.33	1.85		
6	11742	12.01	50.86	49.99	2677.48	0.0178	16.87	1.41	0.003600	1.78
7	11742	12.01	8.98	49.97	1124.79	0.0069	15.52	1.29		
								Total	0.201825	100.00

E[I] = 1.380000
Var[I]= 0.201825
σ[I]= 0.449249
V(I) = 0.325543

E[ln I] = 0.271718
σ [ln I] = 0.317380

Ic= 0.80
ln(I crit) = -0.223144

β = 0.856129
F(z) = 0.059474
Pr(f) % = 94.052644

Crest-3ft	Rh
Head = 15.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	11742	12.01	29.92	49.99	2053.54	0.0134	13.79	1.15		
2	23249	12.01	29.92	50.00	2889.58	0.0097	14.12	1.18	0.042025	29.99
3	235	12.01	29.92	49.51	290.41	0.0637	9.27	0.77		
4	11742	15.18	29.92	49.99	2309.16	0.0120	13.92	0.92	0.096100	68.57
5	11742	8.83	29.92	49.99	1761.20	0.0154	13.61	1.54		
6	11742	12.01	50.86	49.99	2677.48	0.0178	14.06	1.17	0.002025	1.44
7	11742	12.01	8.98	49.97	1124.79	0.0069	12.93	1.08		
								Total	0.140150	100.00

E[I] = 1.150000
Var[I]= 0.140150
σ[I]= 0.374366
V(I) = 0.325536

E[ln I] = 0.089399
σ [ln I] = 0.317374

Ic= 0.80
ln(I crit) = -0.223144

β = 0.281684
F(z) = 0.162367
Pr(f) % = 83.763344

Half Height	Rh
Head = 9.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	11742	12.01	29.92	49.99	2053.54	0.0134	8.27	0.69		
2	23249	12.01	29.92	50.00	2889.58	0.0097	8.47	0.71	0.015625	29.85
3	235	12.01	29.92	49.51	290.41	0.0637	5.56	0.46		
4	11742	15.18	29.92	49.99	2309.16	0.0120	8.35	0.55	0.036100	68.96
5	11742	8.83	29.92	49.99	1761.20	0.0154	8.17	0.93		
6	11742	12.01	50.86	49.99	2677.48	0.0178	8.43	0.70	0.000625	1.19
7	11742	12.01	8.98	49.97	1124.79	0.0069	7.76	0.65		
								Total	0.052350	100.00

E[I] = 0.690000
Var[I]= 0.052350
σ[I]= 0.228801
V(I) = 0.331596

E[ln I] = -0.423224
σ [ln I] = 0.322986

Ic= 0.80
ln(I crit) = -0.223144

β = -1.310345
F(z) = 0.732196
Pr(f) % = 26.780357

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	11742	12.01	29.92	49.99	2053.54	0.0134	2.76	0.23		
2	23249	12.01	29.92	50.00	2889.58	0.0097	2.82	0.23	0.001600	27.35
3	235	12.01	29.92	49.51	290.41	0.0637	1.85	0.15		
4	11742	15.18	29.92	49.99	2309.16	0.0120	2.78	0.18	0.004225	72.22
5	11742	8.83	29.92	49.99	1761.20	0.0154	2.72	0.31		
6	11742	12.01	50.86	49.99	2677.48	0.0178	2.81	0.23	0.000025	0.43
7	11742	12.01	8.98	49.97	1124.79	0.0069	2.59	0.22		
								Total	0.005850	100.00

E[I] = 0.230000
Var[I]= 0.005850
σ[I]= 0.076485
V(I) = 0.332545

E[ln I] = -1.522120
σ [ln I] = 0.323864

Ic= 0.80
ln(I crit) = -0.223144

β = -4.699875
F(z) = 0.999970
Pr(f) % = 0.003025

1249

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: Hamilton Bend (MA 7)

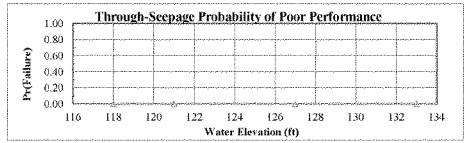
Levee Mile: 0.51
River Mile: 2288660.96 N; 6662820.24 E
Analysis Case Infinite landside blanket

Crest Elev.: 136.00
L/S Toe Elev.: 118.00
W/S Toe Elev.: 118.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	118.00	0.0000
Toe+3ft	3.00	121.00	0.000000
Half Height	9.00	127.00	0.000000
Crest-3ft	15.00	133.00	0.000000
Crest	18.00	136.00	0.000000

Crest — Head = 18.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft — Head = 15.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Half Height — Head = 9.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft — Head = 3.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

1250

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

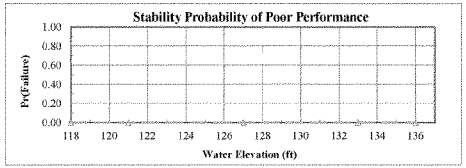
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: Hamilton Bend (MA 7)

Levee Mile: 0.51
River Mile: 2288660.96 N; 6662820.24 E
Analysis Case Infinite landside blanket

Crest Elev.: 136.00
L/S Toe Elev.: 118.00
W/S Toe Elev.: 118.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 2/21/2013

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee ϕ'	29	1	5.00
Levee γ	120	6	5.00
Foundation c'	150	17	11.50
Foundation γ	120	6	5.00
Foundation ϕ'	31	4	11.50



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	118.00	0.0000
Toe+3ft	3.00	121.00	0.000000
Half Height	9.00	127.00	0.000000
Crest-3ft	15.00	133.00	0.000322
Crest	18.00	136.00	0.000000

Crest	Head =	18.00	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.67		
2	28	120	150	120	31	1.71	0.001892	10.54
3	30	120	150	120	31	1.62		
4	29	114	150	120	31	1.69	0.000240	1.34
5	29	126	150	120	31	1.66		
6	29	120	133	120	31	1.73	0.015006	83.59
7	29	120	167	120	31	1.48		
8	29	120	150	114	31	1.70	0.000812	4.52
9	29	120	150	126	31	1.64		
10	29	120	150	120	27	1.74	0.000002	0.01
11	29	120	150	120	35	1.75		

E[FS] =	1.671000	E[ln FS] =	0.510218	Total	0.017953	100.00
Var[FS]=	0.017953				
σ[FS]=	0.133990	σ[ln FS]=	0.080057	β =	6.373187
V(FS) =	0.080185	ln(FS req'd) =	0.000000	F(z) =	0.000000
FS req'd =	1.00			Pr(f) % =	0.000000

Crest-3ft	Head =	15.00	Pr(f)=0	NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31	1.80		
2	28	120	150	120	31	1.75	0.001936	2.11
3	30	120	150	120	31	1.84		
4	29	114	150	120	31	1.83	0.000812	0.88
5	29	126	150	120	31	1.77		
6	29	120	133	120	31	1.38	0.078400	85.41
7	29	120	167	120	31	1.94		
8	29	120	150	114	31	1.73	0.004556	4.96
9	29	120	150	126	31	1.86		
10	29	120	150	120	27	1.72	0.006084	6.63
11	29	120	150	120	35	1.87		

E[FS] =	1.796000	E[ln FS] =	0.571533	Total	0.091789	100.00
Var[FS]=	0.091789				
σ[FS]=	0.302966	σ[ln FS]=	0.167507	β =	3.411982
V(FS) =	0.168689			F(z) =	0.000322
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.032246

Half Height	Head =	9.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] =		E[ln FS] =		Total	
Var[FS]=					
σ[FS]=		σ[ln FS]=		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	29	120	150	120	31			
2	28	120	150	120	31			
3	30	120	150	120	31			
4	29	114	150	120	31			
5	29	126	150	120	31			
6	29	120	133	120	31			
7	29	120	167	120	31			
8	29	120	150	114	31			
9	29	120	150	126	31			
10	29	120	150	120	27			
11	29	120	150	120	35			

E[FS] =		E[ln FS] =		Total	
Var[FS]=					
σ[FS]=		σ[ln FS]=		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

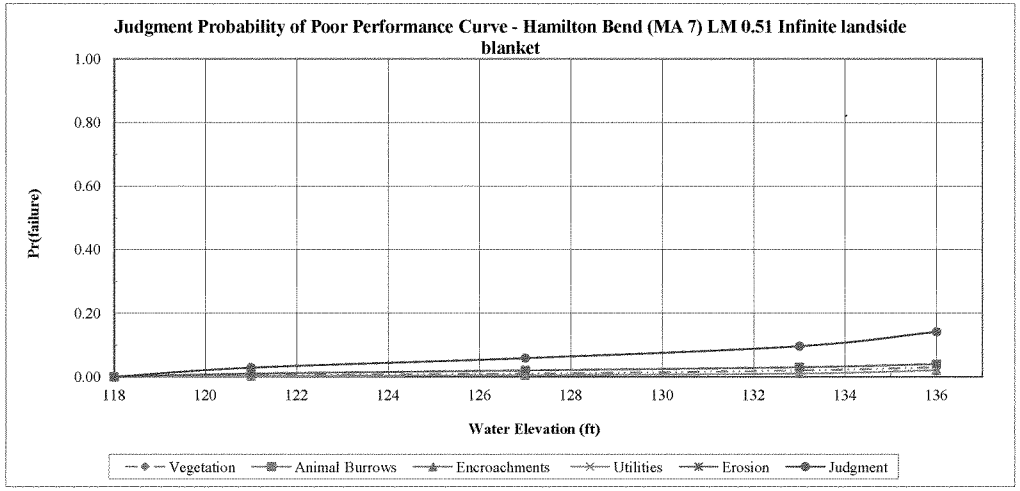
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: Hamilton Bend (MA 7)

Levee Mile: 0.51
River Mile: 2288660.96 N
Analysis Case: Infinite landside blanket

Crest Elev.: 136.00
L/S Toe Elev.: 118.00
W/S Toe Elev.: 118.00

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 2/21/

Water Surface	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
118.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
121.00	0.0050	0.9950	0.0100	0.9900	0.0020	0.9980	0.0020	0.9980	0.0100	0.9900	0.0287	0.9713
127.00	0.0100	0.9900	0.0200	0.9800	0.0050	0.9950	0.0050	0.9950	0.0200	0.9800	0.0587	0.9413
133.00	0.0200	0.9800	0.0300	0.9700	0.0100	0.9900	0.0100	0.9900	0.0300	0.9700	0.0963	0.9037
136.00	0.0300	0.9700	0.0400	0.9600	0.0200	0.9800	0.0200	0.9800	0.0400	0.9600	0.1414	0.8586



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

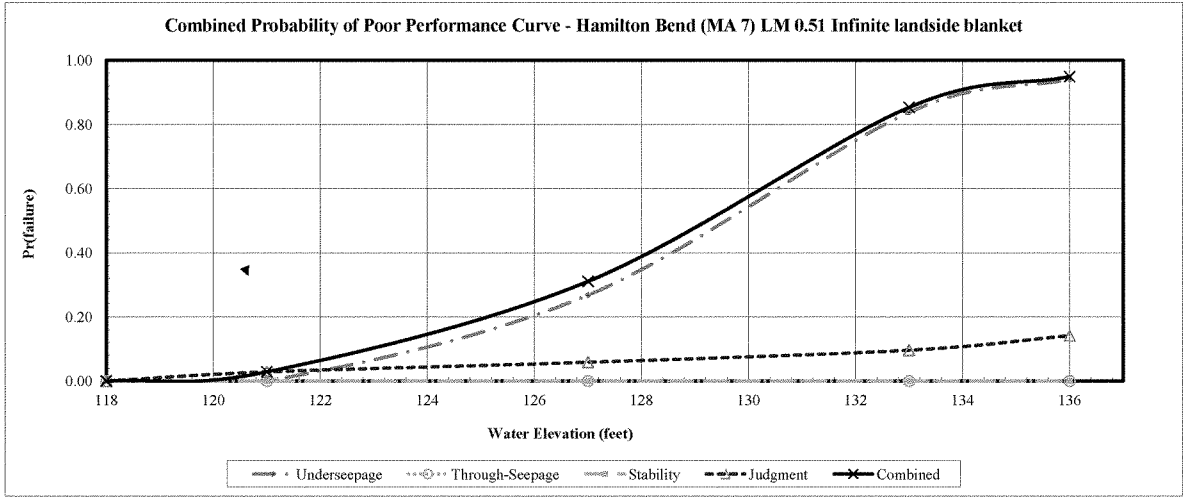
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: Hamilton Bend (MA 7)

Levee Mile: 0.51
River Mile: 2288660.96 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 136.00
L/S Toe Elev.: 118.00
W/S Toe Elev.: 118.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 2/21/20

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
118.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
121.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0287	0.9713	0.0287	0.9713
127.00	0.2678	0.7322	0.0000	1.0000	0.0000	1.0000	0.0587	0.9413	0.3108	0.6892
133.00	0.8376	0.1624	0.0000	1.0000	0.0003	0.9997	0.0963	0.9037	0.8533	0.1467
136.00	0.9405	0.0595	0.0000	1.0000	0.0000	1.0000	0.1414	0.8586	0.9489	0.0511



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Cherokee Canal
Basin and Reach: East Levee

Levee Mile: 9.50
Coordinates: 2301045.948 N: 6637006.261 E
Analysis Case Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/12

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
2F-08-34	7					9					CL-ML	0.01	SM, GC	3	300				
2F-08-35	3.2					8.3					CL-ML	0.01	SM	1.12	112				
2F-08-36	19					9.5					SC/CL	0.007	SW	10	1429				
2F-08-37	11					10.3					ML/SC/ML	0.1	SW	10	100				
2F-08-38	5	8	5	27	63	15.5	9	5	31	56	CL	0.007	SW	10	1429	417	578	313877	98
2F-08-39	10					13.3					ML/SM/ML	0.14	SM	10	71				
2F-08-40	5					1.5					MH	0.01	SC	1	100				
2F-08-41	9.5					1.5					CL	0.007	SC	1	143				
2F-08-42	6					14.5					sML	0.14	SW, SWg, ML	10	71				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
2F-08-34	CL-ML	7	0.01				7	SM, GC	9	3							3
2F-08-35	CL-ML	3.2	0.01				3.2	SM	8.3	1.12							1.12
2F-08-36	SC	10	0.007	CL	9	0.007	19	SW	9.5	10							10
2F-08-37	ML/SC/ML	11	0.1				11	SW	10.3	10							10
2F-08-38	CL	5	0.007				5	SW	15.5	10							10
2F-08-39	ML	8	0.14	SM/ML	8	0.56	10	SM	13.3	10							10
2F-08-40	MH	5	0.01				5	SC	1.5	1							1
2F-08-41	CL	9.5	0.007				9.5	SC	1.5	1							1
2F-08-42	sML	6	0.14				6	SW, SWg, ML	14.5	10							10

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Cherokee Canal
River Section: East Levee

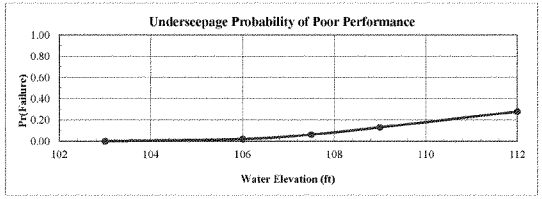
Levee Mile: 9.50
River Mile: 2301045.948 N: 6637006.261 E
Analysis Case Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/12

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permeability Ratio	417	409	98
Blanket Thickness (z)	8	5	63
Aquifer Thickness (d)	9	5	56

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	49	65	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	103.00	0.0000
Toe+3ft	3.00	106.00	0.0195
Half Height	4.50	107.50	0.0620
Crest-3ft	6.00	109.00	0.1300
Crest	9.00	112.00	0.2780

Crest	Rb
Head = 9.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	417	8.00	9.00	47.73	173.27	0.0315	5.45	0.68		
2	826	8.00	9.00	48.35	243.82	0.0252	6.14	0.77	0.070225	21.12
3	8	8.00	9.00	23.62	24.50	0.0796	1.95	0.24		
4	417	13.00	9.00	48.21	220.88	0.0269	5.95	0.46	0.255025	76.71
5	417	3.00	9.00	45.79	106.11	0.0415	4.40	1.47		
6	417	8.00	14.00	48.18	216.11	0.0425	5.91	0.74	0.007225	2.17
7	417	8.00	4.00	46.26	115.52	0.0176	4.58	0.57		
								Total	0.332475	100.00

E[I] = 0.680000
Var[I]= 0.332475
σ[I]= 0.576606
V(I) = 0.847951

E[ln I] = -0.656540
σ [ln I] = 0.736040

Ic= 0.80
ln(I crit) = -0.223144

β = -0.891990
F(z) = 0.722010
Pr(f) % = 27.799044

Crest-3ft	Rb
Head = 6.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	417	8.00	9.00	47.73	173.27	0.0315	3.64	0.46		
2	826	8.00	9.00	48.35	243.82	0.0252	4.10	0.51	0.030625	20.99
3	8	8.00	9.00	23.62	24.50	0.0796	1.30	0.16		
4	417	13.00	9.00	48.21	220.88	0.0269	3.97	0.31	0.112225	76.93
5	417	3.00	9.00	45.79	106.11	0.0415	2.94	0.98		
6	417	8.00	14.00	48.18	216.11	0.0425	3.94	0.49	0.003025	2.07
7	417	8.00	4.00	46.26	115.52	0.0176	3.06	0.38		
								Total	0.145875	100.00

E[I] = 0.460000
Var[I]= 0.145875
σ[I]= 0.381936
V(I) = 0.830295

E[ln I] = -1.038713
σ [ln I] = 0.724132

Ic= 0.80
ln(I crit) = -0.223144

β = -1.434424
F(z) = 0.869975
Pr(f) % = 13.002548

Half Height	Rb
Head = 4.50	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	417	8.00	9.00	47.73	173.27	0.0315	2.73	0.34		
2	826	8.00	9.00	48.35	243.82	0.0252	3.07	0.38	0.016900	20.86
3	8	8.00	9.00	23.62	24.50	0.0796	0.97	0.12		
4	417	13.00	9.00	48.21	220.88	0.0269	2.98	0.23	0.062500	77.16
5	417	3.00	9.00	45.79	106.11	0.0415	2.20	0.73		
6	417	8.00	14.00	48.18	216.11	0.0425	2.95	0.37	0.001600	1.98
7	417	8.00	4.00	46.26	115.52	0.0176	2.29	0.29		
								Total	0.081000	100.00

E[I] = 0.340000
Var[I]= 0.081000
σ[I]= 0.284605
V(I) = 0.837073

E[ln I] = -1.344327
σ [ln I] = 0.728722

Ic= 0.80
ln(I crit) = -0.223144

β = -1.844775
F(z) = 0.938044
Pr(f) % = 6.195558

Toe+3ft	Rb
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	417	8.00	9.00	47.73	173.27	0.0315	1.82	0.23		
2	826	8.00	9.00	48.35	243.82	0.0252	2.05	0.26	0.008100	21.37
3	8	8.00	9.00	23.62	24.50	0.0796	0.65	0.08		
4	417	13.00	9.00	48.21	220.88	0.0269	1.98	0.15	0.028900	76.25
5	417	3.00	9.00	45.79	106.11	0.0415	1.47	0.49		
6	417	8.00	14.00	48.18	216.11	0.0425	1.97	0.25	0.000900	2.37
7	417	8.00	4.00	46.26	115.52	0.0176	1.53	0.19		
								Total	0.037900	100.00

E[I] = 0.230000
Var[I]= 0.037900
σ[I]= 0.194679
V(I) = 0.846431

E[ln I] = -1.739804
σ [ln I] = 0.735021

Ic= 0.80
ln(I crit) = -0.223144

β = -2.367012
F(z) = 0.980464
Pr(f) % = 1.953616

1255

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Cherokee Canal
River Section: East Levee

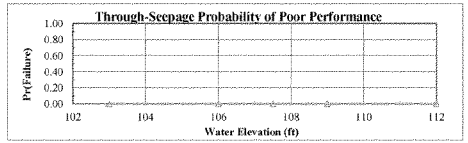
Levee Mile: 9.50
River Mile: 2301045.948 N: 6637006.261 E
Analysis Case Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/12

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	103.00	0.0000
Toe+3ft	3.00	106.00	0.000000
Half Height	4.50	107.50	0.000000
Crest-3ft	6.00	109.00	0.000000
Crest	9.00	112.00	0.000000

Crest — Head = 9.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft — Head = 6.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Half Height — Head = 4.50 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft — Head = 3.00 — Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = E[ln FS] = Total
Var[FS] =
σ[FS] = σ[ln FS] =
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

1256

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

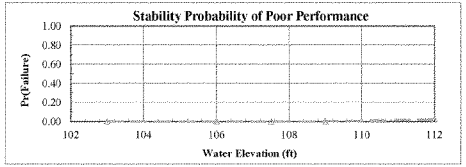
Project: Sutter Feasibility Study
Study Area: Cherokee Canal
River Section: East Levee

Levee Mile: 9.50
River Mile: 2301045.948 N: 6637006.261 E
Analysis Case Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/13/12

Random Variables				
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %	
Levee ϕ'	28	1	5.00	
Levee γ	120	6	5.00	
LEvee c'	150	17	11.50	
Foundation γ	115	6	5.00	
Foundation ϕ'	29	3	11.50	



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	103.00	0.0000
Toe+3ft	3.00	106.00	0.000000
Half Height	4.50	107.50	0.000000
Crest-3ft	6.00	109.00	0.000322
Crest	9.00	112.00	0.021343

Crest	Head =	9.00	Pr(f)=0	NO

Run	Levee ϕ'	Levee γ	LEvee c'	Foundation γ	Foundation ϕ'	FS	Variance Component	% Variance
1 (Mean)	28	120	150	115	29	1.50		
2	27	120	150	115	29	1.48	0.001225	1.44
3	29	120	150	115	29	1.55		
4	28	114	150	115	29	1.52	0.000169	0.20
5	28	126	150	115	29	1.50		
6	28	120	133	115	29	1.11	0.074529	87.51
7	28	120	167	115	29	1.66		
8	28	120	150	109	29	1.44	0.005402	6.34
9	28	120	150	121	29	1.58		
10	28	120	150	115	26	1.45	0.003844	4.51
11	28	120	150	115	32	1.57		

E[FS] =	1.504000	E[ln FS] =	0.389648	Total	0.085169	100.00
Var[FS] =	0.085169				
σ[FS] =	0.291838	σ[ln FS] =	0.192251	β =	2.026769
V(FS) =	0.194041			F(z) =	0.021343
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	2.134304

Crest-3ft	Head =	6.00	Pr(f)=0	NO

Run	Levee ϕ'	Levee γ	LEvee c'	Foundation γ	Foundation ϕ'	FS	Variance Component	% Variance
1 (Mean)	28	120	150	115	29	1.80		
2	27	120	150	115	29	1.75	0.001936	2.11
3	29	120	150	115	29	1.84		
4	28	114	150	115	29	1.83	0.000812	0.88
5	28	126	150	115	29	1.77		
6	28	120	133	115	29	1.38	0.078400	85.41
7	28	120	167	115	29	1.94		
8	28	120	150	109	29	1.73	0.004556	4.96
9	28	120	150	121	29	1.86		
10	28	120	150	115	26	1.72	0.006084	6.63
11	28	120	150	115	32	1.87		

E[FS] =	1.796000	E[ln FS] =	0.571533	Total	0.091789	100.00
Var[FS] =	0.091789					
σ[FS] =	0.302966	σ[ln FS] =	0.167507	β =	3.411982	
V(FS) =	0.168689			F(z) =	0.000322	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.032246	

Half Height	Head =	4.50	Pr(f)=0	YES

Run	Levee ϕ'	Levee γ	LEvee c'	Foundation γ	Foundation ϕ'	FS	Variance Component	% Variance
1 (Mean)	28	120	150	115	29			
2	27	120	150	115	29			
3	29	120	150	115	29			
4	28	114	150	115	29			
5	28	126	150	115	29			
6	28	120	133	115	29			
7	28	120	167	115	29			
8	28	120	150	109	29			
9	28	120	150	121	29			
10	28	120	150	115	26			
11	28	120	150	115	32			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee ϕ'	Levee γ	LEvee c'	Foundation γ	Foundation ϕ'	FS	Variance Component	% Variance
1 (Mean)	28	120	150	115	29			
2	27	120	150	115	29			
3	29	120	150	115	29			
4	28	114	150	115	29			
5	28	126	150	115	29			
6	28	120	133	115	29			
7	28	120	167	115	29			
8	28	120	150	109	29			
9	28	120	150	121	29			
10	28	120	150	115	26			
11	28	120	150	115	32			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

1257

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

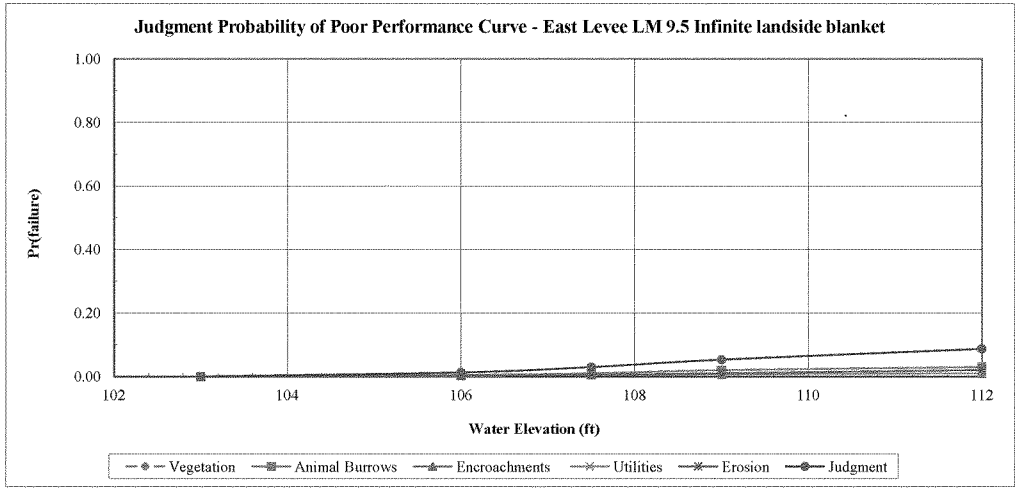
Project: Sutter Feasibility Study
Study Area: Cherokee Canal
River Section: East Levee

Levee Mile: 9.50
River Mile: 2301045.948
Analysis Case: Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 9/13/

Water Surface	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
103.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
106.00	0.0020	0.9980	0.0050	0.9950	0.0020	0.9980	0.0020	0.9980	0.0020	0.9980	0.0129	0.9871
107.50	0.0050	0.9950	0.0100	0.9900	0.0050	0.9950	0.0050	0.9950	0.0050	0.9950	0.0297	0.9703
109.00	0.0100	0.9900	0.0200	0.9800	0.0070	0.9930	0.0070	0.9930	0.0100	0.9900	0.0529	0.9471
112.00	0.0200	0.9800	0.0300	0.9700	0.0100	0.9900	0.0100	0.9900	0.0200	0.9800	0.0870	0.9130



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

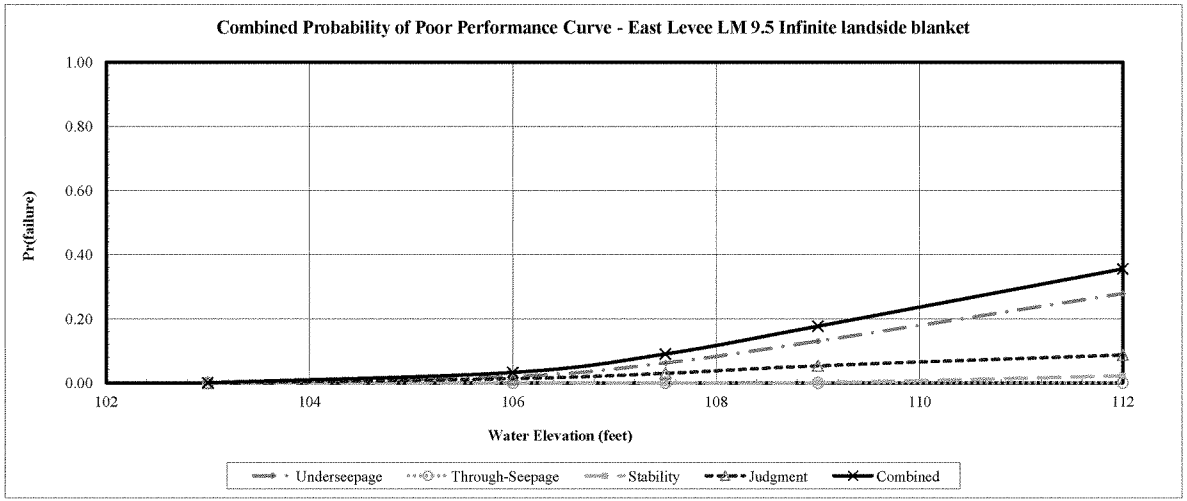
Project: Sutter Feasibility Study
Study Area: Cherokee Canal
River Section: East Levee

Levee Mile: 9.50
River Mile: 2301045.948 N:
Analysis Case: Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/13/12

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
103.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
106.00	0.0195	0.9805	0.0000	1.0000	0.0000	1.0000	0.0129	0.9871	0.0322	0.9678
107.50	0.0620	0.9380	0.0000	1.0000	0.0000	1.0000	0.0297	0.9703	0.0898	0.9102
109.00	0.1300	0.8700	0.0000	1.0000	0.0003	0.9997	0.0529	0.9471	0.1763	0.8237
112.00	0.2780	0.7220	0.0000	1.0000	0.0213	0.9787	0.0870	0.9130	0.3548	0.6452



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Wadsworth Canal - Right Bank
Basin and Reach:

Levee Mile: 0.50
Coordinates: 2168750 N; 6627910 E
Analysis Case

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/14/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
2F-00-01	6					13					CL	0.0071	SP-SC	10	1408				
2F-03-26	6					6					CL	0.0071	SP	28	3944				
2F-00-02	7.87					7					CL/ML/SC	0.0284	SP-SC	14	493				
2F-00-09	5.62					30					CL/ML	0.0284	SM/SP	2.8	99				
2F-00-10	8.41					30					CL/ML	0.0071	SP-SM/SP	10.27	1446				
2F-03-28	4.77	7	2	11	29	2.5	13	11	122	85	CL/SM	0.0284	SP	28	986	1244	1249	1489425	98
WSEWWC_001 A	10.5					11					CL, CH	0.0071	SM/SP-SM	11.14	1569				
WSEWWC_029 B	4					7					CL	0.28	SP-SM	2.8	10				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
2F-00-01	CL	6	0.0071				6.0	SP-SC	13	10							10
2F-03-26	CL	6	0.0071				6.0	SP	6	28							28
2F-00-02	CL	3	0.0284	ML/SC	6	0.035	7.9	SP-SC	7	14							14
2F-00-09	CL	4	0.0284	ML	2	0.035	5.6	SM	2	2.8	SP	28					2.8
2F-00-10	CL	8	0.0071	ML	2	0.035	8.4	SP-SM	2	14	SP	28	10				10.27
2F-03-28	CL	4	0.0284	SM	9.5	0.35	4.8	SP	2.5	28							28
WSEWWC_001 A	CL, CH	10.5	0.0071				10.5	SM	2.5	1.4	SP-SM	8.5	14				11.14
WSEWWC_029 B	CL	4	0.28				4	SP-SM	7	2.8							2.8

1260

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

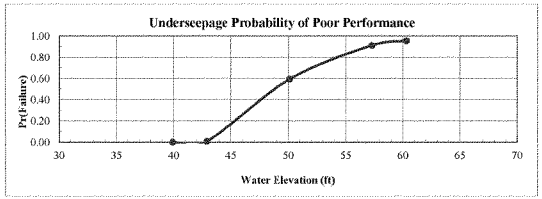
Levee Mile: 0.50
River Mile: 2168750 N; 6627910 E
Analysis Case

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/14/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permeability Ratio	1244	1219	98
Blanket Thickness (z)	7	2	29
Aquifer Thickness (d)	13	11	85

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	25	130	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	39.90	0.0000
Toe+3ft	3.00	42.90	0.0088
Half Height	10.20	50.10	0.5935
Crest-3ft	17.40	57.30	0.9112
Crest	20.40	60.30	0.9547

Crest	Rh
Head = 20.40	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1244	7.00	13.00	24.95	336.46	0.0265	13.97	2.00		
2	2463	7.00	13.00	24.98	473.44	0.0207	15.37	2.20	0.570025	56.35
3	25	7.00	13.00	22.93	47.58	0.0648	4.84	0.69		
4	1244	9.00	13.00	24.96	381.51	0.0242	14.51	1.61	0.265225	26.22
5	1244	5.00	13.00	24.94	284.36	0.0296	13.20	2.64		
6	1244	7.00	24.00	24.98	457.16	0.0392	15.24	2.18	0.176400	17.44
7	1244	7.00	2.00	24.71	131.97	0.0070	9.39	1.34		
								Total	1.011650	100.00

E[I] = 2.000000
Var[I] = 1.011650
σ[I] = 1.005808
V(I) = 0.502904

E[ln I] = 0.580412
σ [ln I] = 0.474838

Ic = 0.80
ln(I crit) = -0.223144

β = 1.222337
F(z) = 0.045297
Pr(f) % = 95.470399

Crest-3ft	Rh
Head = 17.40	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1244	7.00	13.00	24.95	336.46	0.0265	11.91	1.70		
2	2463	7.00	13.00	24.98	473.44	0.0207	13.11	1.87	0.409600	55.90
3	25	7.00	13.00	22.93	47.58	0.0648	4.13	0.59		
4	1244	9.00	13.00	24.96	381.51	0.0242	12.37	1.37	0.193600	26.42
5	1244	5.00	13.00	24.94	284.36	0.0296	11.26	2.25		
6	1244	7.00	24.00	24.98	457.16	0.0392	12.99	1.86	0.129600	17.69
7	1244	7.00	2.00	24.71	131.97	0.0070	8.01	1.14		
								Total	0.732800	100.00

E[I] = 1.700000
Var[I] = 0.732800
σ[I] = 0.856037
V(I) = 0.503551

E[ln I] = 0.417633
σ [ln I] = 0.475385

Ic = 0.80
ln(I crit) = -0.223144

β = 0.878515
F(z) = 0.088843
Pr(f) % = 91.115651

Half Height	Rh
Head = 10.20	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1244	7.00	13.00	24.95	336.46	0.0265	6.98	1.00		
2	2463	7.00	13.00	24.98	473.44	0.0207	7.68	1.10	0.140625	56.31
3	25	7.00	13.00	22.93	47.58	0.0648	2.42	0.35		
4	1244	9.00	13.00	24.96	381.51	0.0242	7.25	0.81	0.065025	26.04
5	1244	5.00	13.00	24.94	284.36	0.0296	6.60	1.32		
6	1244	7.00	24.00	24.98	457.16	0.0392	7.62	1.09	0.044100	17.66
7	1244	7.00	2.00	24.71	131.97	0.0070	4.70	0.67		
								Total	0.249750	100.00

E[I] = 1.000000
Var[I] = 0.249750
σ[I] = 0.499750
V(I) = 0.499750

E[ln I] = -0.111472
σ [ln I] = 0.472169

Ic = 0.80
ln(I crit) = -0.223144

β = -0.236084
F(z) = 0.406519
Pr(f) % = 59.348079

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	1244	7.00	13.00	24.95	336.46	0.0265	2.05	0.29		
2	2463	7.00	13.00	24.98	473.44	0.0207	2.26	0.32	0.012100	56.74
3	25	7.00	13.00	22.93	47.58	0.0648	0.71	0.10		
4	1244	9.00	13.00	24.96	381.51	0.0242	2.13	0.24	0.005625	26.38
5	1244	5.00	13.00	24.94	284.36	0.0296	1.94	0.39		
6	1244	7.00	24.00	24.98	457.16	0.0392	2.24	0.32	0.003600	16.88
7	1244	7.00	2.00	24.71	131.97	0.0070	1.38	0.20		
								Total	0.021325	100.00

E[I] = 0.290000
Var[I] = 0.021325
σ[I] = 0.146031
V(I) = 0.503555

E[ln I] = -1.350871
σ [ln I] = 0.475387

Ic = 0.80
ln(I crit) = -0.223144

β = -2.841621
F(z) = 0.991159
Pr(f) % = 0.884059

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

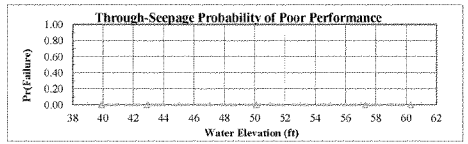
Levee Mile: 0.50
River Mile: 2168750 N; 6627910 E
Analysis Case

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/14/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	39.90	0.0000
Toe+3ft	3.00	42.90	0.000000
Half Height	10.20	50.10	0.000000
Crest-3ft	17.40	57.30	0.000000
Crest	20.40	60.30	0.000000

Crest | Head = 20.40 | Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = | E[ln FS] = | Total
Var[FS] = | | |
σ[FS] = | σ[ln FS] = | β =
V(FS) = | | F(z) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000 | Pr(f) % = 0.000000

Crest-3ft | Head = 17.40 | Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = | E[ln FS] = | Total
Var[FS] = | | |
σ[FS] = | σ[ln FS] = | β =
V(FS) = | | F(z) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000 | Pr(f) % = 0.000000

Half Height | Head = 10.20 | Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = | E[ln FS] = | Total
Var[FS] = | | |
σ[FS] = | σ[ln FS] = | β =
V(FS) = | | F(z) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000 | Pr(f) % = 0.000000

Toe+3ft | Head = 3.00 | Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = | E[ln FS] = | Total
Var[FS] = | | |
σ[FS] = | σ[ln FS] = | β =
V(FS) = | | F(z) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000 | Pr(f) % = 0.000000

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Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

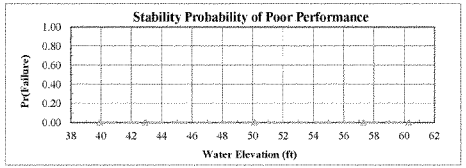
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

Levee Mile: 0.50
River Mile: 2168750 N; 6627910 E
Analysis Case

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/14/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee Φ	32	4	13.00
Levee Cohesion	10	4	40.00
Levee γ	125	9	7.00
Foundation Φ	28	4	13.00
Foundation Cohesion	100	40	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	39.90	0.0000
Toe+3ft	3.00	42.90	0.000000
Half Height	10.20	50.10	0.000000
Crest-3ft	17.40	57.30	0.000000
Crest	20.40	60.30	0.000026

Crest	Head =	20.40	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	32	10	125	28	100	1.49		
2	28	10	125	28	100	1.46	0.000930	4.37
3	36	10	125	28	100	1.52		
4	32	6	125	28	100	1.49	0.000020	0.10
5	32	14	125	28	100	1.50		
6	32	10	116	28	100	1.51	0.000342	1.61
7	32	10	134	28	100	1.47		
8	32	10	125	24	100	1.43	0.004489	21.09
9	32	10	125	32	100	1.56		
10	32	10	125	28	60	1.35	0.015500	72.83
11	32	10	125	28	140	1.60		

E[FS] =	1.491000	E[ln FS] =	0.394683	Total	0.021282	100.00
Var[FS] =	0.021282				
σ[FS] =	0.145884	σ[ln FS] =	0.097610	β =	4.043480
V(FS) =	0.097843			F(z) =	0.000026
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.002633

Crest-3ft	Head =	17.40	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	32	10	125	28	100			
2	28	10	125	28	100			
3	36	10	125	28	100			
4	32	6	125	28	100			
5	32	14	125	28	100			
6	32	10	116	28	100			
7	32	10	134	28	100			
8	32	10	125	24	100			
9	32	10	125	32	100			
10	32	10	125	28	60			
11	32	10	125	28	140			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Half Height	Head =	10.20	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	32	10	125	28	100			
2	28	10	125	28	100			
3	36	10	125	28	100			
4	32	6	125	28	100			
5	32	14	125	28	100			
6	32	10	116	28	100			
7	32	10	134	28	100			
8	32	10	125	24	100			
9	32	10	125	32	100			
10	32	10	125	28	60			
11	32	10	125	28	140			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	32	10	125	28	100			
2	28	10	125	28	100			
3	36	10	125	28	100			
4	32	6	125	28	100			
5	32	14	125	28	100			
6	32	10	116	28	100			
7	32	10	134	28	100			
8	32	10	125	24	100			
9	32	10	125	32	100			
10	32	10	125	28	60			
11	32	10	125	28	140			

E[FS] =		E[ln FS] =		Total	
Var[FS] =					
σ[FS] =		σ[ln FS] =		β =	
V(FS) =				F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

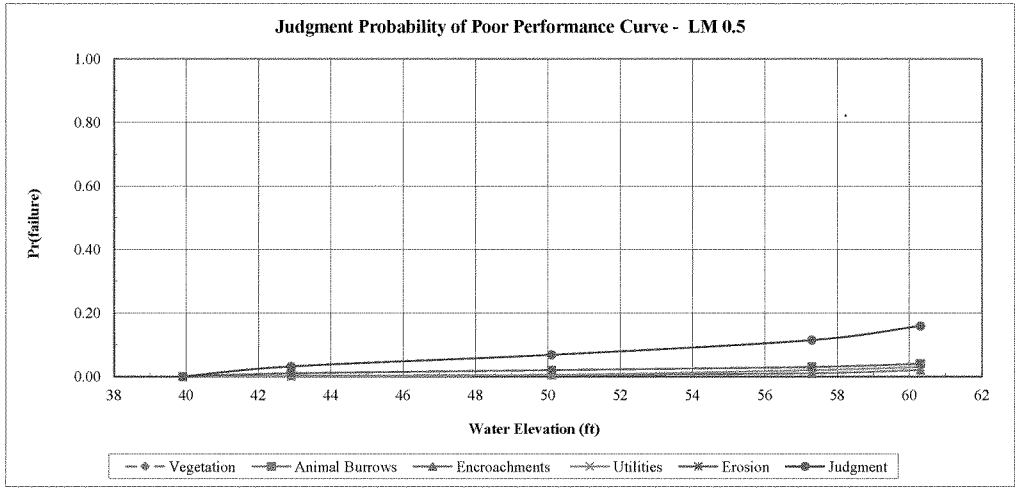
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

Levee Mile: 0.50
River Mile: 2168750 N; 6
Analysis Case:

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/1

Water Surface	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
39.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
42.90	0.0100	0.9900	0.0100	0.9900	0.0020	0.9980	0.0000	1.0000	0.0100	0.9900	0.0316	0.9684
50.10	0.0200	0.9800	0.0200	0.9800	0.0050	0.9950	0.0050	0.9950	0.0200	0.9800	0.0682	0.9318
57.30	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.0300	0.9700	0.1145	0.8855
60.30	0.0400	0.9600	0.0400	0.9600	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.1590	0.8410



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

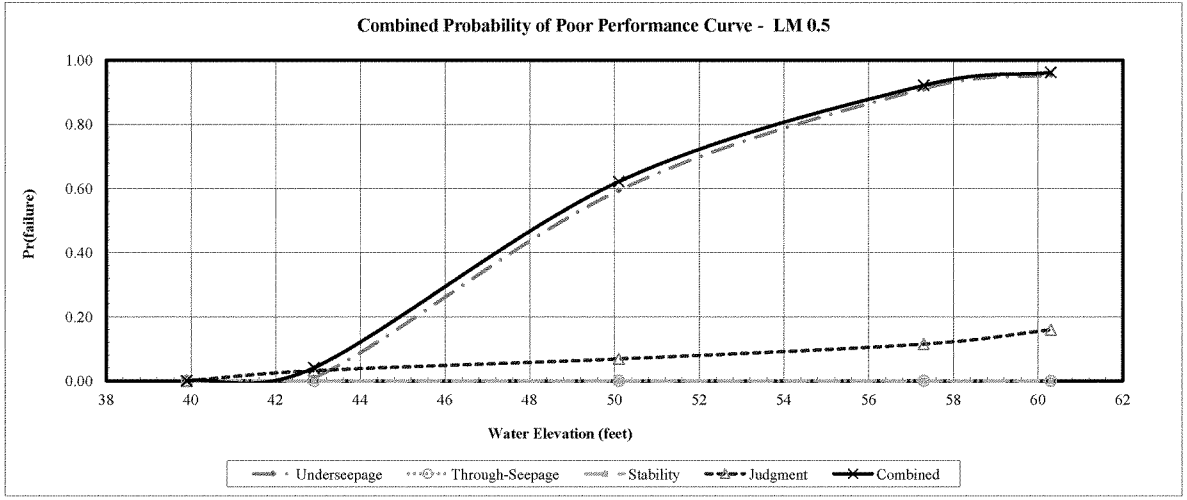
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

Levee Mile: 0.50
River Mile: 2168750 N; 662
Analysis Case:

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/14/

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
39.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
42.90	0.0088	0.9912	0.0000	1.0000	0.0000	1.0000	0.0316	0.9684	0.0402	0.9598
50.10	0.5935	0.4065	0.0000	1.0000	0.0000	1.0000	0.0682	0.9318	0.6212	0.3788
57.30	0.9112	0.0888	0.0000	1.0000	0.0000	1.0000	0.1145	0.8855	0.9213	0.0787
60.30	0.9547	0.0453	0.0000	1.0000	0.0000	1.0000	0.1590	0.8410	0.9619	0.0381



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Sutter Feasibility Study
Channel: Sutter Bypass
Basin and Reach: Left Levee

Levee Mile: 4.00
Coordinates: 2168110 N, 6626590 E
Analysis Case Infinite waterside/landside blanket

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/14/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WSESBP 011B	14					9					sCL/CH	0.007	SP-SM	10	1429				
WSESBP 015B	9					16.5					CL,s,CL,ML	0.1	SM	3	30				
WSESBP 016B	10.5					9					SM/CL	0.007	SP-SM	10	1429				
WSESBP 017B	8	10	4	25	40	2	10	6	43	60	CL,SM	0.3	SP-SM	10	33	725	650	427548	90
WSESBP 018B	14					8					CL,SM/CL	0.007	SP-SM,ML,sMI	3	429				
WSESBP 019B	4.8					17.5					CL/ML	0.01	SP-SM	10	1000				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	(kf)
WSESBP 011B	sCL	6	0.007	CH	8	0.007	14	SP-SM	9	10							10
WSESBP 015B	CL,s,CL,ML	9	0.1				9	SM	16.5	3							3
WSESBP 016B	SM	2	0.007	CL	8.5	0.007	10.5	SP-SM	9	10							10
WSESBP 017B	CL,SM	8	0.3				8	SP-SM	2	10							10
WSESBP 018B	CL,SM	2.5	0.007	CL	11.5	0.007	14	SP-SM,ML,sMI	8	3							3
WSESBP 019B	CL	4.5	0.01	ML	3	0.1	4.8	SP-SM	17.5	10							10

1266

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: Left Levee

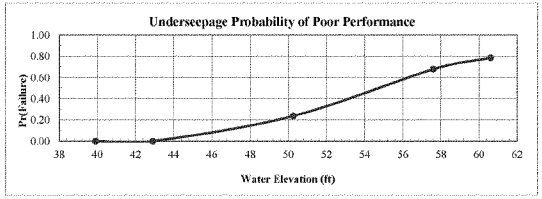
Levee Mile: 4.00
River Mile: 2168110 N; 6626590 E
Analysis Case Infinite waterside/landside blanket

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/14/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaeability Ratio	725	650	90
Blanket Thickness (z)	10	4	40
Aquifer Thickness (d)	10	6	60

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	15	150	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	39.90	0.0000
Toe+3ft	3.00	42.90	0.0004
Half Height	10.35	50.25	0.2366
Crest-3ft	17.70	57.60	0.6780
Crest	20.70	60.60	0.7846

Crest	Rh
Head = 20.70	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	12.84	1.28		
2	1375	10.00	10.00	14.99	370.81	0.0187	14.33	1.43	0.129600	33.32
3	75	10.00	10.00	14.85	86.60	0.0398	7.13	0.71		
4	725	14.00	10.00	14.99	318.59	0.0207	13.64	0.97	0.230400	59.24
5	725	6.00	10.00	14.97	208.57	0.0268	11.56	1.93		
6	725	10.00	16.00	14.99	340.59	0.0316	13.94	1.39	0.028900	7.43
7	725	10.00	4.00	14.96	170.29	0.0119	10.51	1.05		
								Total	0.388900	100.00

E[I] = 1.280000
Var[I]= 0.388900
σ[I]= 0.623618
V(I) = 0.487202

E[ln I] = 0.140368
σ [ln I] = 0.461503

Ic= 0.80
ln(I crit) = -0.223144

β = 0.304154
F(z) = 0.215445
Pr(f) % = 78.455479

Crest-3ft	Rh
Head = 17.70	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	10.98	1.10		
2	1375	10.00	10.00	14.99	370.81	0.0187	12.25	1.23	0.096100	33.69
3	75	10.00	10.00	14.85	86.60	0.0398	6.10	0.61		
4	725	14.00	10.00	14.99	318.59	0.0207	11.66	0.83	0.168100	58.94
5	725	6.00	10.00	14.97	208.57	0.0268	9.88	1.65		
6	725	10.00	16.00	14.99	340.59	0.0316	11.92	1.19	0.021025	7.37
7	725	10.00	4.00	14.96	170.29	0.0119	8.99	0.90		
								Total	0.285225	100.00

E[I] = 1.100000
Var[I]= 0.285225
σ[I]= 0.534065
V(I) = 0.485513

E[ln I] = -0.010518
σ [ln I] = 0.460061

Ic= 0.80
ln(I crit) = -0.223144

β = -0.022862
F(z) = 0.321980
Pr(f) % = 67.801936

Half Height	Rh
Head = 10.35	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	6.42	0.64		
2	1375	10.00	10.00	14.99	370.81	0.0187	7.16	0.72	0.032400	34.16
3	75	10.00	10.00	14.85	86.60	0.0398	3.56	0.36		
4	725	14.00	10.00	14.99	318.59	0.0207	6.82	0.49	0.055225	58.22
5	725	6.00	10.00	14.97	208.57	0.0268	5.78	0.96		
6	725	10.00	16.00	14.99	340.59	0.0316	6.97	0.70	0.007225	7.62
7	725	10.00	4.00	14.96	170.29	0.0119	5.26	0.53		
								Total	0.094850	100.00

E[I] = 0.640000
Var[I]= 0.094850
σ[I]= 0.307977
V(I) = 0.481214

E[ln I] = -0.550431
σ [ln I] = 0.456385

Ic= 0.80
ln(I crit) = -0.223144

β = -1.206066
F(z) = 0.763353
Pr(f) % = 23.664715

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	S	hx	I	Variance Component	% Variance
1 (Mean)	725	10.00	10.00	14.98	269.26	0.0230	1.86	0.19		
2	1375	10.00	10.00	14.99	370.81	0.0187	2.08	0.21	0.003025	35.38
3	75	10.00	10.00	14.85	86.60	0.0398	1.03	0.10		
4	725	14.00	10.00	14.99	318.59	0.0207	1.98	0.14	0.004900	57.31
5	725	6.00	10.00	14.97	208.57	0.0268	1.68	0.28		
6	725	10.00	16.00	14.99	340.59	0.0316	2.02	0.20	0.000625	7.31
7	725	10.00	4.00	14.96	170.29	0.0119	1.52	0.15		
								Total	0.008550	100.00

E[I] = 0.190000
Var[I]= 0.008550
σ[I]= 0.092466
V(I) = 0.486664

E[ln I] = -1.767012
σ [ln I] = 0.461044

Ic= 0.80
ln(I crit) = -0.223144

β = -3.832633
F(z) = 0.999594
Pr(f) % = 0.040605

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: Left Levee

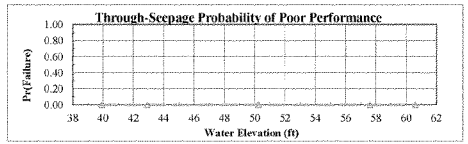
Levee Mile: 4.00
River Mile: 2168110 N; 6626590 E
Analysis Case Infinite waterside/landside blanket

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/14/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)			10.00
Initial Porosity (n)			10.00
Initial Permeability (Ko)			30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	39.90	0.0000
Toe+3ft	3.00	42.90	0.000000
Half Height	10.35	50.25	0.000000
Crest-3ft	17.70	57.60	0.000000
Crest	20.70	60.60	0.000000

Crest | Head = 20.70 | Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] =
V(FS) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | Head = 17.70 | Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] =
V(FS) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Half Height | Head = 10.35 | Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] =
V(FS) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | Head = 3.00 | Horizontal Gradient (Ix) =

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)							
2							
3							
4							
5							
6							
7							

E[FS] = | E[ln FS] = | Total
Var[FS] =
σ[FS] = | σ[ln FS] =
V(FS) =
FS req'd = 1.00 | ln(FS req'd) = 0.000000
β =
F(z) =
Pr(f) % = 0.000000

1268

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

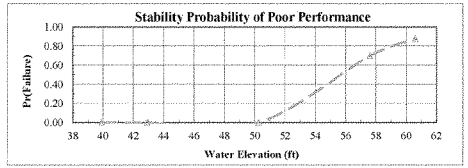
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: Left Levee

Levee Mile: 4.00
River Mile: 2168110 N; 6626590 E
Analysis Case Infinite waterside/landside blanket

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: T. Huynh
Checked By: E.W. James/J.M. Bolton
Date: Updated 9/14/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee φ'	28	3	12.00
Levee γ	115	6	5.00
Foundation c'	200	66	33.00
Foundation γ	115	6	5.00
Foundation φ'	28	3	12.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	39.90	0.0000
Toe+3ft	3.00	42.90	0.000000
Half Height	10.35	50.25	0.000457
Crest-3ft	17.70	57.60	0.695853
Crest	20.70	60.60	0.875362

Crest — Head = 20.70 — Pr(f)=0 = NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	28	115	200	115	28	0.88		
2	25	115	200	115	28	0.79	0.008930	83.83
3	31	115	200	115	28	0.98		
4	28	109	200	115	28	0.84	0.001722	16.17
5	28	121	200	115	28	0.92		
6	28	115	134	115	28	0.88	0.000000	0.00
7	28	115	266	115	28	0.88		
8	28	115	200	109	28	0.88	0.000000	0.00
9	28	115	200	121	28	0.88		
10	28	115	200	115	25	0.88	0.000000	0.00
11	28	115	200	115	31	0.88		

E[FS] = 0.880000 — E[ln FS] = -0.134664 — Total 0.010653 — 100.00
Var[FS] = 0.010653
σ[FS] = 0.103211 — σ[ln FS] = 0.116885 — β = -1.152112
V(FS) = 0.117285 — F(z) = 0.875362
FS req'd = 1.00 — ln(FS req'd) = 0.000000 — Pr(f) % = 87.536249

Crest-3ft — Head = 17.70 — Pr(f)=0 = NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	28	115	200	115	28	0.95		
2	25	115	200	115	28	0.85	0.009604	70.29
3	31	115	200	115	28	1.05		
4	28	109	200	115	28	0.90	0.001560	11.42
5	28	121	200	115	28	0.98		
6	28	115	134	115	28	1.05	0.002500	18.30
7	28	115	266	115	28	0.95		
8	28	115	200	109	28	0.95	0.000000	0.00
9	28	115	200	121	28	0.95		
10	28	115	200	115	25	0.95	0.000000	0.00
11	28	115	200	115	31	0.95		

E[FS] = 0.946000 — E[ln FS] = -0.063089 — Total 0.013664 — 100.00
Var[FS] = 0.013664
σ[FS] = 0.116894 — σ[ln FS] = 0.123099 — β = -0.512509
V(FS) = 0.123567 — F(z) = 0.695853
FS req'd = 1.00 — ln(FS req'd) = 0.000000 — Pr(f) % = 69.585275

Half Height — Head = 10.35 — Pr(f)=0 = NO

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	28	115	200	115	28	1.48		
2	25	115	200	115	28	1.31	0.030102	99.21
3	31	115	200	115	28	1.66		
4	28	109	200	115	28	1.47	0.000240	0.79
5	28	121	200	115	28	1.50		
6	28	115	134	115	28	1.48	0.000000	0.00
7	28	115	266	115	28	1.48		
8	28	115	200	109	28	1.48	0.000000	0.00
9	28	115	200	121	28	1.48		
10	28	115	200	115	25	1.48	0.000000	0.00
11	28	115	200	115	31	1.48		

E[FS] = 1.484000 — E[ln FS] = 0.387899 — Total 0.030343 — 100.00
Var[FS] = 0.030343
σ[FS] = 0.174191 — σ[ln FS] = 0.116978 — β = 3.316000
V(FS) = 0.117379 — F(z) = 0.000457
FS req'd = 1.00 — ln(FS req'd) = 0.000000 — Pr(f) % = 0.045658

Toe+3ft — Head = 3.00 — Pr(f)=0 = YES

Run	Levee φ'	Levee γ	Foundation c'	Foundation γ	Foundation φ'	FS	Variance Component	% Variance
1 (Mean)	28	115	200	115	28			
2	25	115	200	115	28			
3	31	115	200	115	28			
4	28	109	200	115	28			
5	28	121	200	115	28			
6	28	115	134	115	28			
7	28	115	266	115	28			
8	28	115	200	109	28			
9	28	115	200	121	28			
10	28	115	200	115	25			
11	28	115	200	115	31			

E[FS] = — E[ln FS] = — Total
Var[FS] =
σ[FS] = — σ[ln FS] = — β =
V(FS) = — F(z) =
FS req'd = 1.00 — ln(FS req'd) = 0.000000 — Pr(f) % = 0.000000

1269

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

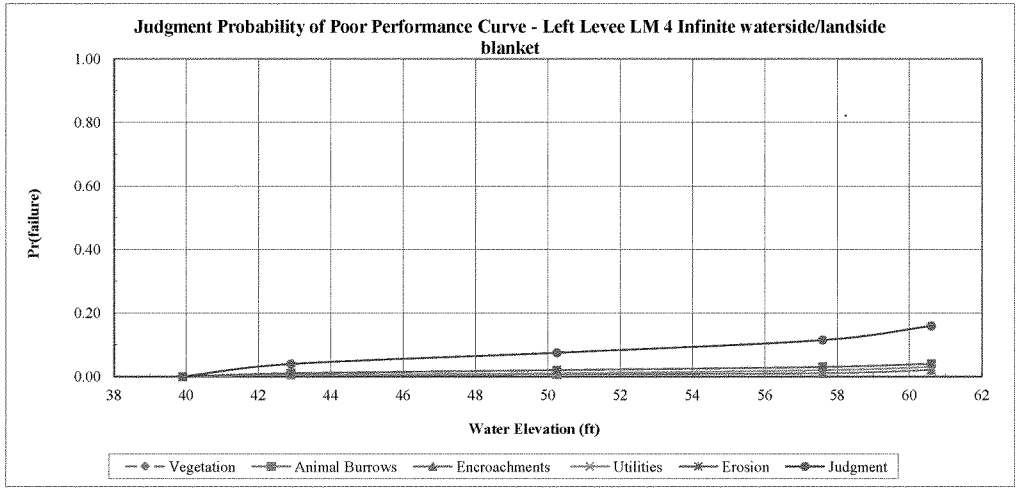
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: Left Levee

Levee Mile: 4.00
River Mile: 2168110 N; 6
Analysis Case: Infinite waterside/landside bl

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: T. Huynh
Checked By: E.W. James/J.
Date: Updated 9/14/

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
39.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
42.90	0.0100	0.9900	0.0100	0.9900	0.0050	0.9950	0.0050	0.9950	0.0100	0.9900	0.0394	0.9606
50.25	0.0200	0.9800	0.0200	0.9800	0.0070	0.9930	0.0100	0.9900	0.0200	0.9800	0.0747	0.9253
57.60	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.0300	0.9700	0.1145	0.8855
60.60	0.0400	0.9600	0.0400	0.9600	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.1590	0.8410



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

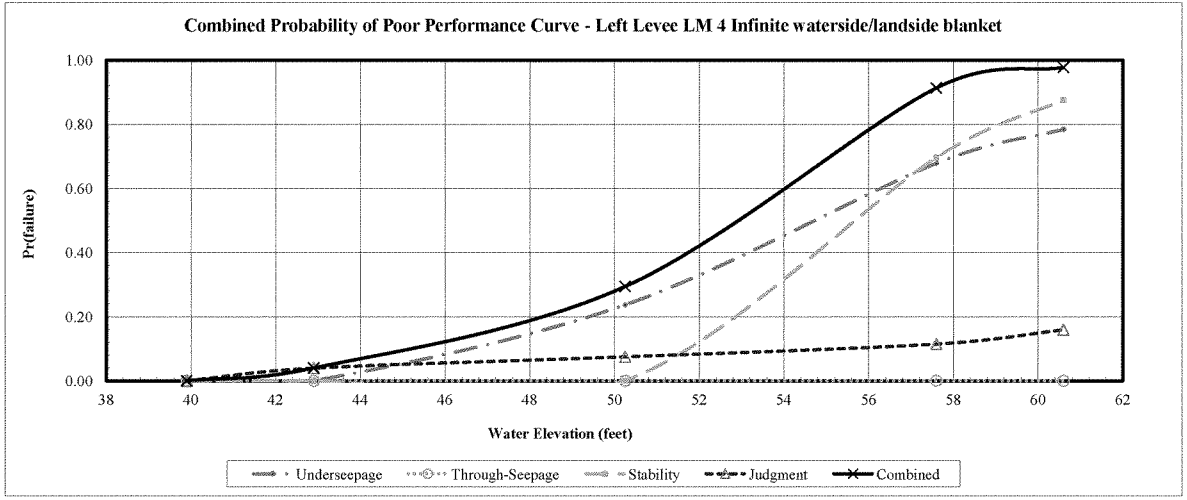
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: Left Levee

Levee Mile: 4.00
River Mile: 2168110 N; 662
Analysis Case: Infinite waterside/landside blanket

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

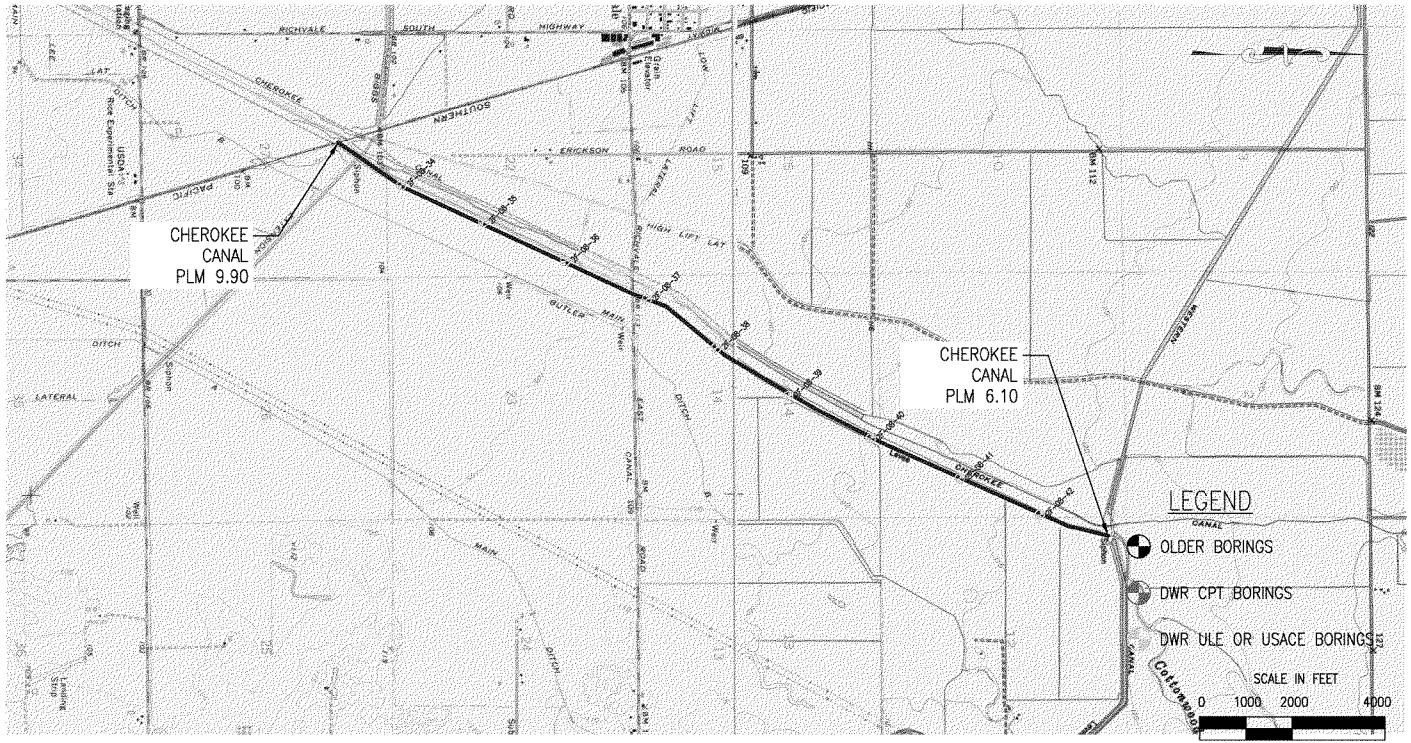
Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/14/20

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
39.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
42.90	0.0004	0.9996	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0398	0.9602
50.25	0.2366	0.7634	0.0000	1.0000	0.0005	0.9995	0.0747	0.9253	0.2940	0.7060
57.60	0.6780	0.3220	0.0000	1.0000	0.6959	0.3041	0.1145	0.8855	0.9133	0.0867
60.60	0.7846	0.2154	0.0000	1.0000	0.8754	0.1246	0.1590	0.8410	0.9774	0.0226



ENCLOSURE F

CHEROKEE CANAL LEFT LEVEE BORING LOGS



SUTTER BASIN FEASIBILITY STUDY – CHEROKEE CANAL

STUDY MAP SHOWING EXPLORATORY BORINGS

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER AND BUTTE COUNTY — CALIFORNIA

SUTTER FEASIBILITY STUDY

GEOTECHNICAL ENGINEERING APPENDIX
STUDY MAP SHOWING
GEOTECHNICAL EXPLORATIONS
CHEROKEE CANAL

DATE:	SCALE:
7 DEC 2012	1" = 2000'

Boring Designation 2F-08-34

DRILLING LOG	DIVISION South Pacific	INSTALLATION Sacramento District	SHEET 1 OF 2 SHEETS

1. PROJECT Sutter Basin Feasibility Study Richvale, CA	9. COORDINATE SYSTEM State Plane CA Zone 2 · HORIZONTAL NAD83 · VERTICAL NAVD88
	10. SIZE AND TYPE OF BIT 8-inch HSA
2. HOLE NUMBER 2F-08-34 · LOCATION COORDINATES N 2,301,046.0 E 6,637,006.0	11. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY R&M Environmental	12. TOTAL SAMPLES · DISTURBED 3 · UNDISTURBED 11
4. NAME OF DRILLER Kelin Jensen	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED · DEG FROM VERTICAL --- · BEARING	14. ELEVATION GROUND WATER INITIAL 87.0 12/2/08 STATIC
	15. DATE STARTED 12/2/08 · DATE COMPLETED 12/2/08
6. THICKNESS OF OVERBURDEN 41.5	16. ELEVATION TOP OF BORING 112.0
7. DEPTH DRILLED INTO ROCK 0.0	17. TOTAL CORE RECOVERY FOR BORING N/A
8. TOTAL DEPTH OF BORING 41.5	18. LOGGED BY C. Payton · CHECKED BY E. James

ELEV	DEPTH	SAMPLE	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							LEVEE FILL LEAN CLAY (CL); moist; dark grayish brown (10YR 4/2); trace sand; low plasticity fines; firm; PP = 2.25 tsf.										
			5 6 7	13	9			83									
108.0	4.0																
			3 6 8	14	11		LEVEE FILL Silty CLAY (CL-ML); moist; yellowish brown (10YR 5/6); low plasticity fines; firm; PP = 2.0 tsf.	50	L1	0	30	70	41	25		CL	
106.5	5.5																
			2 3 4	7	7		LEVEE FILL FAT CLAY with Sand (CH); moist; dark grayish brown (10YR 4/2); trace sand; low plasticity fines; firm; PP = 1.25 tsf.	60									
			4 7 7	14	9		Very dark gray (10YR 3/1); PP = 1.75 tsf.	60	L2						26		
			3 5 8	13	10		Very dark gray (5Y 3/1); PP = 1.25 tsf.	33	L3				49	35			
			4 6 8	14	14		Dark gray (10YR 4/1); low plasticity fines; hard; PP = 1.25 to 1.5 tsf.	67									
								96	S-1	0	23	77	50	33		CH	
97.0	15.0																
			7 14 21	35	30		Silty CLAY (CL-ML); moist; brown (10YR 5/3); PP = 4 to 4.5 tsf.	93	L4						24		
			8 10 12	22	23			100									
			12 14 15	29	25		PP > 4.5 tsf.	100									
							PP > 4.5 tsf.										

0.0 · 2.5 · 5.0 · 7.5 · 10.0 · 12.5 · 15.0 · 17.5 · 20.0

Boring Designation 2F-08-34

DRILLING LOG (Cont Sheet)	INSTALLATION Sacramento District	SHEET 2 OF 2 SHEETS
PROJECT Sutter Basin Feasibility Study Richvale, CA	COORDINATE SYSTEM State Plane CA Zone 2 / HORIZONTAL NAD83	VERTICAL NAVD88
LOCATION COORDINATES N 2,301,046.0 E 6,637,006.0	ELEVATION TOP OF BORING 112.0	

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							Silty CLAY (CL-ML); moist; brown (10YR 5/3); PP = 4 to 4.5 tsf. *(continued)*										
90.0	22.0						SILTY SAND (SM); wet; brown (10YR 4/3); fine to coarse sand; 10% low plasticity fines; dense.										
			10 23 26	49	48			33	L5	0	75	26			23		
81.5	30.5		26				Moist; yellowish brown (10YR 5/6).										
81.0	31.0		50 50/5"	R	R		Clayey GRAVEL (GC); wet; yellowish brown (10YR 5/6); fine, subrounded gravel; 35% low plasticity fines; 10% fine to coarse sand; very dense.	33	L6						14		
							ELASTIC SILT (MH); moist; yellowish brown (10YR 5/4) light yellowish brown (10YR 6/4); low plasticity fines; hard; Well indurated. Mottled with iron oxide staining..										
			19 50/5"	R	R			67	L7				53	14			
73.7	38.3						SAND (SW); moist; dark yellowish brown (10YR 4/4); fine sand; dense; Silt lenses.										
70.5	41.5		7 20 26	46	45		Grayish brown (10YR 5/2); medium sand; 0% fines.	100	L8								

20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0

Boring Designation 2F-08-35

DRILLING LOG	DIVISION South Pacific	INSTALLATION Sacramento District	SHEET 1 OF 2 SHEETS

1. PROJECT Sutter Basin Feasibility Study Richvale, CA	9. COORDINATE SYSTEM State Plane CA Zone 2 · HORIZONTAL NAD83 · VERTICAL NAVD88
	10. SIZE AND TYPE OF BIT 8-inch HSA
2. HOLE NUMBER 2F-08-35 · LOCATION COORDINATES N 2,302,812.0 E 6,637,807.0	11. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY R&M Environmental	12. TOTAL SAMPLES · DISTURBED 3 · UNDISTURBED 16
4. NAME OF DRILLER Kelin Jensen	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED · DEG FROM VERTICAL --- · BEARING	14. ELEVATION GROUND WATER INITIAL 97.5 12/3/08 STATIC 98.5 12/3/08
	15. DATE STARTED 12/3/08 · DATE COMPLETED 12/3/08
6. THICKNESS OF OVERBURDEN 41.5	16. ELEVATION TOP OF BORING 113.0
7. DEPTH DRILLED INTO ROCK 0.0	17. TOTAL CORE RECOVERY FOR BORING N/A
8. TOTAL DEPTH OF BORING 41.5	18. LOGGED BY C. Payton · CHECKED BY E. James

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							LEVEE FILL LEAN CLAY (CL); moist; dark brown (10YR 3/3) yellowish brown (10YR 5/4); low plasticity fines; firm; Road base gravel.										
			4 6 8	14	9		Yellowish brown (10YR 5/4); PP = 1.25 tsf.	100	L1				34	19			
108.3	4.7		2 3 5	8	6		LEVEE FILL SILTY CLAY (CL-ML); moist; dark brown (10YR 3/3); low plasticity fines; firm; PP = 1.5 tsf.	93									
			2 4 4	8	8			100									
105.5	7.5																
			2 3 4	7	5		LEVEE FILL LEAN CLAY (CL); very dark gray (10YR 3/1); firm; PP = 0.7 tsf.	100									
			3 5 7	12	10		Dark gray (10YR 4/1); PP = 1.25 tsf, TV = 0.37 kg/cm^2.	100									
101.5	11.5		4 6 8	14	14		Dark gray (10YR 4/1).	100									
98.3	14.7						SILTY CLAY (CL-ML); moist; yellowish brown (10YR 5/4); very hard; PP = 1.25 tsf.	84	S-1								
			8 12 16	28	24		SILTY SAND (SM); wet; brown (10YR 4/3); 60% fine to medium sand; 40% low plasticity fines; medium dense.	100									
95.0	18.0		10 16 19	35	36			100	L2	0	69	32					
94.5	18.5		12 22 24	46	40		SANDY SILT (ML); moist; yellowish brown (10YR 5/4); dense. SANDY SILT with Gravel (SM); wet; dark yellowish brown (10YR 4/4); 30% fine sand; dense.	87									

0.0 · 2.5 · 5.0 · 7.5 · 10.0 · 12.5 · 15.0 · 17.5 · 20.0

Boring Designation 2F-08-35

DRILLING LOG (Cont Sheet)	INSTALLATION Sacramento District	SHEET 2 OF 2 SHEETS
PROJECT Sutter Basin Feasibility Study Richvale, CA	COORDINATE SYSTEM State Plane CA Zone 2 / HORIZONTAL NAD83 / VERTICAL NAVD88	
LOCATION COORDINATES N 2,302,812.0 E 6,637,807.0	ELEVATION TOP OF BORING 113.0	

ELEV	DEPTH	SAMPLE Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		26 36 40	76	74		SANDY SILT with Gravel (SM); wet; dark yellowish brown (10YR 4/4); 30% fine sand; dense. *(continued)* Very dense.	93	L3	2	86	12			14		
90.0	23.0					CLAYEY SAND (SC); moist; dark yellowish brown (10YR 4/4); 10% fine to medium sand; hard.										
		4 17 29	46	45			0									
		16 50	R	R			67	L4	0	51	49			25		
84.0	29.0					SANDY SILT (ML); yellowish brown (10YR 5/6); 40% fine sand; hard.										
		11 27 40	67	65			93	L5	0	61	39	38	19		SC	
77.2	35.8					SILTY SAND (SM); wet; yellowish brown (10YR 5/4); 40% fine to medium sand; 35% low plasticity fines; dense.										
		9 16 26	42	43			100	L6								
72.8	40.2															
71.5	41.5	3 7 24	31	32		SILT (ML); moist; yellowish brown (10YR 5/8); trace sand; firm.	67	L7								

20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0

Boring Designation 2F-08-36

DRILLING LOG	DIVISION South Pacific	INSTALLATION Sacramento District	SHEET 1 OF 2 SHEETS

1. PROJECT Sutter Basin Feasibility Study Richvale, CA	9. COORDINATE SYSTEM State Plane CA Zone 2 · HORIZONTAL NAD83 · VERTICAL NAVD88
	10. SIZE AND TYPE OF BIT 8-inch HSA
2. HOLE NUMBER 2F-08-36 · LOCATION COORDINATES N 2,304,588.0 E 6,638,644.0	11. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY R&M Environmental	12. TOTAL SAMPLES · DISTURBED · UNDISTURBED 8
4. NAME OF DRILLER Kelin Jensen	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED · DEG FROM VERTICAL --- · BEARING	14. ELEVATION GROUND WATER INITIAL 84.5 12/4/08 STATIC
	15. DATE STARTED 12/4/08 · DATE COMPLETED 12/4/08
6. THICKNESS OF OVERBURDEN 39.5	16. ELEVATION TOP OF BORING 114.5
7. DEPTH DRILLED INTO ROCK 0.0	17. TOTAL CORE RECOVERY FOR BORING N/A
8. TOTAL DEPTH OF BORING 39.5	18. LOGGED BY C. Payton · CHECKED BY E. James

ELEV	DEPTH	SAMPLE	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS	
							LEAN CLAY (CL); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..											0.0
			3 8 9	17				100					50	37	21			2.5
			9 2 8	10				80										5.0
			3 4 6	10				67										
								100					52	37				7.5
								100										10.0
103.5	11.0						SILT (ML).	100										
								84										12.5
								100		0	51	49	32	18		SC		15.0
							SILTY CLAY with Sand (ML). SILT (ML).	100										17.5
							SILTY CLAY (ML).	87										20.0

Boring Designation 2F-08-36

DRILLING LOG (Cont Sheet)	INSTALLATION Sacramento District		SHEET 2 OF 2 SHEETS
PROJECT Sutter Basin Feasibility Study Richvale, CA	COORDINATE SYSTEM State Plane CA Zone 2	HORIZONTAL NAD83	VERTICAL NAVD88
LOCATION COORDINATES N 2,304,588.0 E 6,638,644.0	ELEVATION TOP OF BORING 114.5		

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SILT (ML). *(continued)*	93					48	26			
								0									
								67		0	19	81	36	22		CL	
84.5	30.0						SAND (SW).	93									
								100									
76.5	38.0						SAND (SW).										
75.0	39.5																

20.0, 22.5, 25.0, 27.5, 30.0, 32.5, 35.0, 37.5

Boring Designation 2F-08-37

DRILLING LOG	DIVISION South Pacific	INSTALLATION Sacramento District	SHEET 1 OF 2 SHEETS

1. PROJECT Sutter Basin Feasibility Study Richvale, CA	9. COORDINATE SYSTEM State Plane CA Zone 2 · HORIZONTAL NAD83 · VERTICAL NAVD88
	10. SIZE AND TYPE OF BIT 8-inch HSA
2. HOLE NUMBER 2F-08-37 · LOCATION COORDINATES N 2,306,348.0 E 6,639,470.0	11. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY R&M Environmental	12. TOTAL SAMPLES · DISTURBED · UNDISTURBED 6
4. NAME OF DRILLER Kelin Jensen	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED · DEG FROM VERTICAL --- · BEARING	14. ELEVATION GROUND WATER INITIAL 96.5 12/4/08 STATIC 99.5 12/4/08
	15. DATE STARTED 12/4/08 · DATE COMPLETED 12/4/08
6. THICKNESS OF OVERBURDEN 40.5	16. ELEVATION TOP OF BORING 117.5
7. DEPTH DRILLED INTO ROCK 0.0	17. TOTAL CORE RECOVERY FOR BORING N/A
8. TOTAL DEPTH OF BORING 40.5	18. LOGGED BY C. Payton · CHECKED BY E. James

ELEV	DEPTH	SAMPLE	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							ELASTIC SILT (MH); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
								83		2	22	76	42	23		CL	
								50									
								60									
108.8	8.7							60							23		
							FAT CLAY (CL).										
								33									
105.5	12.0							67									
							SANDY SILT (ML).										
								96					45	23			
101.6	15.9							93									
							CLAYEY SAND with Gravel (SC).										
								100									
99.1	18.4																
							SANDY SILT (ML).	100									

0.0 · 2.5 · 5.0 · 7.5 · 10.0 · 12.5 · 15.0 · 17.5 · 20.0

Boring Designation 2F-08-37

DRILLING LOG (Cont Sheet)	INSTALLATION Sacramento District	SHEET 2 OF 2 SHEETS
PROJECT Sutter Basin Feasibility Study Richvale, CA	COORDINATE SYSTEM State Plane CA Zone 2 / HORIZONTAL NAD83	VERTICAL NAVD88
LOCATION COORDINATES N 2,306,348.0 E 6,639,470.0	ELEVATION TOP OF BORING 117.5	

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SANDY SILT (ML). *(continued)*			0	45	55			29		
94.5	23.0						SAND (SW).										
								33									
								33									
84.2	33.3						SILT (ML).										
								67									
77.0	40.5																

Elevation scale: 20.0, 22.5, 25.0, 27.5, 30.0, 32.5, 35.0, 37.5, 40.0

Boring Designation 2F-08-38

DRILLING LOG	DIVISION South Pacific	INSTALLATION Sacramento District	SHEET 1 OF 2 SHEETS

1. PROJECT Sutter Basin Feasibility Study Richvale, CA	9. COORDINATE SYSTEM State Plane CA Zone 2 · HORIZONTAL NAD83 · VERTICAL NAVD88
	10. SIZE AND TYPE OF BIT 8-inch HSA
2. HOLE NUMBER 2F-08-38 · LOCATION COORDINATES N 2,307,833.0 E 6,640,524.0	11. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY R&M Environmental	12. TOTAL SAMPLES · DISTURBED · UNDISTURBED 9
4. NAME OF DRILLER Kelin Jensen	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED · DEG FROM VERTICAL --- · BEARING	14. ELEVATION GROUND WATER INITIAL 99.5 12/5/08 STATIC
	15. DATE STARTED 12/5/08 · DATE COMPLETED 12/5/08
6. THICKNESS OF OVERBURDEN 42.0	16. ELEVATION TOP OF BORING 119.0
7. DEPTH DRILLED INTO ROCK 0.0	17. TOTAL CORE RECOVERY FOR BORING N/A
8. TOTAL DEPTH OF BORING 42.0	18. LOGGED BY C. Payton · CHECKED BY E. James

ELEV	DEPTH	SAMPLE	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SILT (ML); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
116.0	3.0																
115.5	3.5						LEAN CLAY (CL).	83		0	47	53	40	23		CL	
							ELASTIC SILT with Sand (MH).										
114.5	4.5																
114.0	5.0						LEAN CLAY (CL).	50									
113.7	5.3						ELASTIC SILT with Sand (MH).										
112.9	6.1						LEAN CLAY (CL).										
							ELASTIC SILT with Sand (MH).	60									
								60		0	38	62			27		
110.3	8.7						LEAN CLAY (CL).										
								33									
								67									
								96									
105.0	14.0						SANDY SILT (ML).										
								93		0	28	72	34	14		CL	
								100									
100.0	19.0							100									
							SAND (SW).										

0.0 · 2.5 · 5.0 · 7.5 · 10.0 · 12.5 · 15.0 · 17.5 · 20.0

Boring Designation 2F-08-38

DRILLING LOG (Cont Sheet)	INSTALLATION Sacramento District		SHEET 2 OF 2 SHEETS
PROJECT Sutter Basin Feasibility Study Richvale, CA	COORDINATE SYSTEM State Plane CA Zone 2	HORIZONTAL NAD83	VERTICAL NAVD88
LOCATION COORDINATES N 2,307,833.0 E 6,640,524.0	ELEVATION TOP OF BORING 119.0		

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SAND (SW). *(continued)*										
97.8	21.2														24		
							SANDY SILT (ML).										
95.7	23.3																
							SAND (SW).										
								33		0	73	27			25		
91.0	28.0																
							SANDY SILT (ML).										
								33					30	13			
87.9	31.1																
							SAND (SW).										
84.5	34.5																
							SILT (ML).										
								67									
										0	33	67			39		
								100									
77.0	42.0																

Depth scale: 20.0, 22.5, 25.0, 27.5, 30.0, 32.5, 35.0, 37.5, 40.0

Boring Designation 2F-08-39

DRILLING LOG	DIVISION South Pacific	INSTALLATION Sacramento District	SHEET 1 OF 2 SHEETS

1. PROJECT Sutter Basin Feasibility Study Richvale, CA	9. COORDINATE SYSTEM State Plane CA Zone 2 · HORIZONTAL NAD83 · VERTICAL NAVD88
	10. SIZE AND TYPE OF BIT 8-inch HSA
2. HOLE NUMBER 2F-08-39 · LOCATION COORDINATES N 2,309,396.0 E 6,641,562.0	11. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY R&M Environmental	12. TOTAL SAMPLES · DISTURBED · UNDISTURBED 7
4. NAME OF DRILLER Kelin Jensen	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED · DEG FROM VERTICAL --- · BEARING	14. ELEVATION GROUND WATER INITIAL 100.0 12/8/09 STATIC 103.0 12/8/09
	15. DATE STARTED 12/8/09 · DATE COMPLETED 12/8/09
6. THICKNESS OF OVERBURDEN 42.0	16. ELEVATION TOP OF BORING 121.0
7. DEPTH DRILLED INTO ROCK 0.0	17. TOTAL CORE RECOVERY FOR BORING N/A
8. TOTAL DEPTH OF BORING 42.0	18. LOGGED BY C. Payton · CHECKED BY E. James

ELEV	DEPTH	SAMPLE	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SANDY SILT with Gravel (ML); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
117.3	3.7						SILT (ML).	83		0	35	65	35	22		CL	
116.5	4.5						ELASTIC SILT (MH).										
							Silty CLAY (CL).	50									
115.0	6.0																
114.5	6.5						ELASTIC SILT (MH).	60									
							LEAN CLAY (CL).										
							Silty CLAY (CL).	60					52	28			
								33									
								67									
108.5	12.5																
							SILT (ML).	96		0	37	63	41	26	25	CL	
								93		0	32	68	NV	NP		ML	
								100									
								100									

0.0 · 2.5 · 5.0 · 7.5 · 10.0 · 12.5 · 15.0 · 17.5 · 20.0

Boring Designation 2F-08-39

DRILLING LOG (Cont Sheet)	INSTALLATION Sacramento District	SHEET 2 OF 2 SHEETS
PROJECT Sutter Basin Feasibility Study Richvale, CA	COORDINATE SYSTEM State Plane CA Zone 2 / HORIZONTAL NAD83	VERTICAL NAVD88
LOCATION COORDINATES N 2,309,396.0 E 6,641,562.0	ELEVATION TOP OF BORING 121.0	

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
100.5	20.5						SILT (ML). *(continued)*										
							Silty SAND (SM).			0	72	28			24		
97.5	23.5						Sandy SILT (ML).										
								33									
92.5	28.5						SAND (SW).										
								33									
								67									
								100									
79.2	41.8																
79.0	42.0						SILT (ML).										

20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0

Boring Designation 2F-08-40

DRILLING LOG	DIVISION South Pacific	INSTALLATION Sacramento District	SHEET 1 OF 2 SHEETS

1. PROJECT Sutter Basin Feasibility Study Richvale, CA	9. COORDINATE SYSTEM State Plane CA Zone 2 · HORIZONTAL NAD83 · VERTICAL NAVD88
	10. SIZE AND TYPE OF BIT 8-inch HSA
2. HOLE NUMBER 2F-08-40 · LOCATION COORDINATES N 2,311,175.0 E 6,642,474.0	11. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY R&M Environmental	12. TOTAL SAMPLES · DISTURBED · UNDISTURBED 5
4. NAME OF DRILLER Kelin Jensen	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED · DEG FROM VERTICAL --- · BEARING	14. ELEVATION GROUND WATER INITIAL 106.0 12/9/09 STATIC 107.5 12/9/09
	15. DATE STARTED 12/9/09 · DATE COMPLETED 12/9/09
6. THICKNESS OF OVERBURDEN 40.0	16. ELEVATION TOP OF BORING 122.5
7. DEPTH DRILLED INTO ROCK 0.0	17. TOTAL CORE RECOVERY FOR BORING N/A
8. TOTAL DEPTH OF BORING 40.0	18. LOGGED BY C. Payton · CHECKED BY E. James

ELEV	DEPTH	SAMPLE	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							ELASTIC SILT (MH); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
119.7	2.8																
119.4	3.1						Silty SAND (SM).										
119.2	3.3						Sandy SILT (ML).	83		7	25	68	46	33		CL	
							LEAN CLAY (CL).	50									
								60									
							LEAN CLAY (CL).										
113.5	9.0							60		0	38	62	34	19	34	CL	
							ELASTIC SILT (MH).	33									
								67									
							ELASTIC SILT (MH).										
108.5	14.0							96									
							Clayey SAND (SC).										
107.0	15.5						ELASTIC SILT (MH).	93		8	41	51	43	16		ML	
								100									
								100									

0.0 · 2.5 · 5.0 · 7.5 · 10.0 · 12.5 · 15.0 · 17.5 · 20.0

Boring Designation 2F-08-40

DRILLING LOG (Cont Sheet)	INSTALLATION Sacramento District	SHEET 2 OF 2 SHEETS
PROJECT Sutter Basin Feasibility Study Richvale, CA	COORDINATE SYSTEM State Plane CA Zone 2 / HORIZONTAL NAD83	VERTICAL NAVD88
LOCATION COORDINATES N 2,311,175.0 E 6,642,474.0	ELEVATION TOP OF BORING 122.5	

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
102.0	20.5						ELASTIC SILT (MH). *(continued)*										
101.3	21.2						SAND (SP).										
							Sandy SILT (ML).										
								33									
								33									
										0	27	73			24		
							SILT (ML).										
								67									
82.5	40.0																

20.0, 22.5, 25.0, 27.5, 30.0, 32.5, 35.0, 37.5, 40.0

Boring Designation 2F-08-41

DRILLING LOG	DIVISION South Pacific	INSTALLATION Sacramento District	SHEET 1 OF 2 SHEETS

1. PROJECT Sutter Basin Feasibility Study Richvale, CA	9. COORDINATE SYSTEM State Plane CA Zone 2 · HORIZONTAL NAD83 · VERTICAL NAVD88
	10. SIZE AND TYPE OF BIT 8-inch HSA
2. HOLE NUMBER 2F-08-41 · LOCATION COORDINATES N 2,313,098.0 E 6,643,342.0	11. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY R&M Environmental	12. TOTAL SAMPLES · DISTURBED · UNDISTURBED 7
4. NAME OF DRILLER Kelin Jensen	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED · DEG FROM VERTICAL --- · BEARING	14. ELEVATION GROUND WATER INITIAL 107.0 12/9/09 STATIC 110.0 12/9/09
	15. DATE STARTED 12/9/09 · DATE COMPLETED 12/9/09
6. THICKNESS OF OVERBURDEN 40.5	16. ELEVATION TOP OF BORING 124.5
7. DEPTH DRILLED INTO ROCK 0.0	17. TOTAL CORE RECOVERY FOR BORING N/A
8. TOTAL DEPTH OF BORING 40.5	18. LOGGED BY C. Payton · CHECKED BY E. James

ELEV	DEPTH	SAMPLE	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SANDY LEAN CLAY (CL); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
							LEAN CLAY (CL).	83		1	27	73	36	25		CL	
								50									
119.0	5.5						ELASTIC SILT (MH).										
118.0	6.5						LEAN CLAY (CL).	60									
								60					48	33			
								33									
								67									
								96									
108.5	16.0						Clayey SAND (SC).	93									
107.2	17.3							100		0	32	68			32		
107.0	17.5						CLAYEY SAND (SC-SM).										
							ELASTIC SILT (MH).	100									

0.0 · 2.5 · 5.0 · 7.5 · 10.0 · 12.5 · 15.0 · 17.5 · 20.0

Boring Designation 2F-08-41

DRILLING LOG (Cont Sheet)	INSTALLATION Sacramento District	SHEET 2 OF 2 SHEETS
PROJECT Sutter Basin Feasibility Study Richvale, CA	COORDINATE SYSTEM State Plane CA Zone 2 / HORIZONTAL NAD83	VERTICAL NAVD88
LOCATION COORDINATES N 2,313,098.0 E 6,643,342.0	ELEVATION TOP OF BORING 124.5	

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							ELASTIC SILT (MH). *(continued)*										
100.0	24.5												NV	NP			
							SILT (ML).										
								33									
								33									
							Sandy SILT (ML).										
								67							33		
							SILT (ML).										
84.0	40.5																

20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0

Boring Designation 2F-08-42

DRILLING LOG	DIVISION South Pacific	INSTALLATION Sacramento District	SHEET 1 OF 2 SHEETS

1. PROJECT Sutter Basin Feasibility Study Richvale, CA	9. COORDINATE SYSTEM State Plane CA Zone 2 · HORIZONTAL NAD83 · VERTICAL NAVD88
	10. SIZE AND TYPE OF BIT 8-inch HSA
2. HOLE NUMBER 2F-08-42 · LOCATION COORDINATES N 2,314,828.0 E 6,644,123.0	11. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61 with 140-lb automatic trip slide hammer
3. DRILLING AGENCY R&M Environmental	12. TOTAL SAMPLES · DISTURBED · UNDISTURBED 9
4. NAME OF DRILLER Kelin Jensen	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED · DEG FROM VERTICAL --- · BEARING	14. ELEVATION GROUND WATER INITIAL 110.0 12/10/08 STATIC
	15. DATE STARTED 12/10/08 · DATE COMPLETED 12/10/08
6. THICKNESS OF OVERBURDEN 41.6	16. ELEVATION TOP OF BORING 125.5
7. DEPTH DRILLED INTO ROCK 0.0	17. TOTAL CORE RECOVERY FOR BORING N/A
8. TOTAL DEPTH OF BORING 41.6	18. LOGGED BY C. Payton · CHECKED BY E. James

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SILTY CLAY (CL); ASTM D2488 used for field classifications. Sample decriptions were corrected to reflect lab results and reclassified using ASTM D2487 where applicable. Contacts are dashed where approximate or inferred, and solid where observed..										
								83		0	21	80	49	33		CL	
							LEAN CLAY (CL).	50									
								60									
															24		
								60									
116.0	9.5						SANDY SILT (ML).	33									
								67									
								96									
110.0 ▽	15.5						SAND (SW).	93									
108.8	16.7						SAND with Gravel (SWG).										
108.2	17.3						SANDY SILT (ML).	100		25	64	11			21		
107.1	18.4						SAND (SW).	100									

0.0 · 2.5 · 5.0 · 7.5 · 10.0 · 12.5 · 15.0 · 17.5 · 20.0

Boring Designation 2F-08-42

DRILLING LOG (Cont Sheet)	INSTALLATION: Sacramento District	SHEET 2 OF 2 SHEETS
PROJECT: Sutter Basin Feasibility Study Richvale, CA	COORDINATE SYSTEM: State Plane CA Zone 2	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: N 2,314,828.0 E 6,644,123.0	ELEVATION TOP OF BORING: 125.5	

ELEV	DEPTH	SAMPLE	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							SAND (SW). *(continued)*										
104.1	21.4						SILT (ML).			1	50	49	40	16		SC	
102.0	23.5						SAND (SW).										
		■						33		0	95	6			32		
95.5	30.0						LEAN CLAY (CL).										
		■						33					78	51			
90.5	35.0						SILT (ML).										
		■						67							36		
		■						100									

Depth scale: 20.0, 22.5, 25.0, 27.5, 30.0, 32.5, 35.0, 37.5, 40.0

SPK FORM 1836-A
SEP 05

FOR CONTINUATION OF HOUSE DOCUMENT 113-157

SUTTER BASIN PILOT FEASIBILITY FINAL REPORT—FINAL ENVIRONMENTAL IMPACT REPORT/SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT APPENDICES

SEE PART 2