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

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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)	

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

			Location (NAD 83)						
Item No.	Reach	STA	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 50 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+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 documenation 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	

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
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	6,665,998.34	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	
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 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)~~	

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
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 Hermansen 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	2,200,600.09	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

			Location (NAD 83)						
Item No.	Reach	STA	Northing	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	6,668,425.95	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				
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 close 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 MHM Job No. 78-158~~	~~Cutoff Wall~~	~~Pipe eas 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

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 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

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
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

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
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+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 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	6,672,496.38	Telephone Call box on waterside hinge point	No Rehabilitation Required	**Relocate outside of of the proposed right-of-way.**	TL	
289	16	1019+82	2,177,832.15	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	2,176,706.50	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	

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
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	2,176,461.52	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	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**	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. Strom 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

			Location (NAD 83)						
Item No.	Reach	STA	Northing	Easting	Encroachment	Proposed Levee Improvement	Required Improvement Work	Type	cover
351	13	881+43	2,164,944.70	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. ?)	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.**	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~~		~~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	4.0
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

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 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 clease 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. Diffcult 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. Cozzolino.	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 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	
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+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)	
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+27	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

			Location (NAD 83)						
Item No.	Reach	STA	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	OH
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

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)

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

			Location (NAD 83)						
Item No.	Reach	STA	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 Hauler.	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~~	~~2,282,509.99~~	~~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	6,662,702.59	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	6,664,690.55	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	2,277,864.11	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(P)	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)	14.0
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	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	6,660,521.29	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 land side 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	6,661,630.24	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 bow levee.	Cutoff wall	**Replace in accordance with USACE standard.**	SS(P)	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	2,258,506.36	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 Pekeema 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	2,247,975.94	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	1741+32	2,245,620.98	6,665,550.58	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	2,241,496.45	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 Main 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

			Location (NAD 83)						
Item No.	Reach	STA	Northing	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)	17.0
	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 CFVPB sent an encroachment violation notice on September 20, 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 CVFPB sent an encroachment violation notice on July 26, 2011 to Theodore Bill. 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	2,226,796.70	6,665,666.06	RD 777 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

			Location (NAD 83)						
Item No.	Reach	STA	Northing	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, 170 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(G)~~	
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 4556 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 documenation 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 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	6,665,998.34	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	

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
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 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)~~	
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)~~	

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
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 Hermansen 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	2,200,600.09	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
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	2,194,694.58	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 closae 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 MHM Job No. 78-158~~	~~Cutoff Wall~~	~~Pipe eas 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 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 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	2,183,133.99	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
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

			Location (NAD 83)						
Item No.	Reach	STA	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)	1.3
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+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 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	
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	

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
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	2,177,832.15	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	2,176,706.50	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	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

			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	2,176,461.52	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	
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	

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	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**	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	
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

			Location (NAD 83)						
Item No.	Reach	STA	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. Strom 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
351	13	881+43	2,164,944.70	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. ?)	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

			Location (NAD 83)						
Item No.	Reach	STA	Northing	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~~		~~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			
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 claose 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. Diffcult 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. Cozzolino.	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+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
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

			Location (NAD 83)						
Item No.	Reach	STA	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	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
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+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 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+27	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)	
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	OH

TABLE 5-3 ALTERNATIVE SB8 - LEVEE ENCROACHMENT LIST

			Location (NAD 83)						
Item No.	Reach	STA	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
SEEP	
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

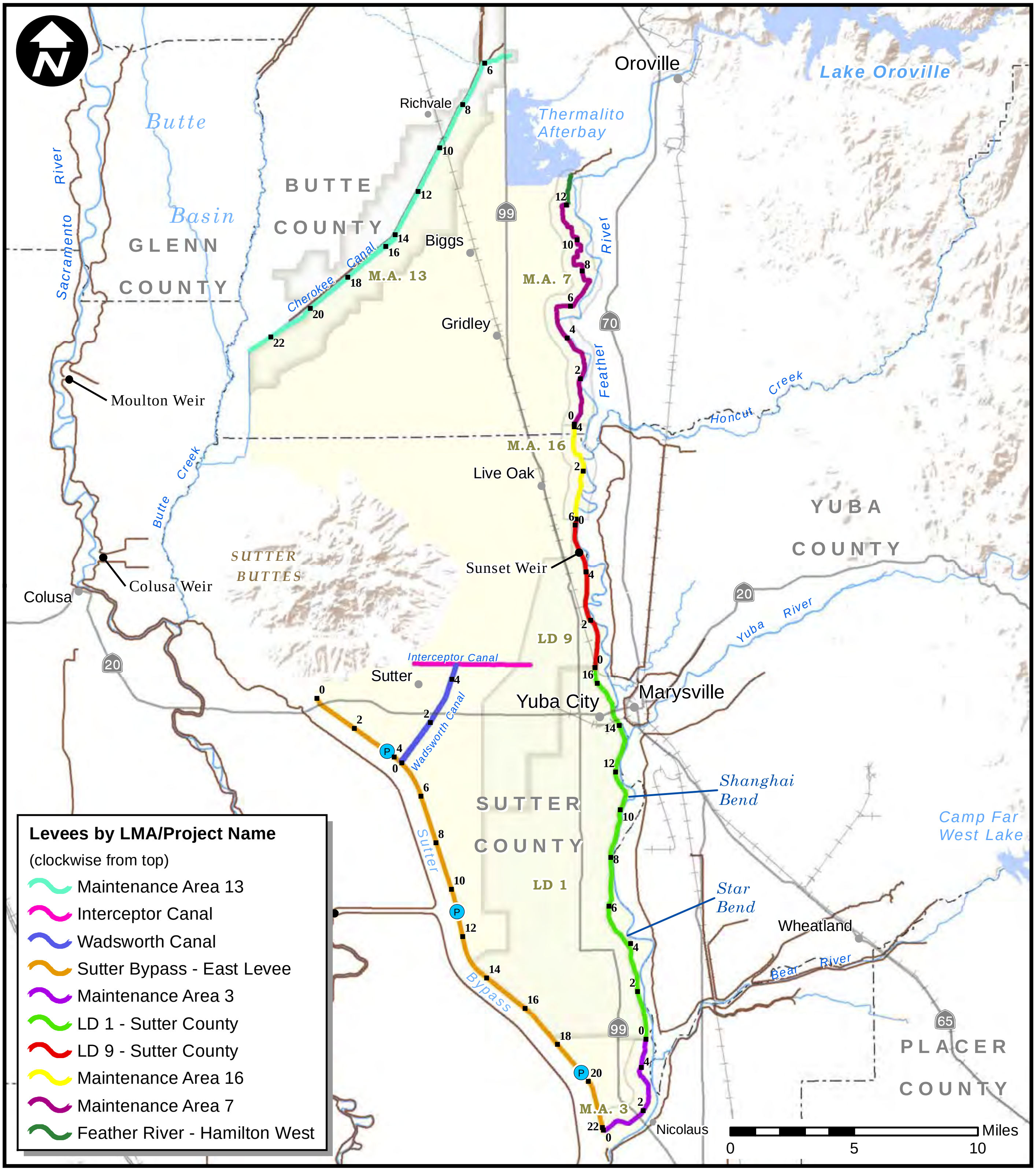
Table 5-4B Summary of Utilities & Encroachments for Construction Contracts

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	Lake or Reservoir
Levee Maintenance Agency	River or Stream
Federal Levee	Highway
Levee Mile	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

SUTTER BASIN PROJECT AREA

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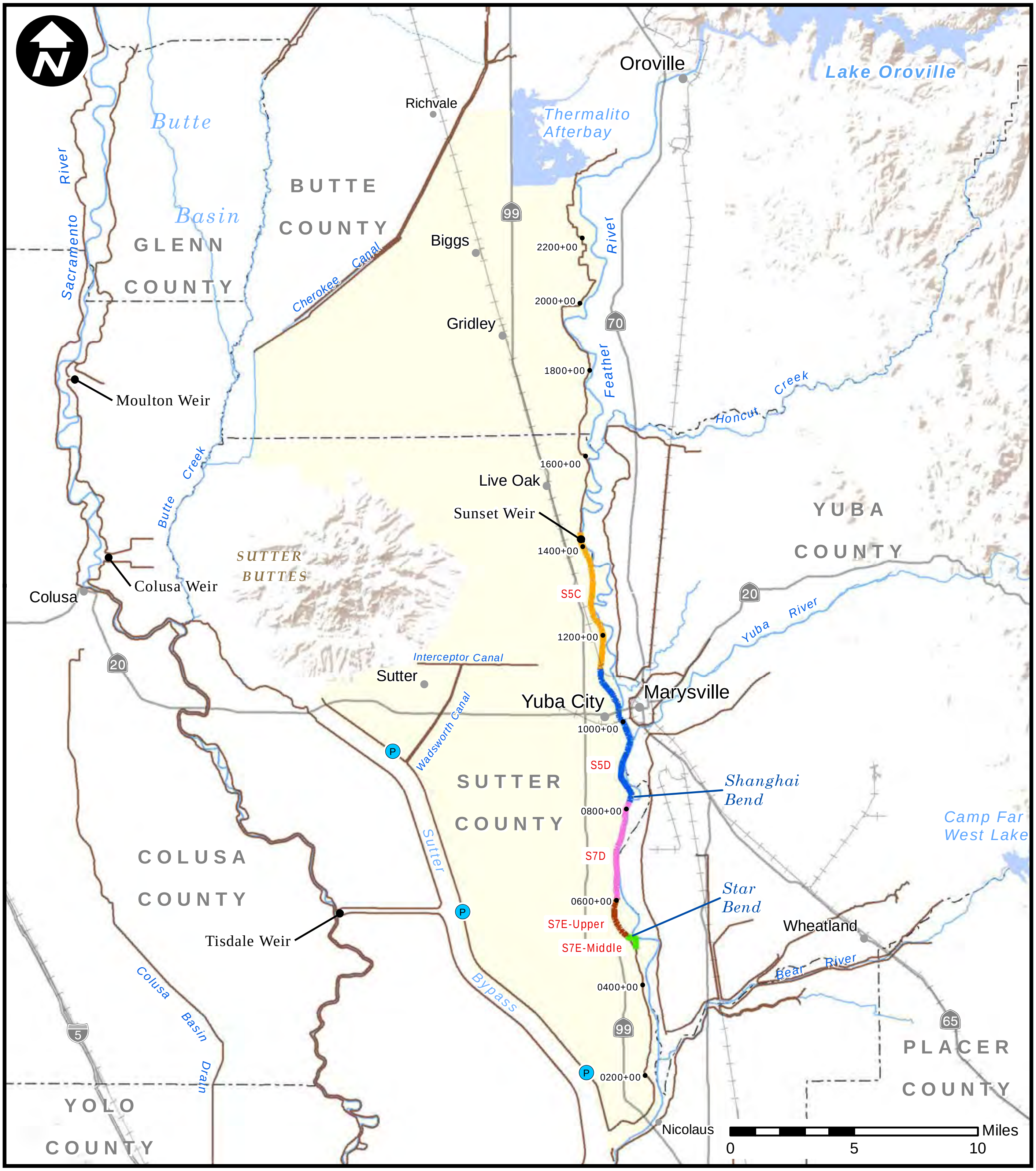
PLATE 1-1



Legend

Study Area Extent	Lake or Reservoir
S5B Project Reach	River or Stream
Federal Levee	Highway
Stationing Point	Railroad
P 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

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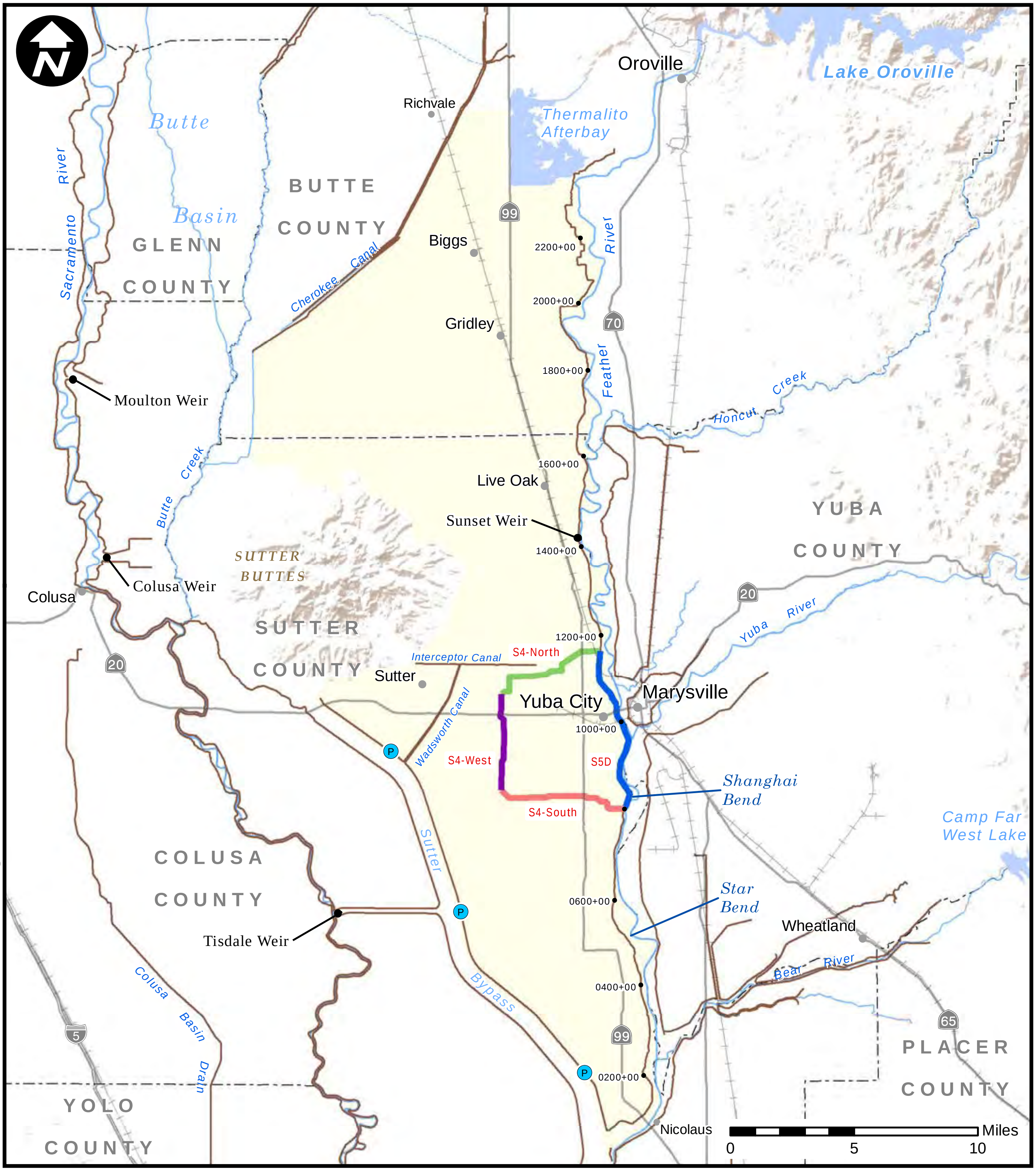

Legend

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-3: YUBA CITY RING LEVEE

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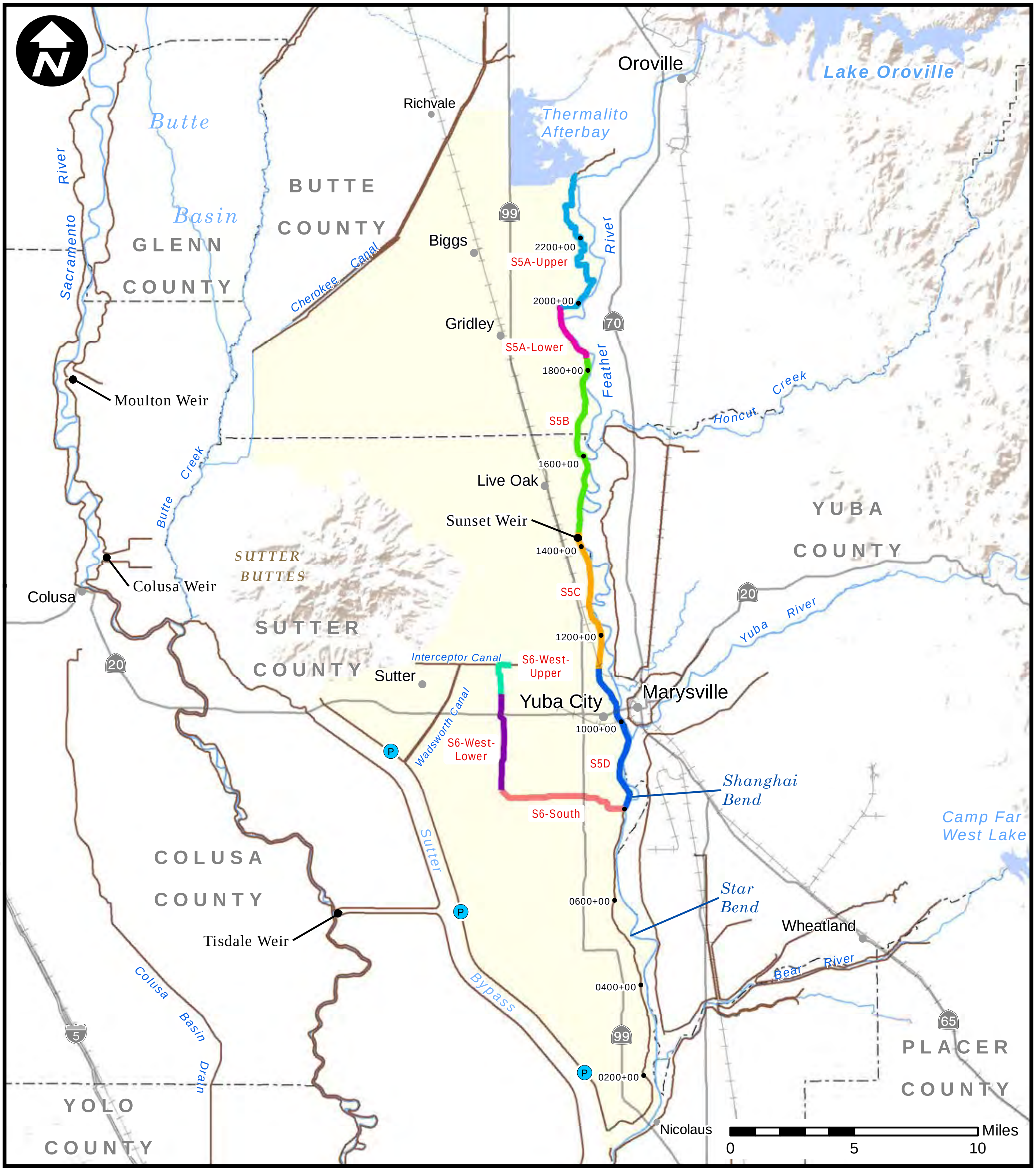

Legend

- 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-4: LITTLE J LEVEE

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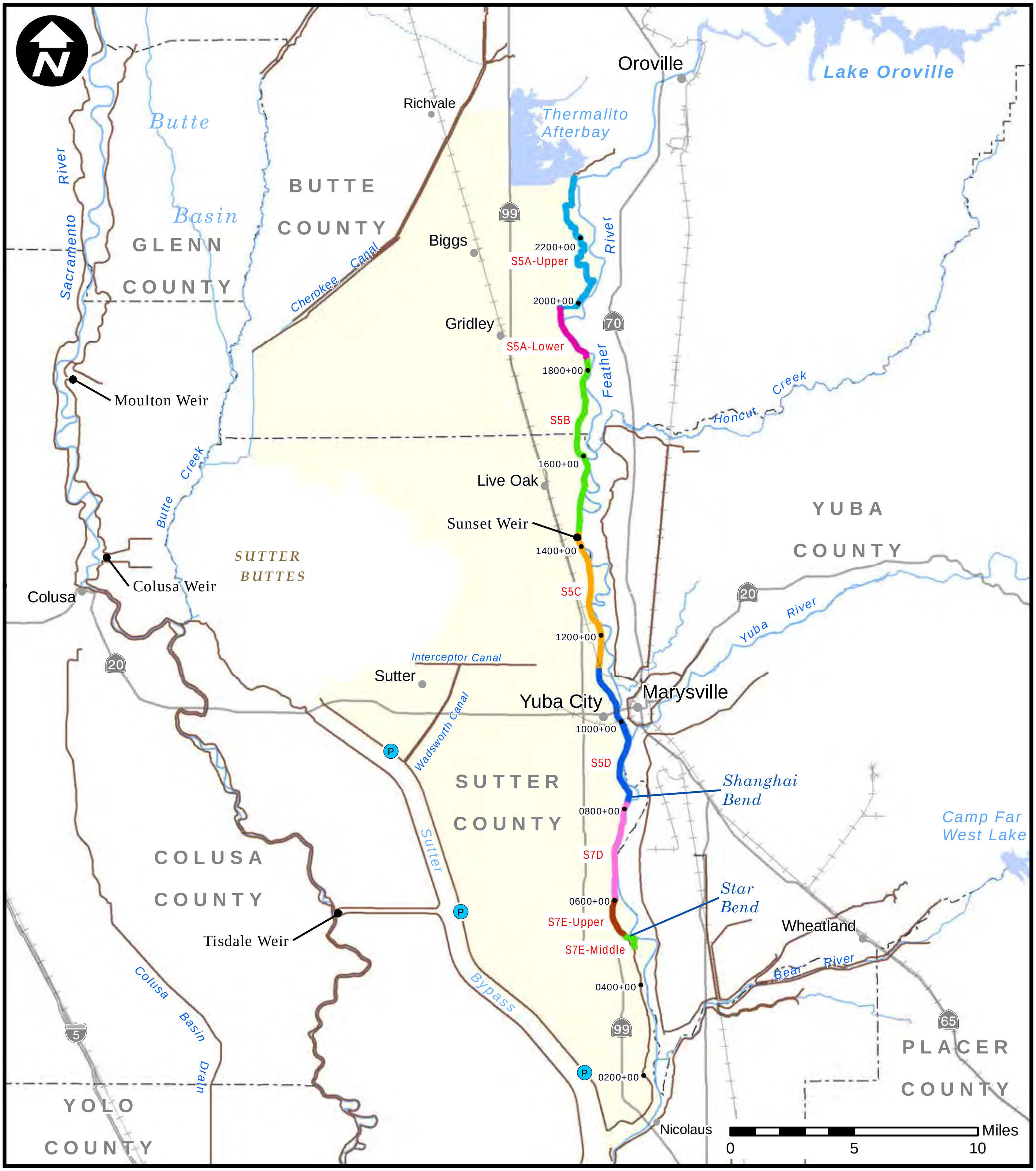
PLATE 1-4



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-5: FIX-IN-PLACE FEATHER RIVER LEVEES: THERMAILTO TO STAR BEND

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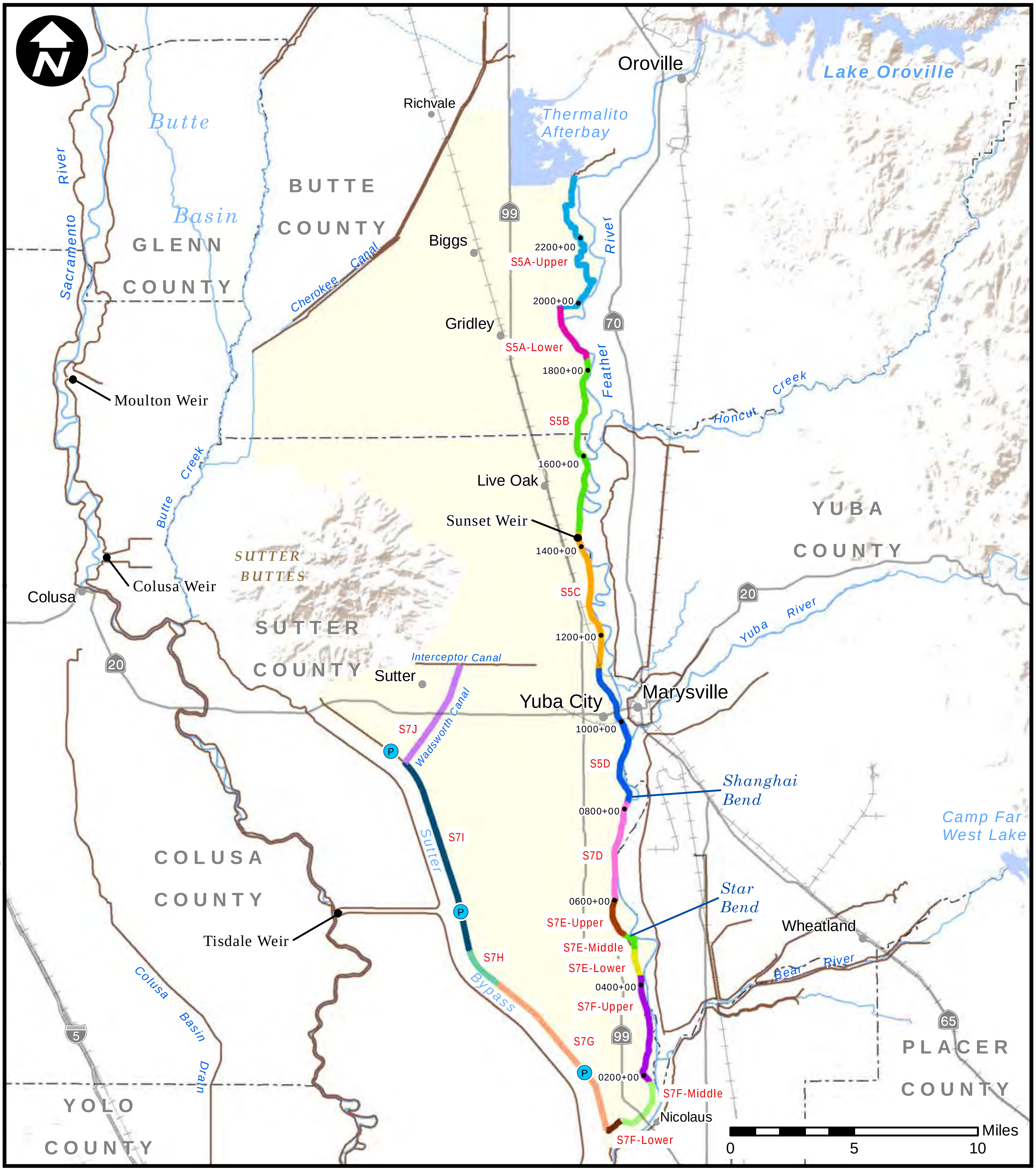

Legend

- Study Area Extent
- Project Reach (S5B)
- 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-6: FIX-IN-PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH CANAL LEVEES

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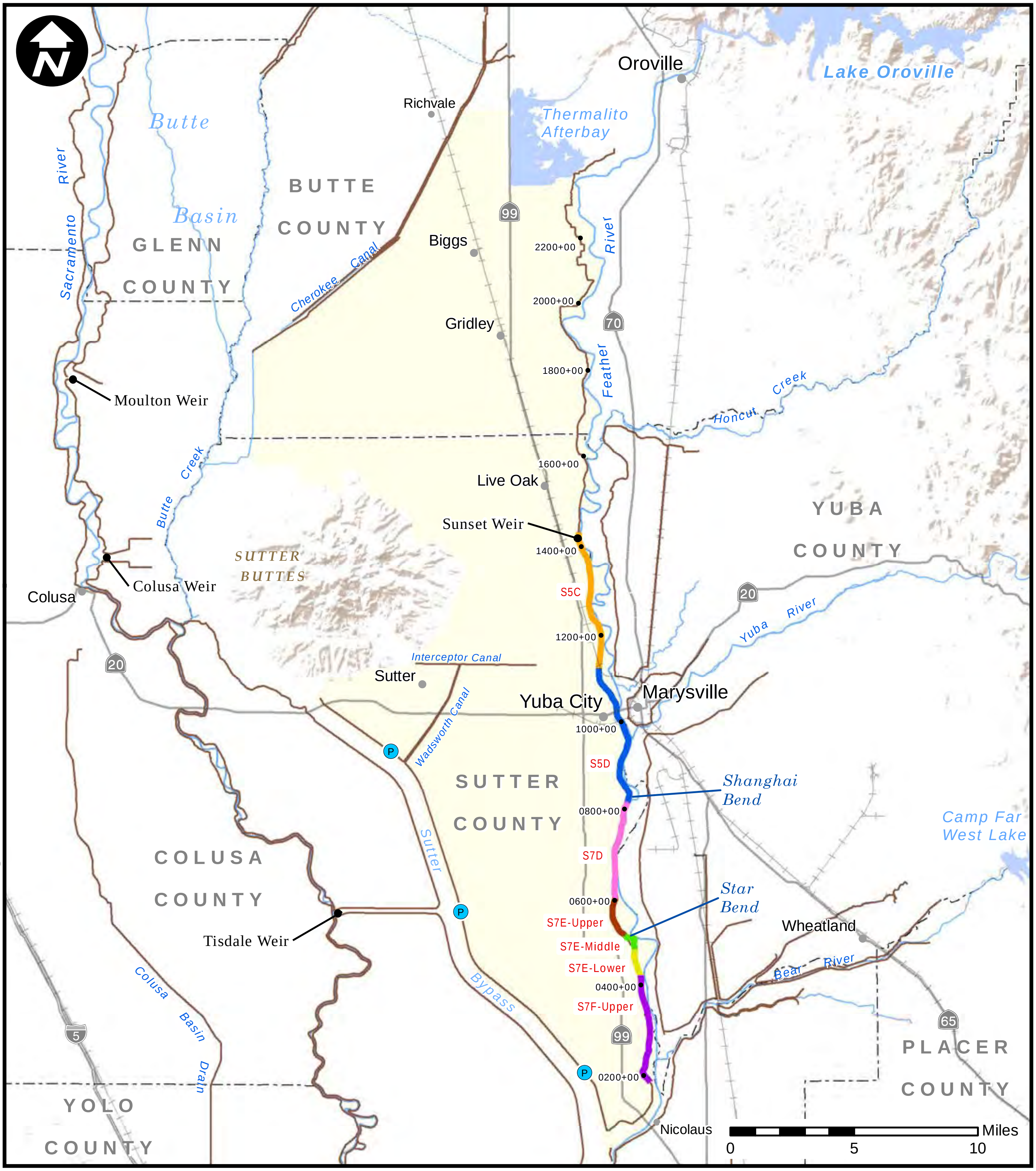
PLATE 1-6



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

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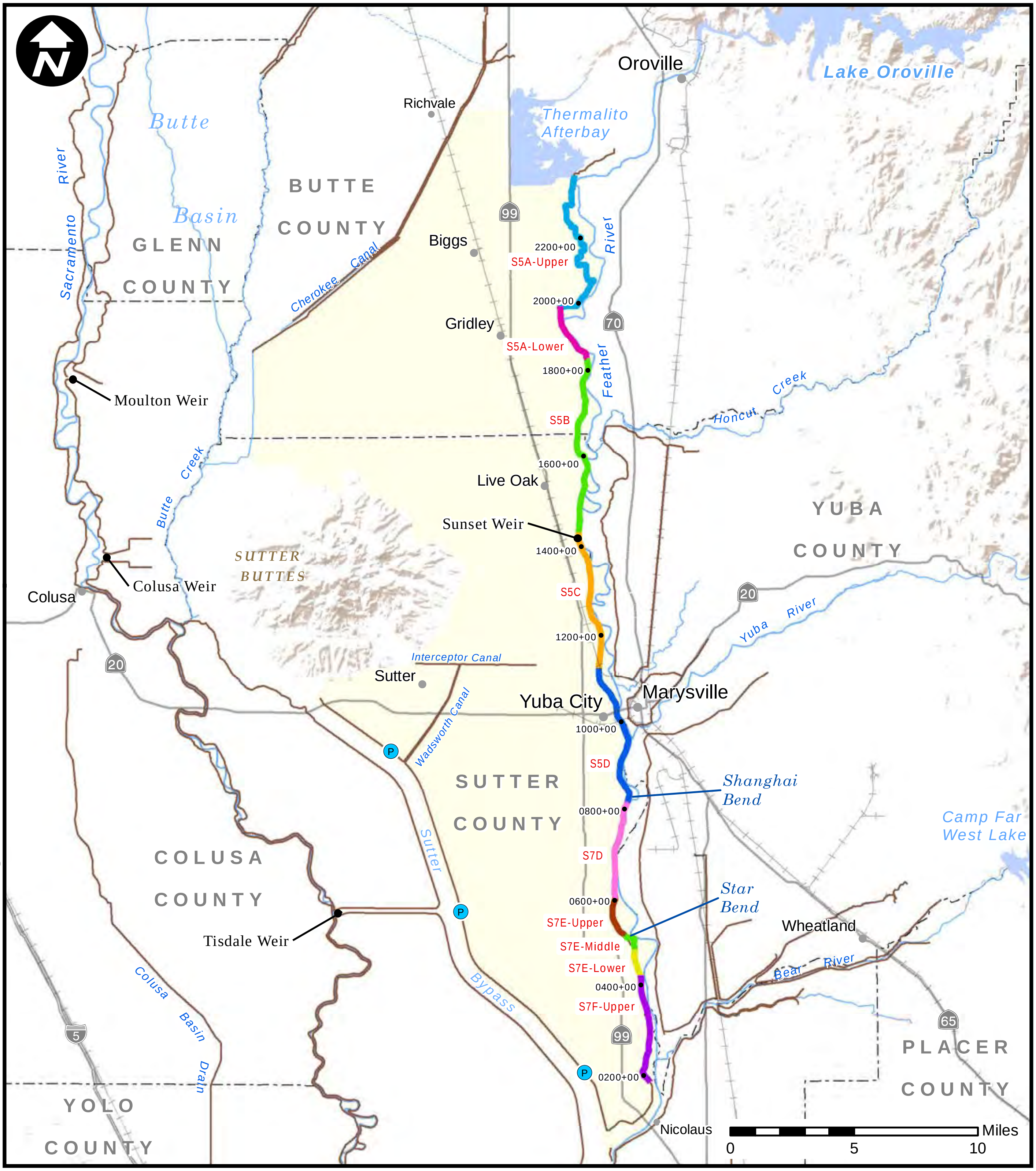

Legend

- Study Area Extent
- Project Reach (S5B)
- 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-8: FIX-IN-PLACE FEATHER RIVER LEVEES: THERMALITO TO LAUREL AVE

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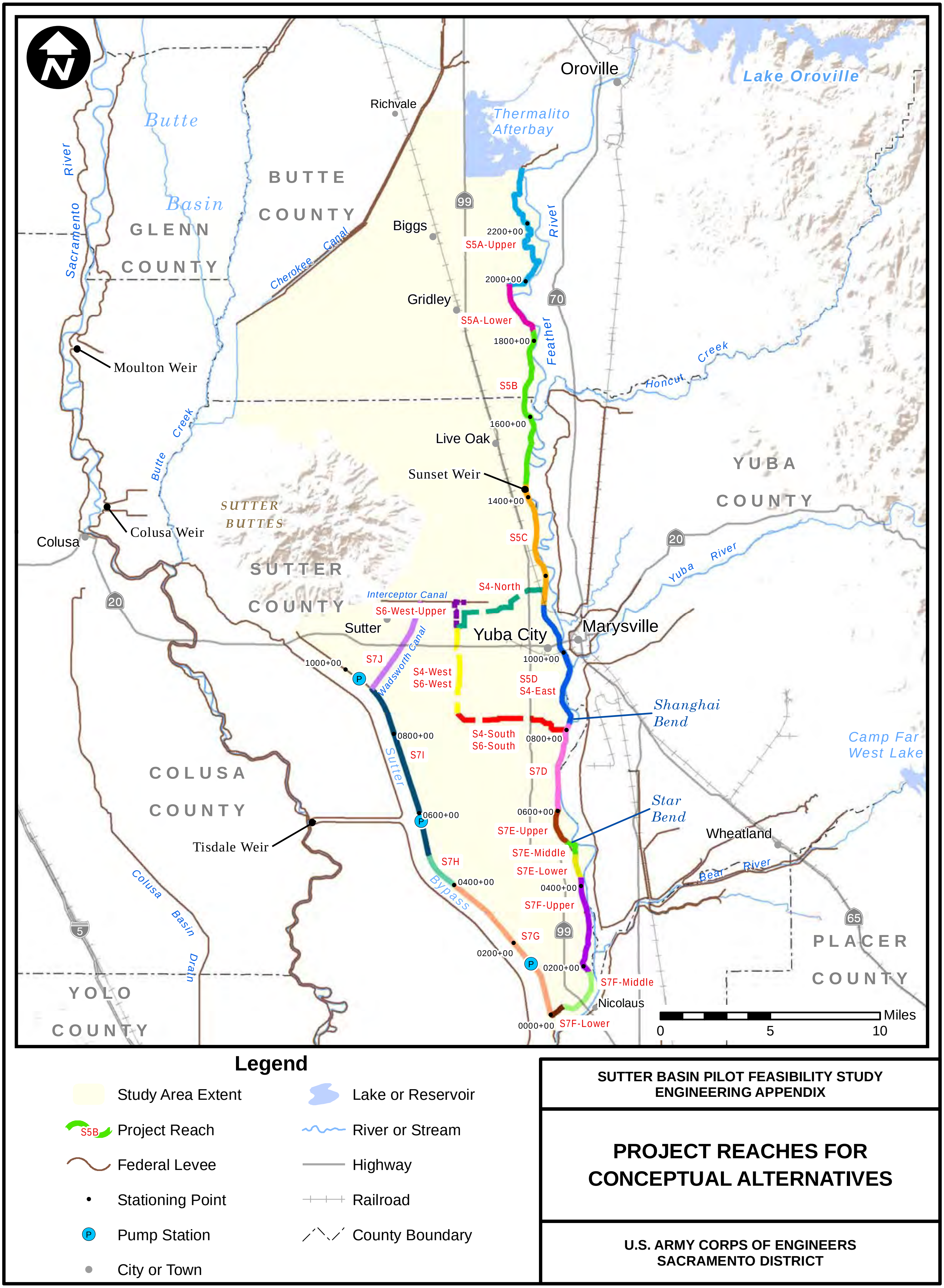

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ENGINEERING APPENDIX

PROJECT REACHES FOR CONCEPTUAL ALTERNATIVES

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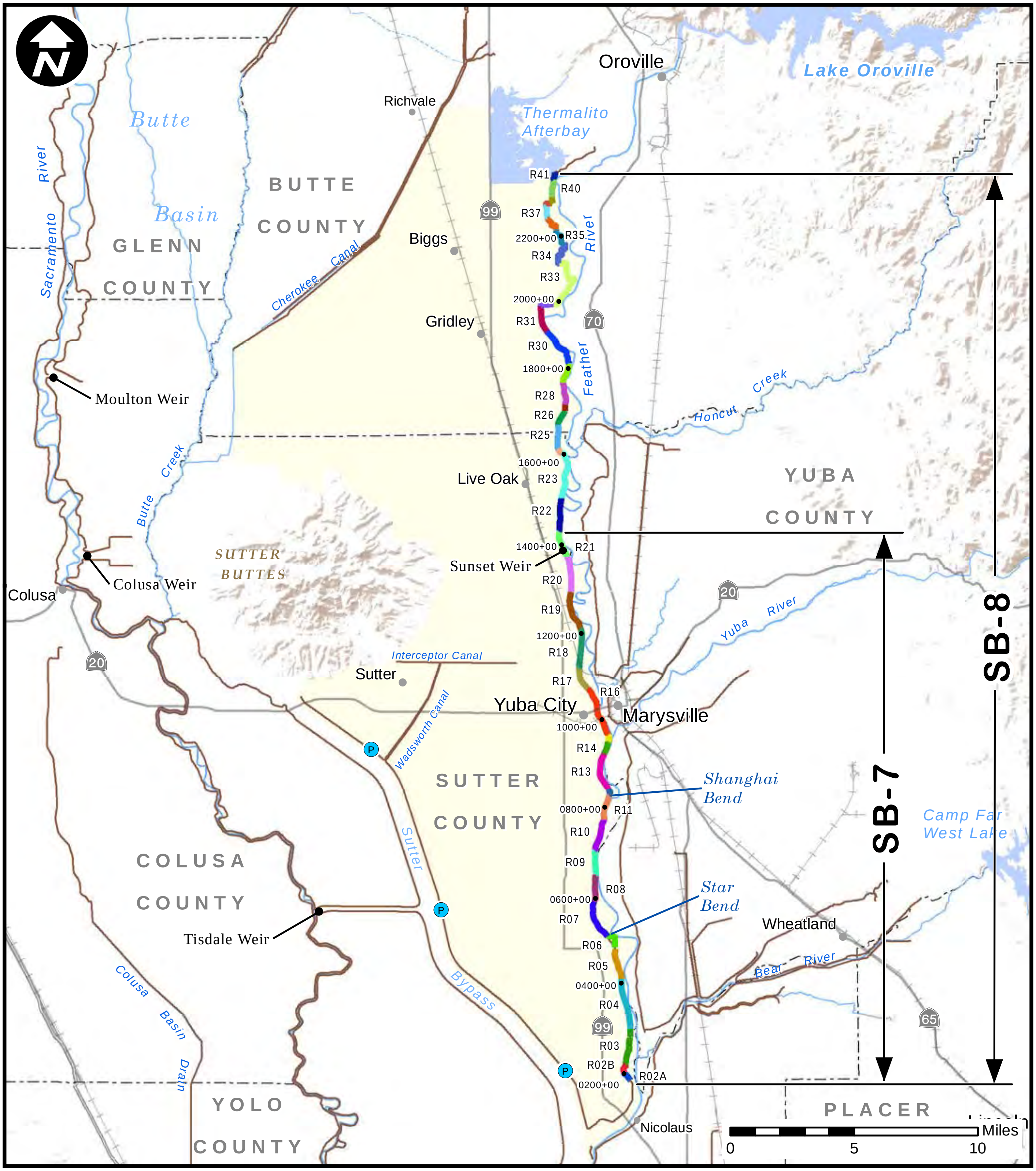

Legend

- 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
SUTTER BASIN, CALIFORNIA

PROJECT REACHES FOR FINAL ALTERNATIVES

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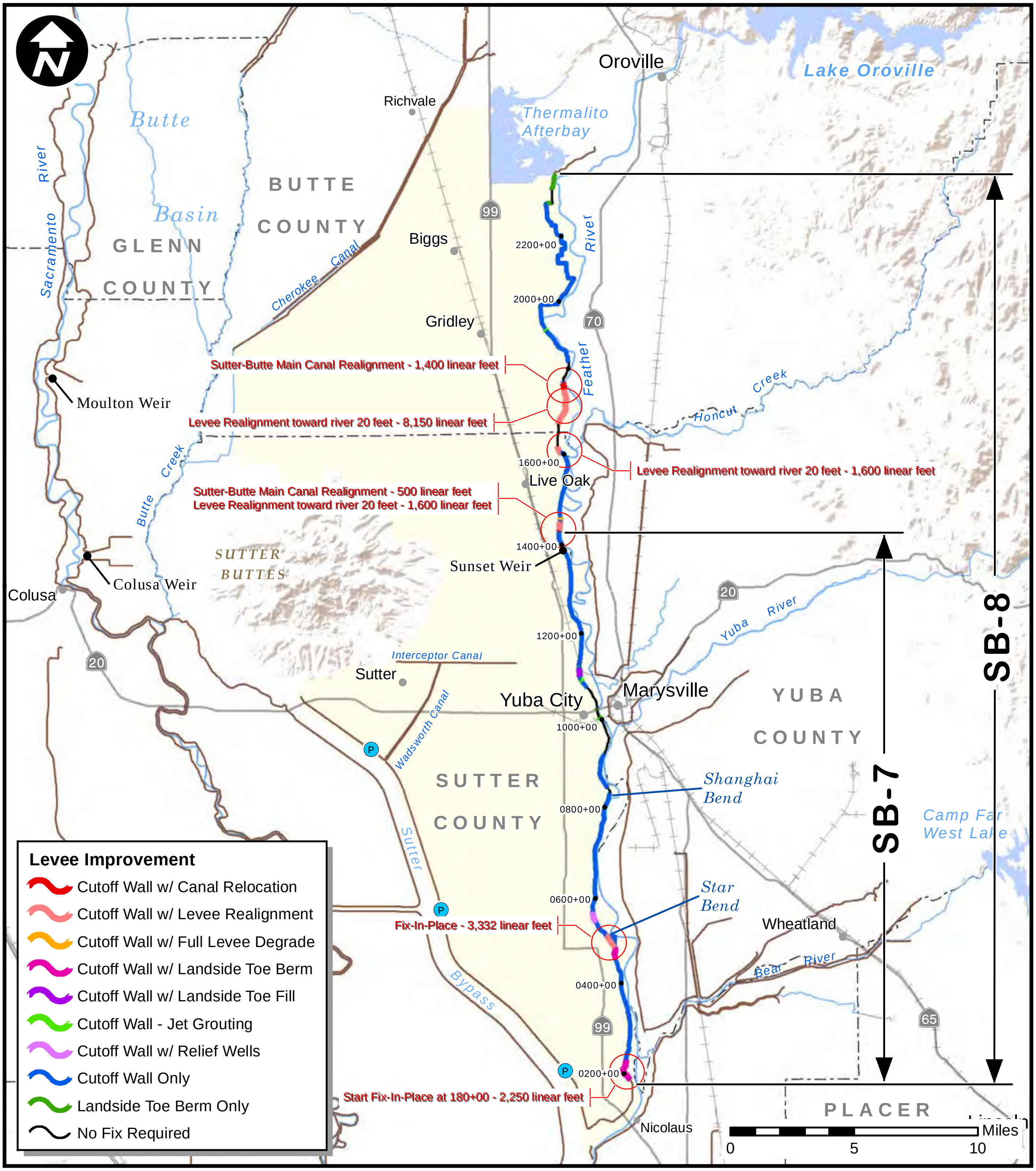

Legend

- 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

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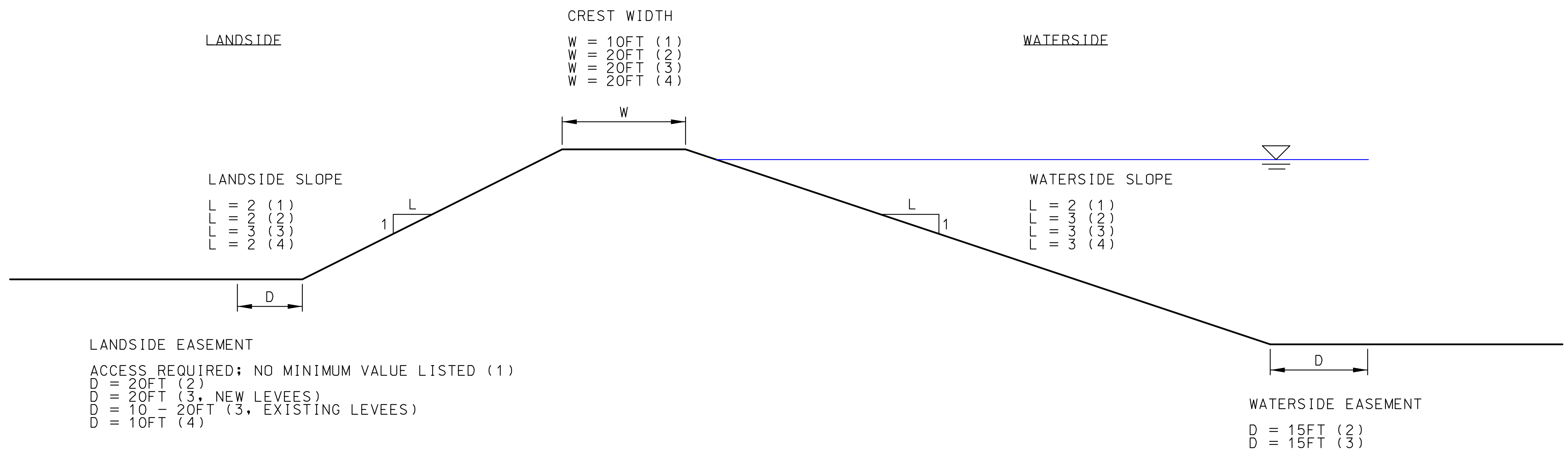

REFERENCES

(1) EM 1110-2-1913, DESIGN & CONSTRUCTION OF LEVEES, APRIL 2000
(2) SPK, GEOTECHNICAL LEVEE PRACTICE (REFP10L0 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: TUNG LE | Dwn by: TUNG LE | Reviewed by: - | Submitted by: - CHIEF, CIV ENGR DES SEC A
Spec No.: - | Date: - | Design file no: - | Drawing Code: - | Rev. -
File name: | Plot date: 28-MAR-2013 | Plot scale: -

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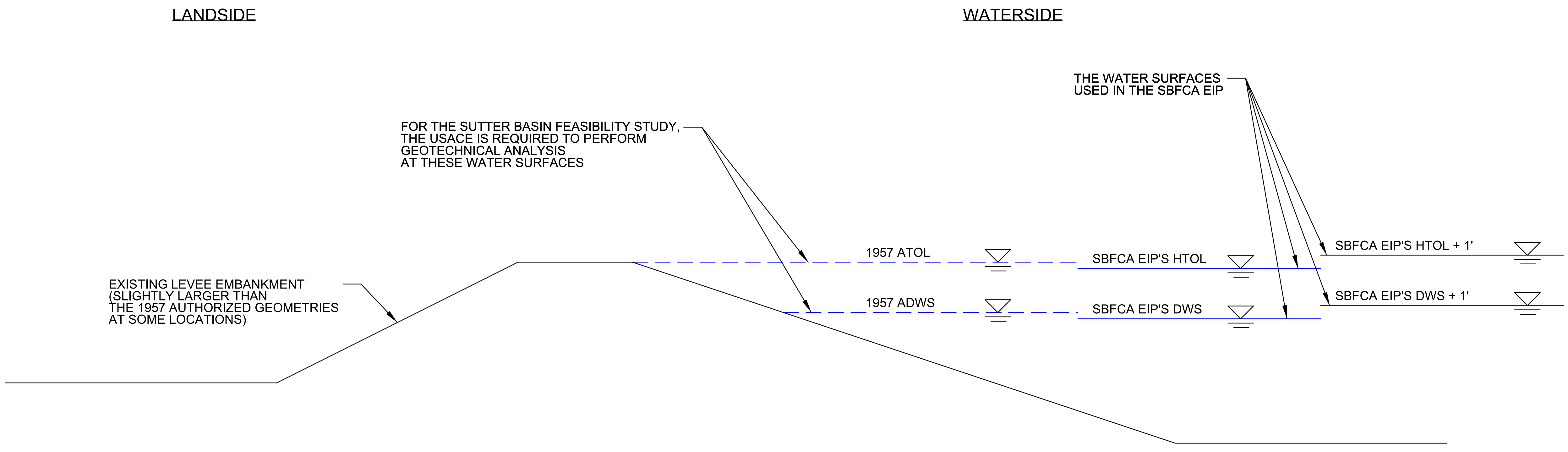
SUTTER BUTTE COUNTY CALIFORNIA
SUTTER BASIN FEASIBILITY STUDY
ENGINEERING APPENDIX

PLATE 2-4
TYPICAL LEVEE GEOMETRIES
MINIMUM REQUIREMENTS

Sheet reference number:
-
Sheet - of -
AM-XX

LANDSIDE WATERSIDE



(NOT TO SCALE)

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

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Dwn by: TUNG LE
Reviewed by: –
Submitted by: –
CHIEF, CIV ENGR DES SEC A
Spec No.: –
Date: –
Rev.: –
Design file no: –
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Plot date: 28-MAR-2013
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SUTTER BUTTE COUNTY CALIFORNIA
SUTTER BASIN FEASIBILITY STUDY
ENGINEERING APPENDIX

PLATE 2-5
CURRENT AUTHORIZATION &
GEOTECHNICAL ANALYSIS

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

ROW Encroachment[1]

Encroachment Located Within Project ROW Limits[2] Only

Levee Prism Structure Encroachment[3]	Levee Prism Wet Utility Encroachment[3]	Levee Prism Dry Utility Encroachment[3]	ROW Structure Encroachment	ROW Wet Utility Encroachment	ROW Dry Utility Encroachment
Retaining Wall	Pump Discharge Line	Telephone Cable	Home	Ag or Drainage Canal[4]	Telephone Cable
Railroad Tracks	Gravity Drainage Pipeline	Overhead Power	Shed	Water Supply Pipeline	Overhead Utility[4]
Home	Sewer Outfall	Fiber Optic Cable	Roadway	Sewer Pipeline	Fiber Optic Cable
Shed	Natural Gas Pipeline		Railroad Tracks	Natural Gas Pipeline	
Roadway/Bridge	Ag Turnout			Ag well	
				Ag Turnout	

Notes:

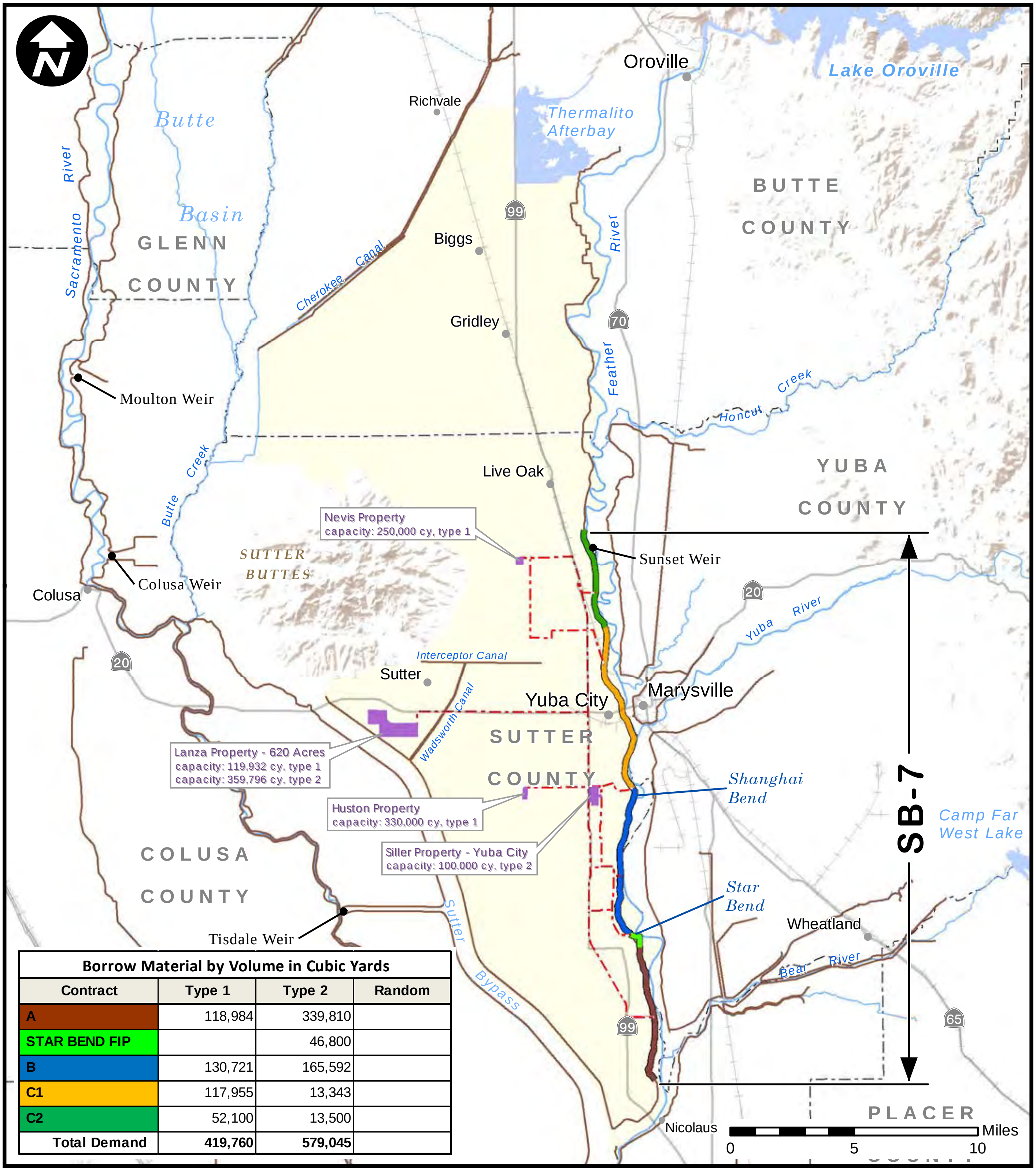
1. All utilities running parallel to the levee, unless located within the levee prism, are considered ROW Encroachments. All utilities running perpendicular to the levee are considered Levee Prism Encroachments, with the exception of overhead utilities, which are ONLY a levee prism encroachment if a 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	Lake or Reservoir
Haul Route	River or Stream
Contract Extent	Highway
Federal Levee	Railroad
City or Town	County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-7: CONSTRUCTION CONTRACT BORROW SITES AND HAUL ROUTES

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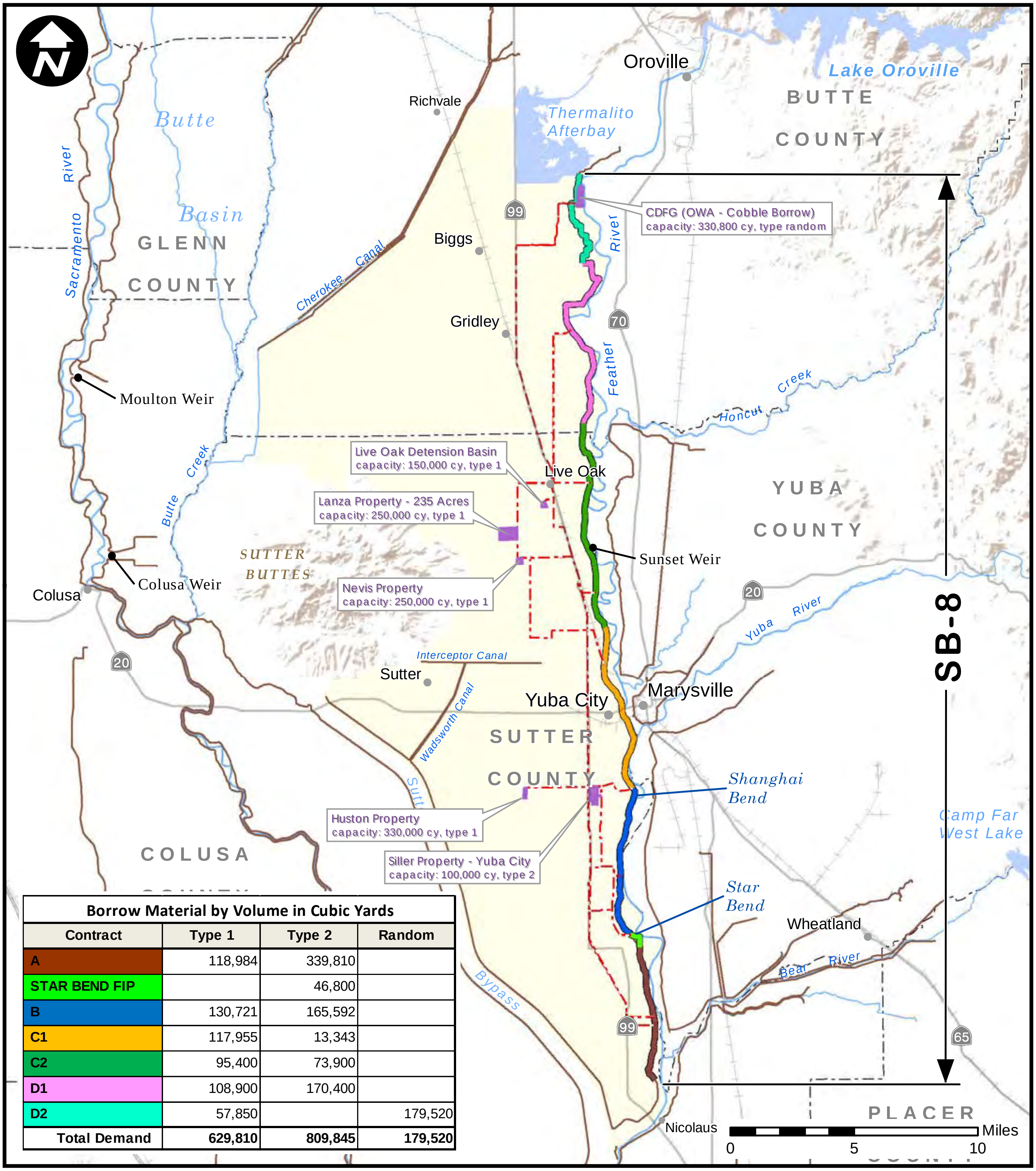
SACRAMENTO DISTRICT

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
- Lake or Reservoir
- Haul Route
- River or Stream
- Contract Extent
- Highway
- Federal Levee
- Railroad
- City or Town
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-8: CONSTRUCTION CONTRACT BORROW SITES AND HAUL ROUTES

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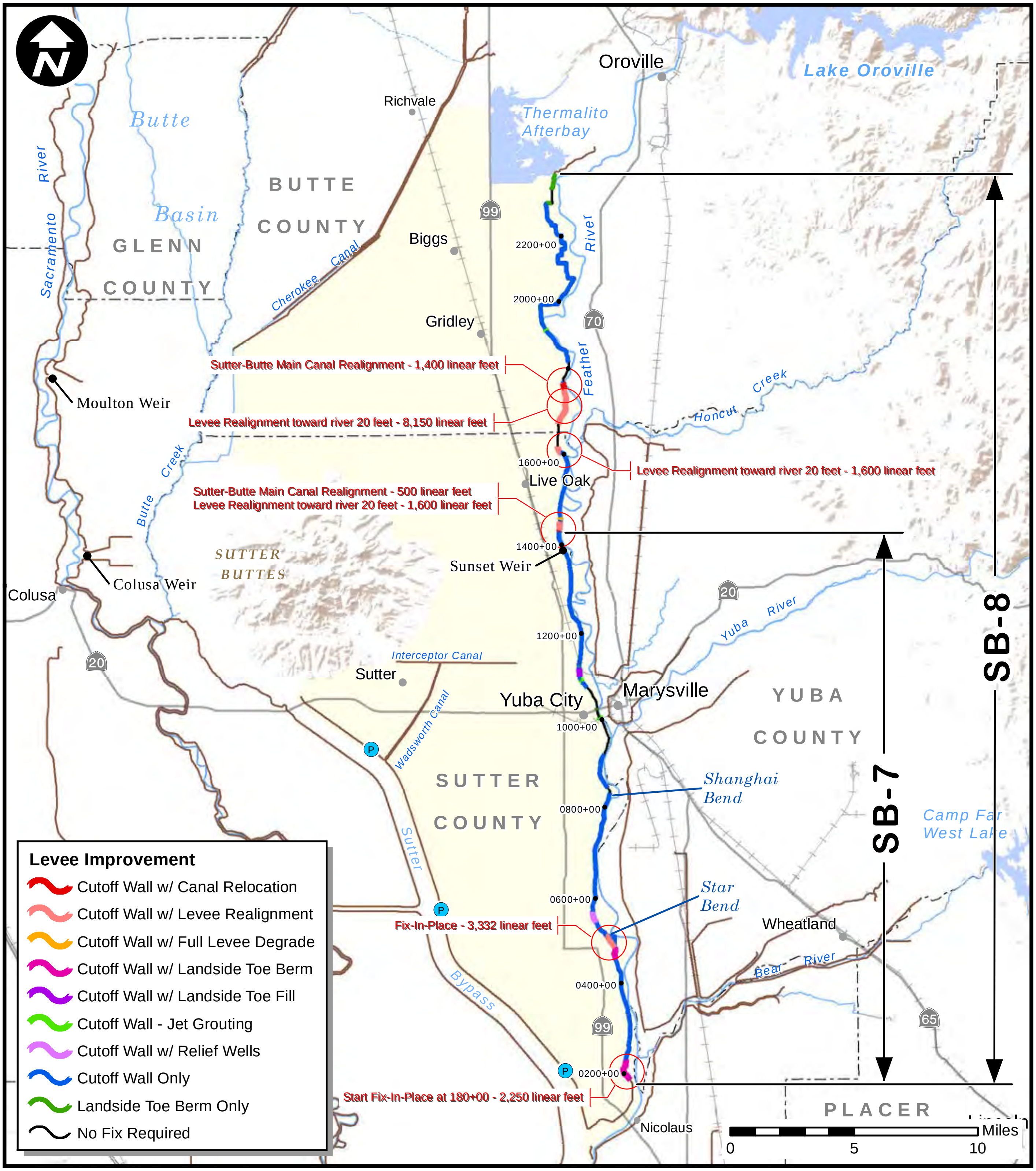

Legend

- 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

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PLATE G-1

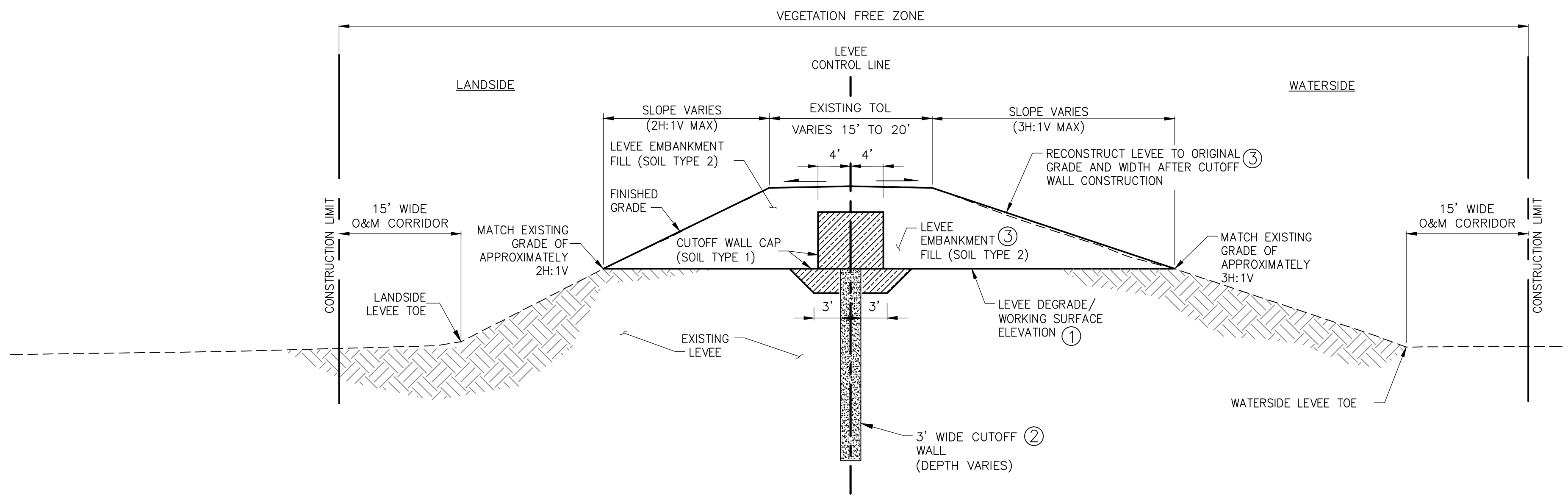

PLATE G-2A: TYPICAL CUTOFF WALL

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-2A
TYPICAL LEVEE IMPROVEMENT-CUTOFF WALL

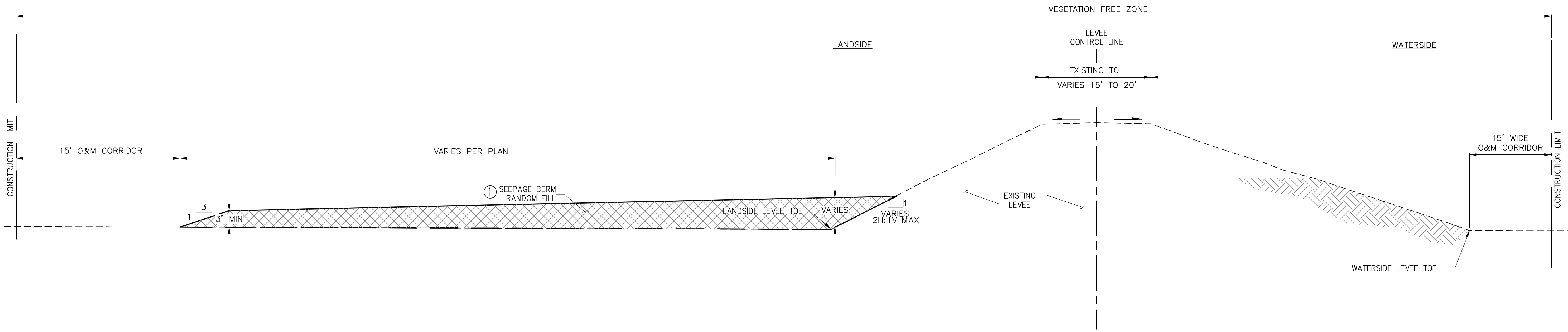

PLATE G2-B: TYPICAL SEEPAGE BERM

SCALE: NONE

CONSTRUCTION SEQUENCE:

(1) INSTALL RANDOM FILL FOR SEEPAGE BERM

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PLATE G-2B
TYPICAL LEVEE IMPROVEMENT – SEEPAGE BERM

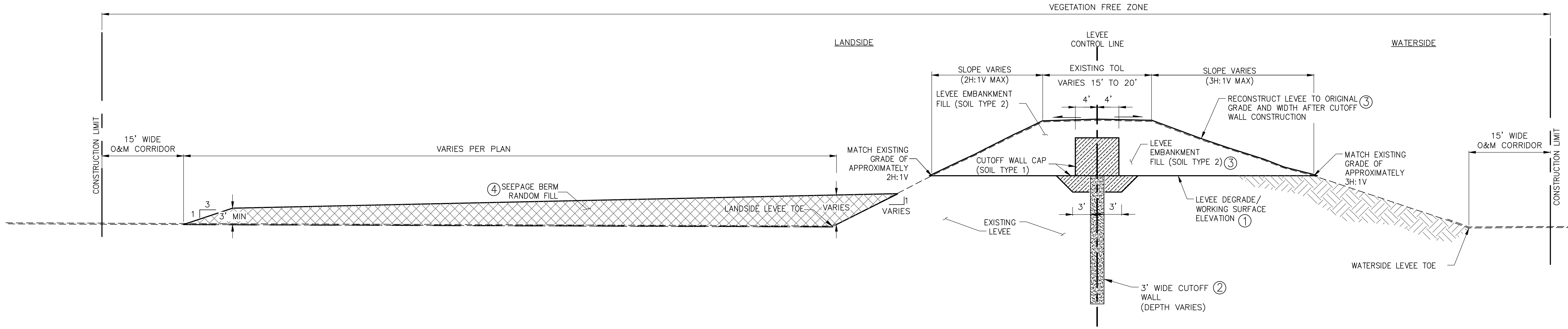

PLATE G-2C1: TYPICAL CUTOFF WALL WITH SEEPAGE BERM

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.
4. INSTALL RANDOM FILL FOR SEEPAGE BERM

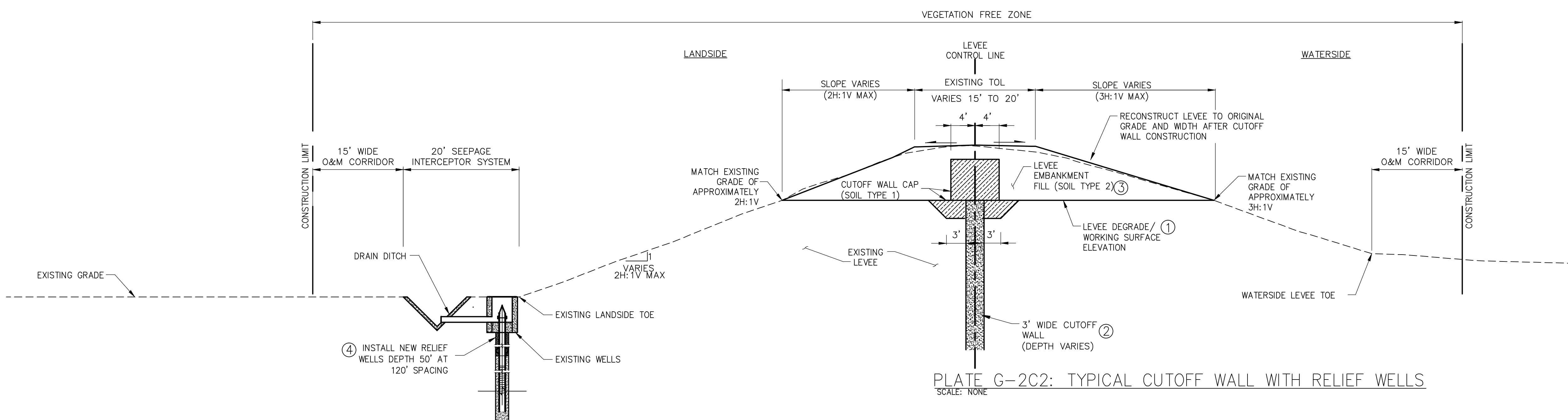

PLATE G-2C2: TYPICAL CUTOFF WALL WITH RELIEF WELLS

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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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-2C
TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH SEEPAGE BERM OR RELIEF WELLS

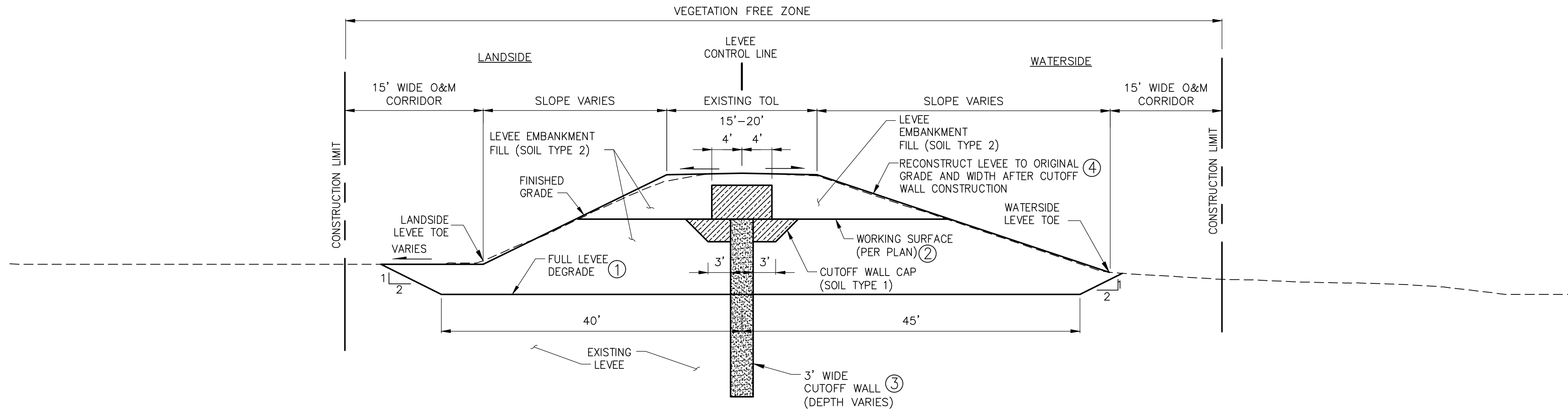

PLATE G-2D1: TYPICAL CUTOFF WALL WITH FULL LEVEE DEGRADE

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. FILL UP TO WORKING SURFACE ELEVATION
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.

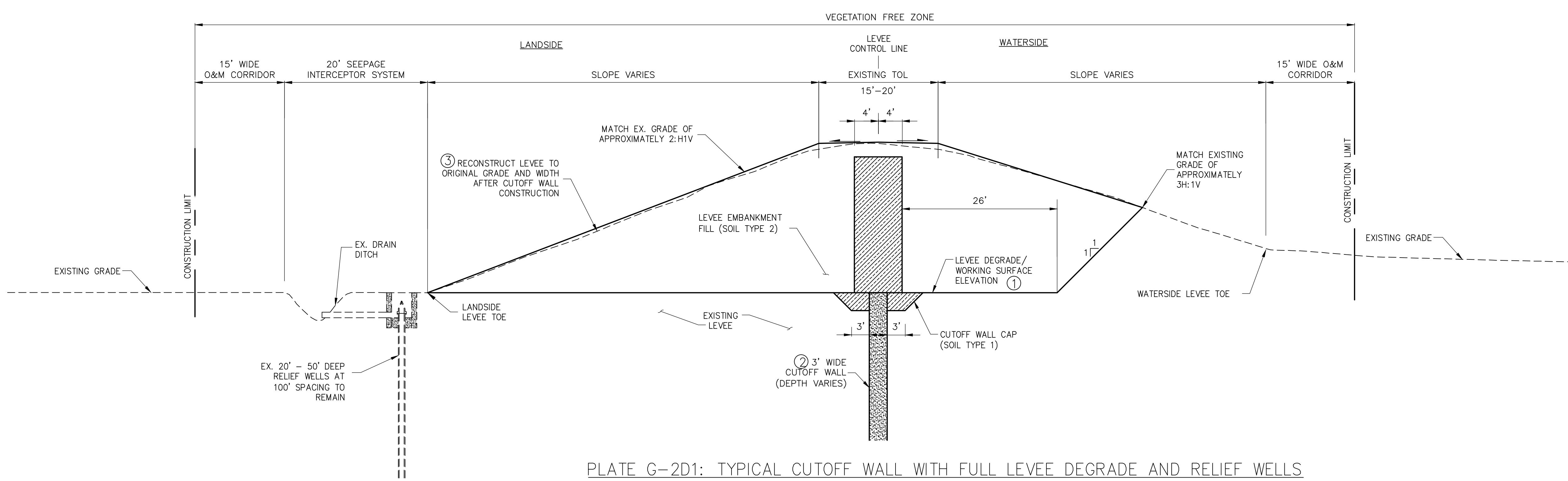

PLATE G-2D1: TYPICAL CUTOFF WALL WITH FULL LEVEE DEGRADE AND RELIEF WELLS

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.

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PLATE G-2D
TYPICAL LEVEE IMPROVEMENT - CUTOFF WALL WITH FULL LEVEE DEGRADE AND RELIEF WELLS

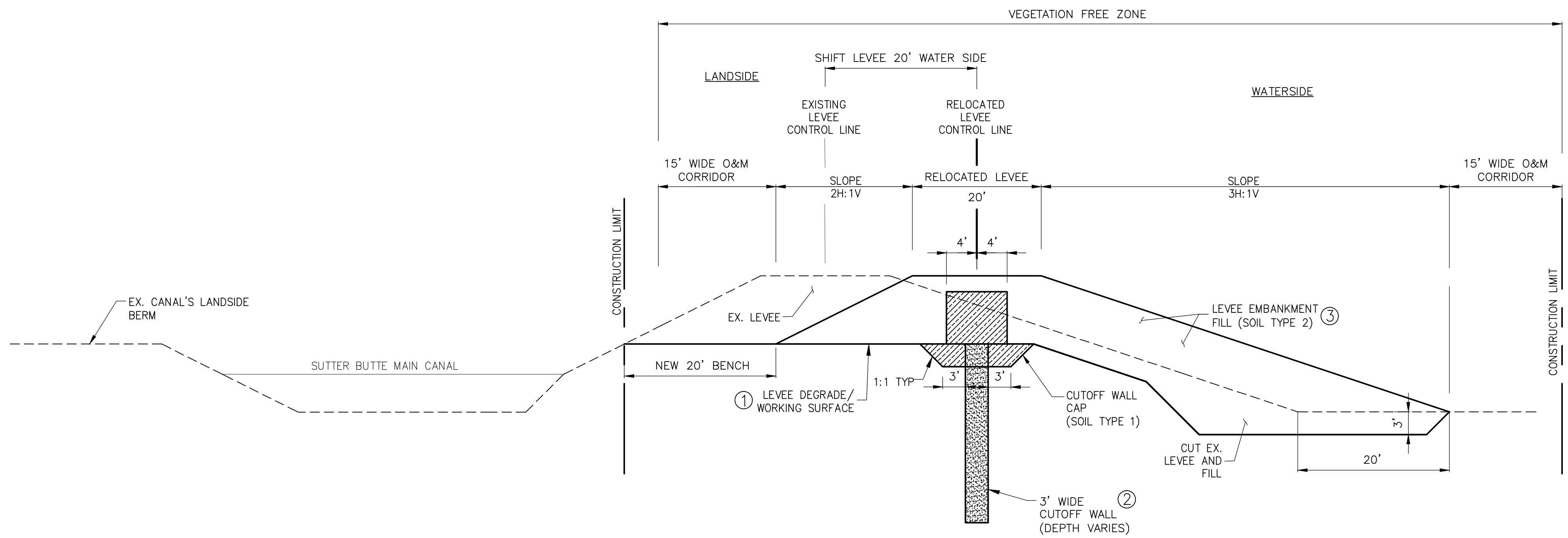

PLATE G-2E: TYPICAL CUTOFF WALL WITH LEVEE RELOCATION

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. CONSTRUCT RELOCATED LEVEE EMBANKMENT.

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PLATE G-2E
TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH LEVEE RELOCATION

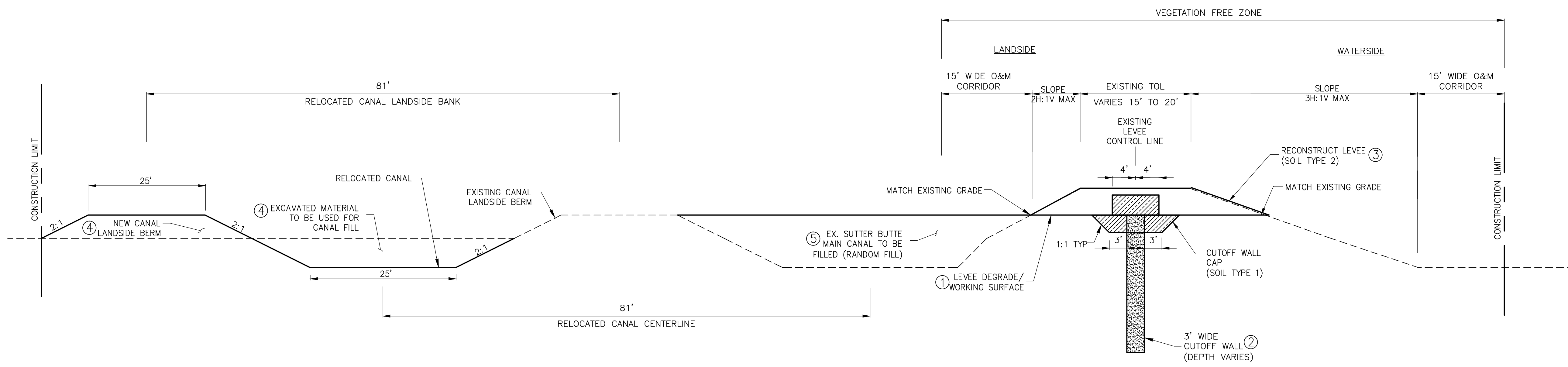

PLATE G-2F: TYPICAL CUTOFF WALL WITH CANAL RELOCATION

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

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ENGINEERING APPENDIX
PLATE G-2F
TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH CANAL RELOCATION

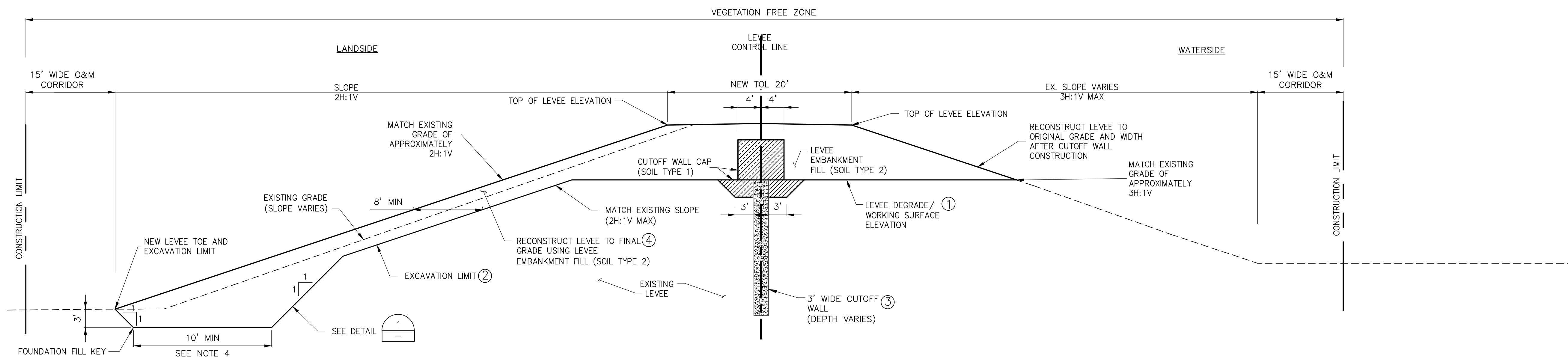
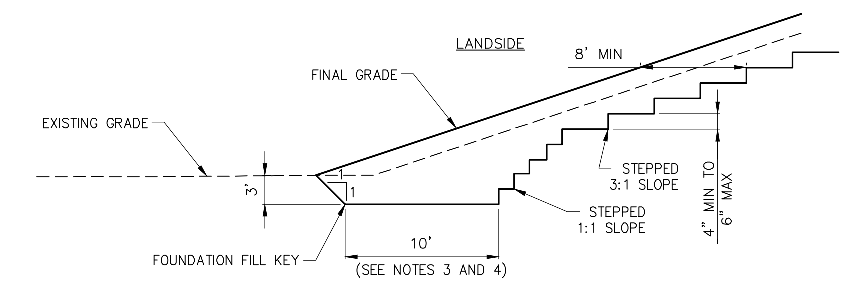


PLATE G-2G: TYPICAL CUTOFF WALL WITH LANDSIDE TOE FILL

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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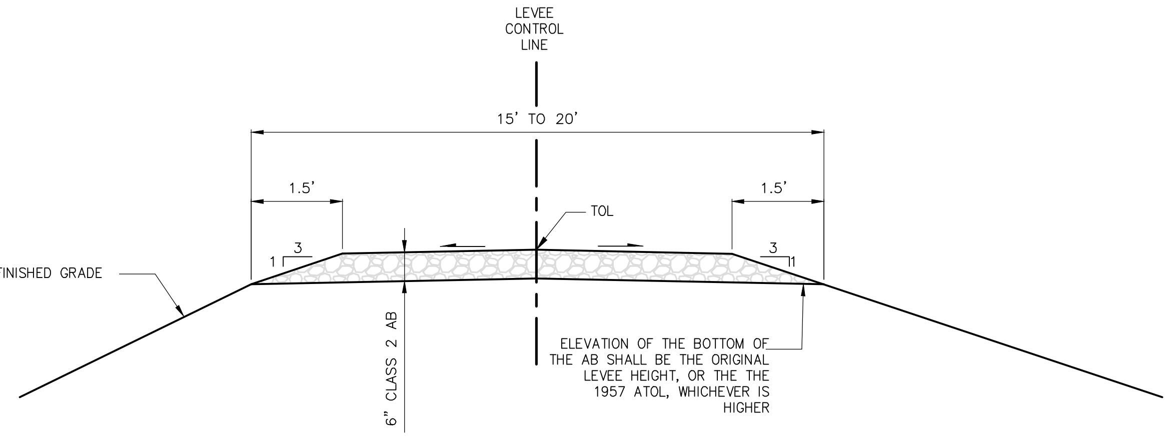
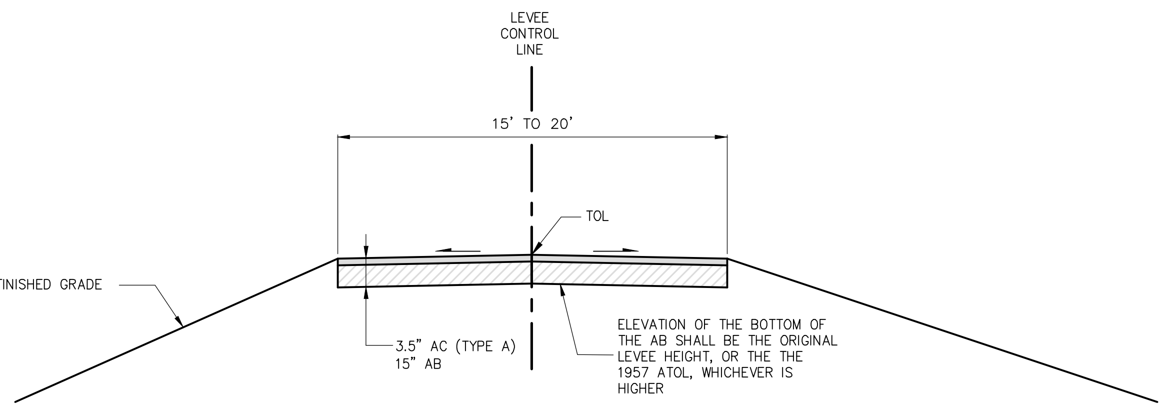
PLATE G-2G
TYPICAL LEVEE IMPROVEMENT – TYPICAL CUTOFF WALL WITH LANDSIDE TOE FILL



CROWN SURFACING DETAIL (TYP)

NTS



PAVED LEVEE ROAD SECTION

NTS

PLATE G-2H: TYPICAL LEVEE ROAD DETAIL

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PLATE G-2H
TYPICAL LEVEE IMPROVEMENT – TYPICAL LEVEE ROAD DETAIL

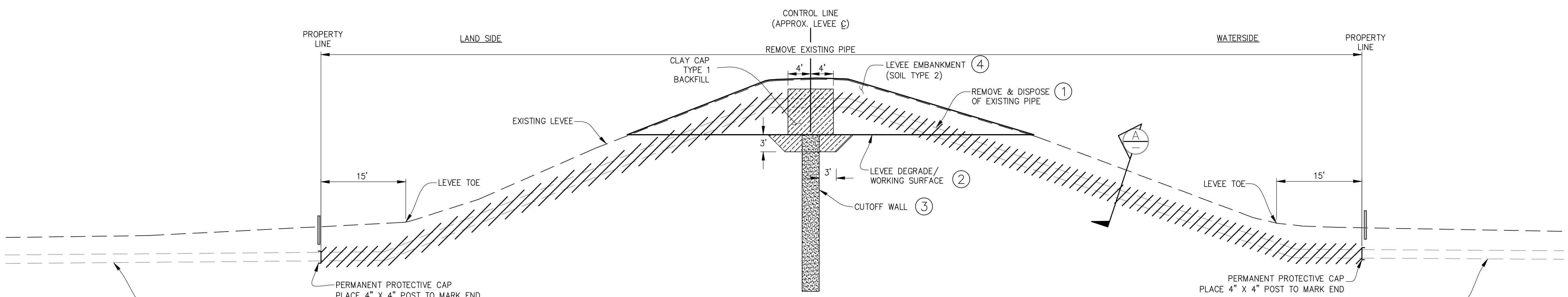
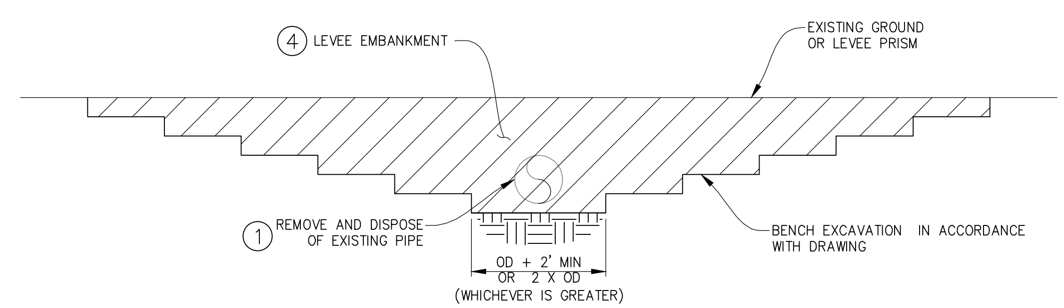


PLATE G-3A: TYPICAL REMOVAL & DISPOSAL OF ABANDONED RAISED PIPE (TYPE 1A)

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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PLATE G-3A
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND DISPOSAL OF ABANDONED RAISED PIPE

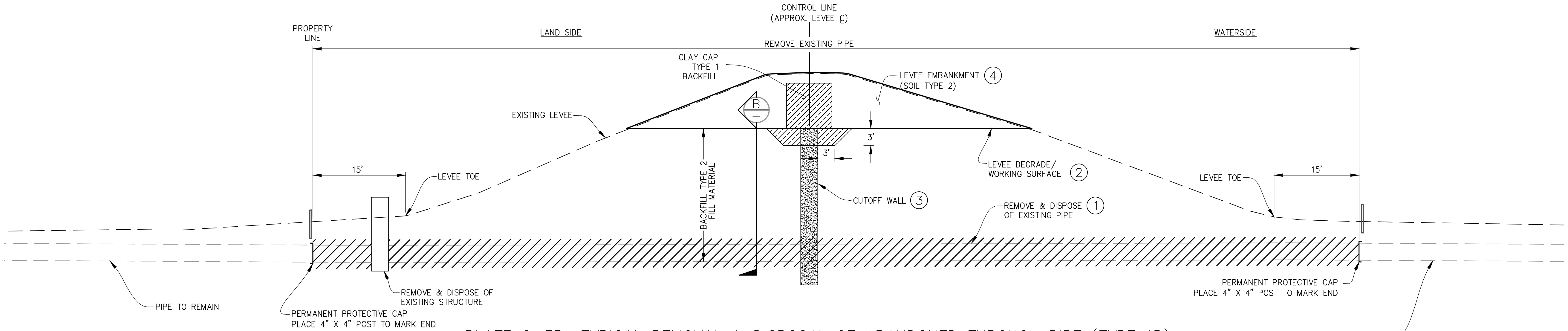
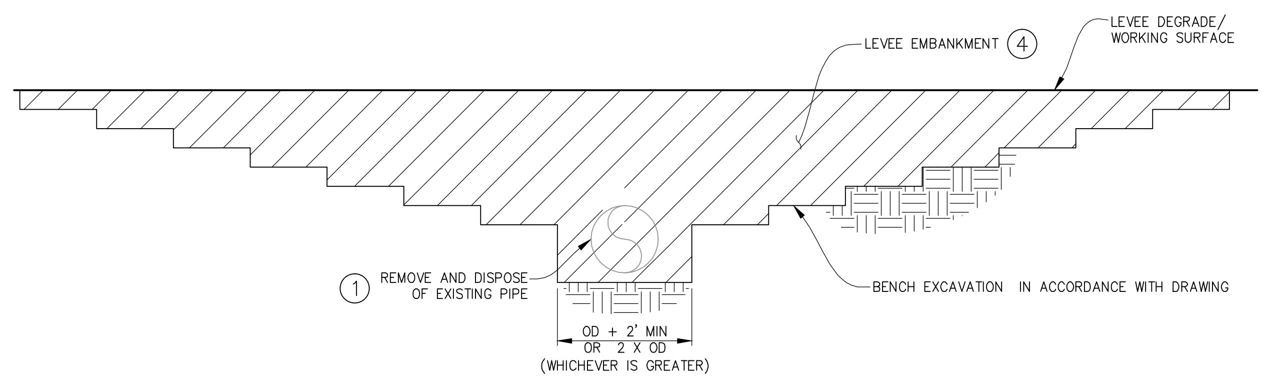


PLATE G–3B: TYPICAL REMOVAL & DISPOSAL OF ABANDONED THROUGH PIPE (TYPE 1B)

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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PLATE G–3B
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND DISPOSAL OF ABANDONED THROUGH PIPE

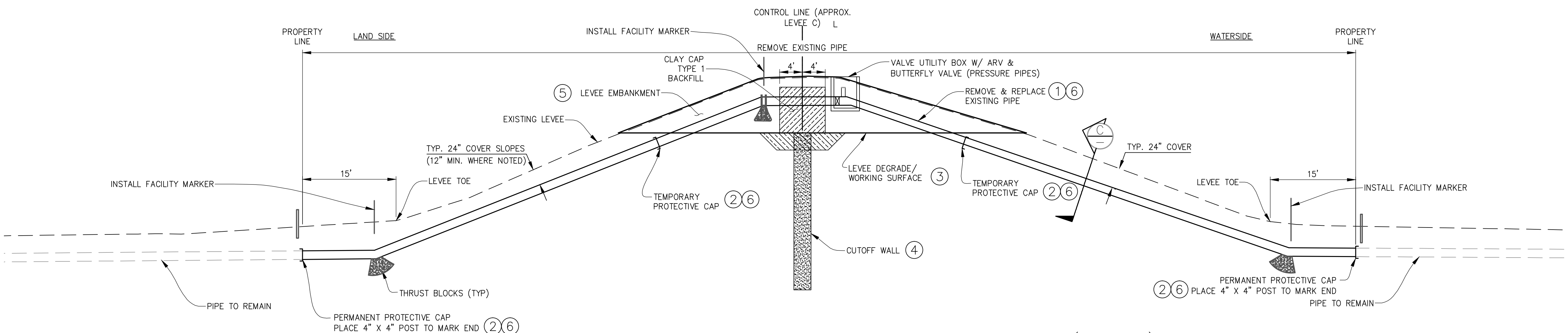


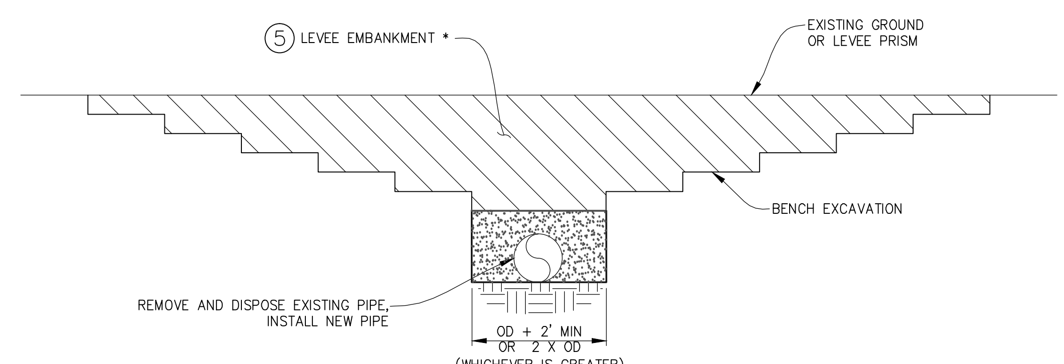
PLATE G-3C: TYPICAL REMOVAL & REPLACEMENT OF RAISED PIPE (TYPE 2A)

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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PLATE G-3C
TYPICAL UTILITY IMPROVEMENT - REMOVAL AND REPLACEMENT OF RAISED PIPE

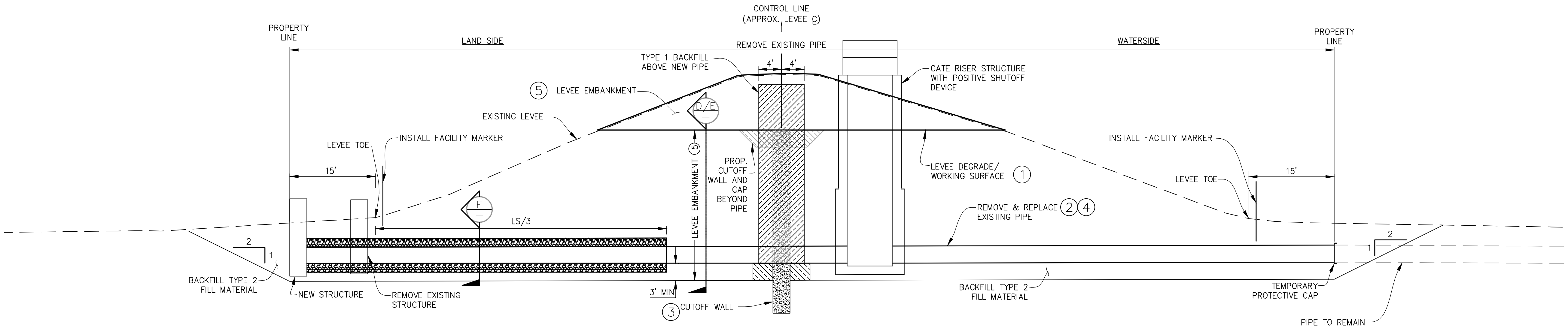
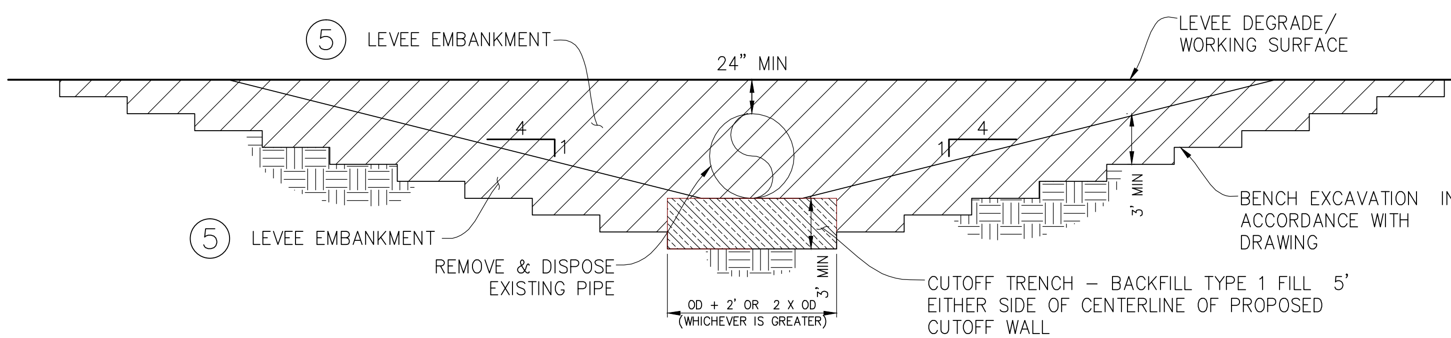


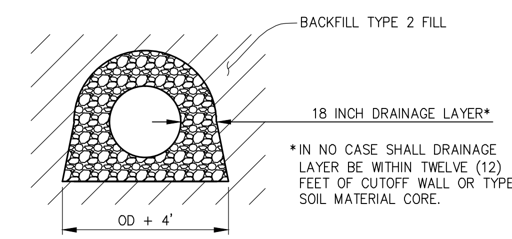
PLATE G-3D: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE (TYPE 2B)
SCALE: NONE

CONSTRUCTION SEQUENCE:

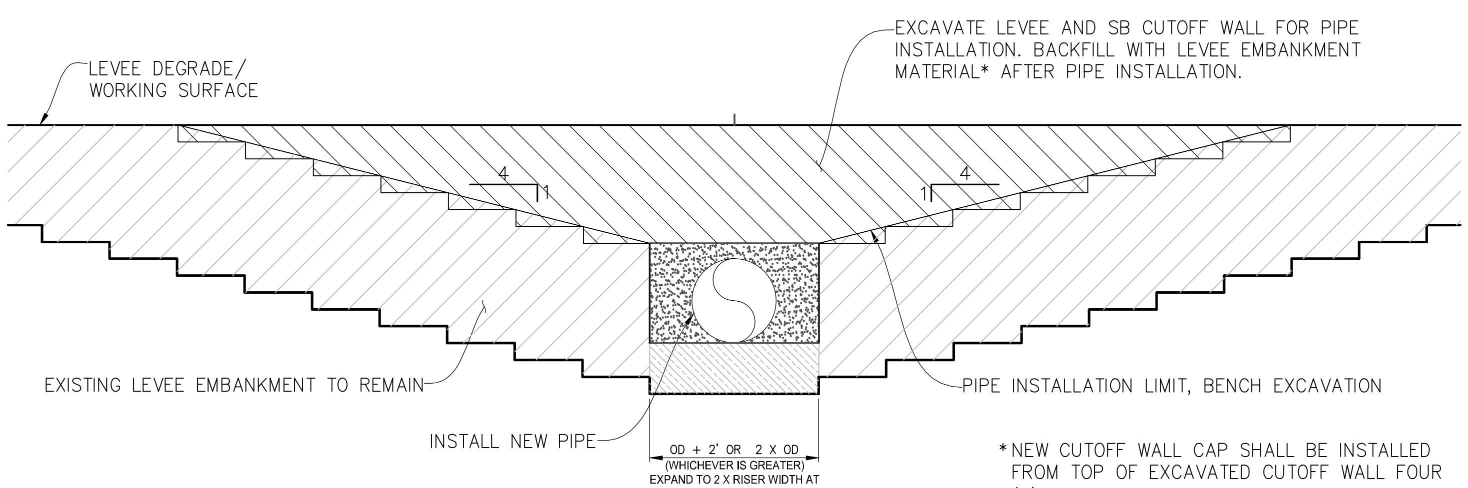
1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE (SEE SECTION D).
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE (SEE SECTION E).
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AN RISER INSTALLATION.



SECTION D
SCALE: NONE



SECTION F
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

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D1	DESCRIPTION1	DATE1	APPROVAL1
D2	DESCRIPTION2	DATE2	APPROVAL2
D3	DESCRIPTION3	DATE3	APPROVAL3
D4	DESCRIPTION4	DATE4	APPROVAL4
D5	DESCRIPTION5	DATE5	APPROVAL5
D6	DESCRIPTION6	DATE6	APPROVAL6
D7	DESCRIPTION7	DATE7	APPROVAL7
D8	DESCRIPTION8	DATE8	APPROVAL8

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Dwn by: – Spec No.: – Design file no: –
Reviewed by: – Drawing Code: –
Submitted by: – File name: $$$$$$$$
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PLATE G-3D
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE

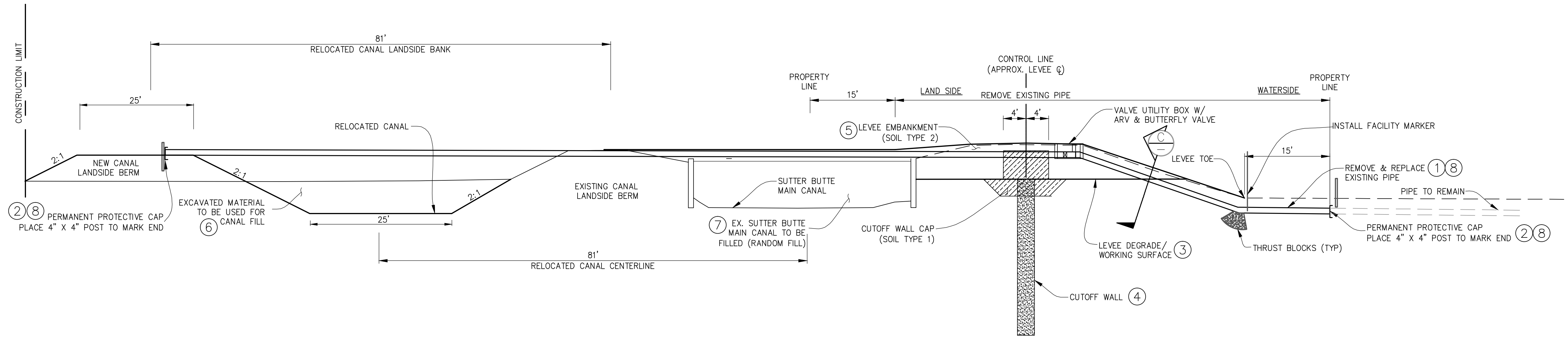
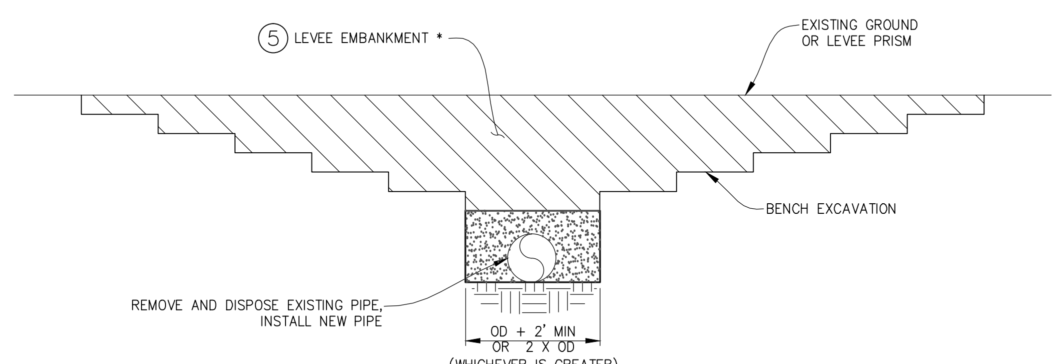


PLATE G-3E1: TYPICAL REMOVAL & REPLACEMENT OF RAISED PIPE WITH CANAL RELOCATION (TYPE 3A1)

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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PLATE G-3E1
TYPICAL UTILITY IMPROVEMENT - REMOVAL AND REPLACEMENT OF RAISED PIPE W/ CANAL RELOCATION

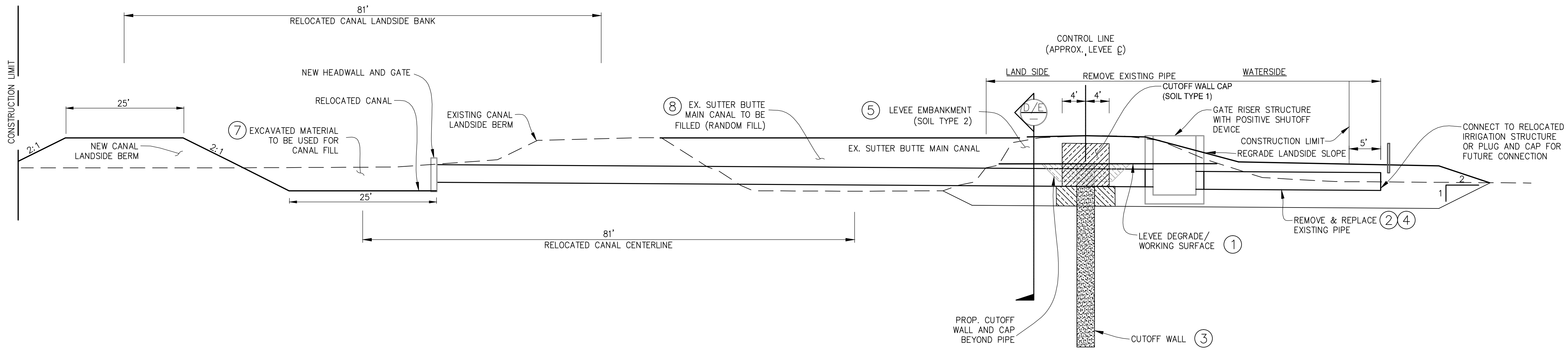
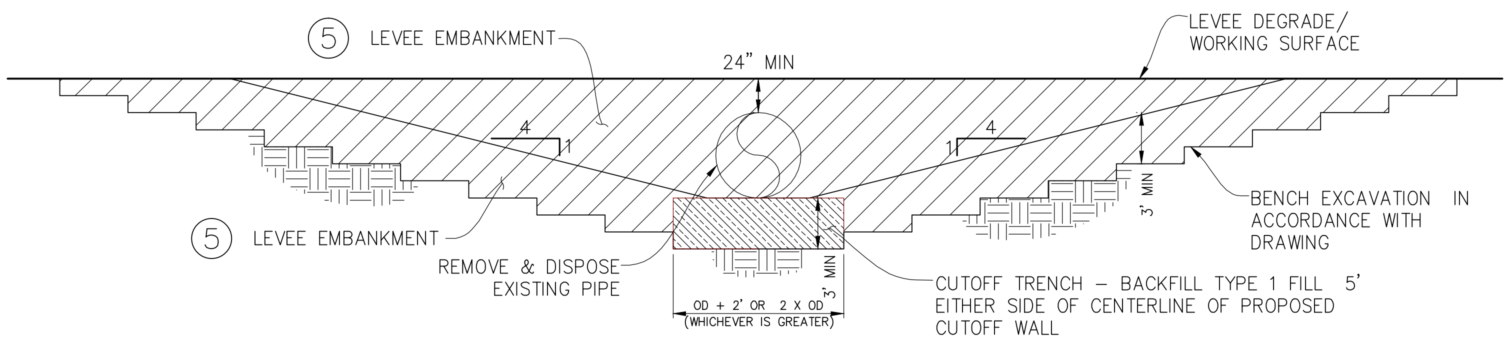


PLATE G–3E2: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE WITH CANAL RELOCATION (TYPE 3A2)

SCALE: NONE

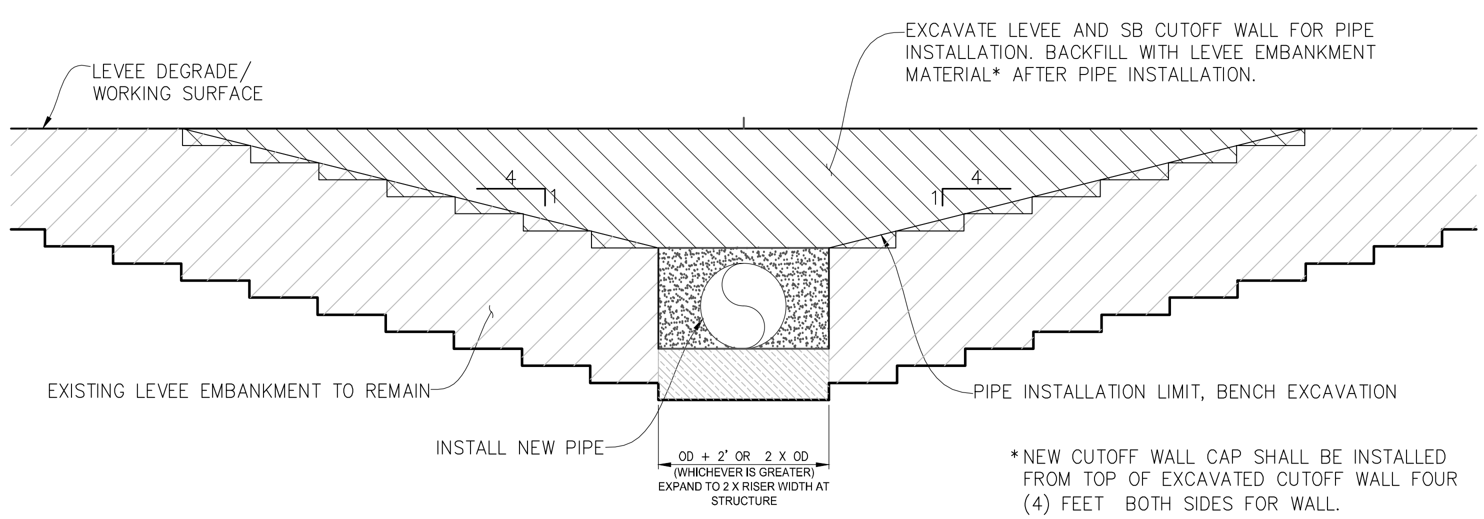
CONSTRUCTION SEQUENCE:

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



*NEW CUTOFF WALL CAP SHALL BE INSTALLED FROM TOP OF EXCAVATED CUTOFF WALL FOUR (4) FEET BOTH SIDES FOR WALL.

SECTION E

SCALE: NONE

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PLATE G–3E2
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE W/ CANAL RELOCATION

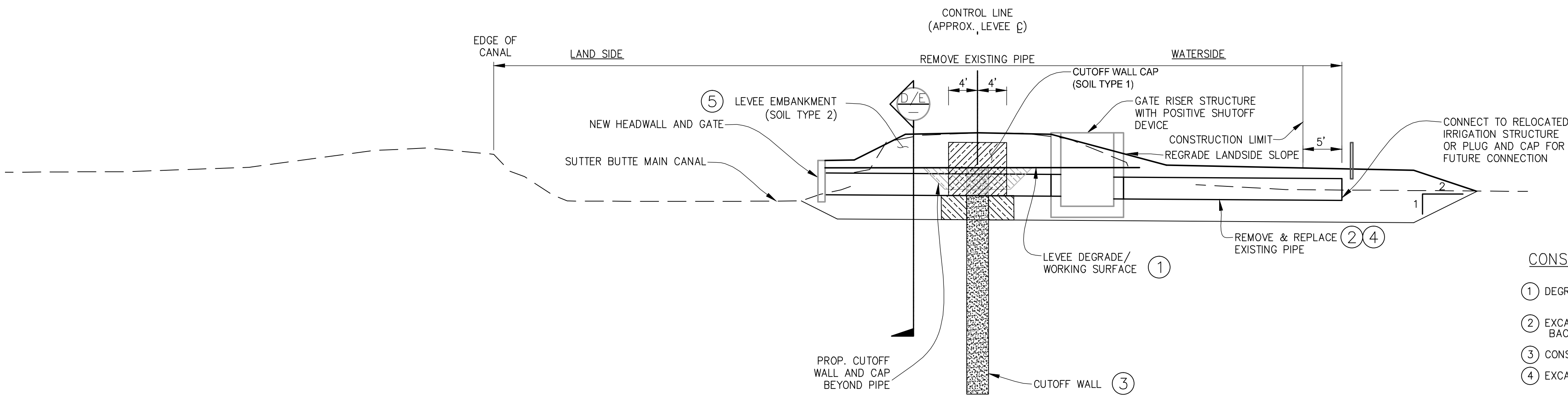
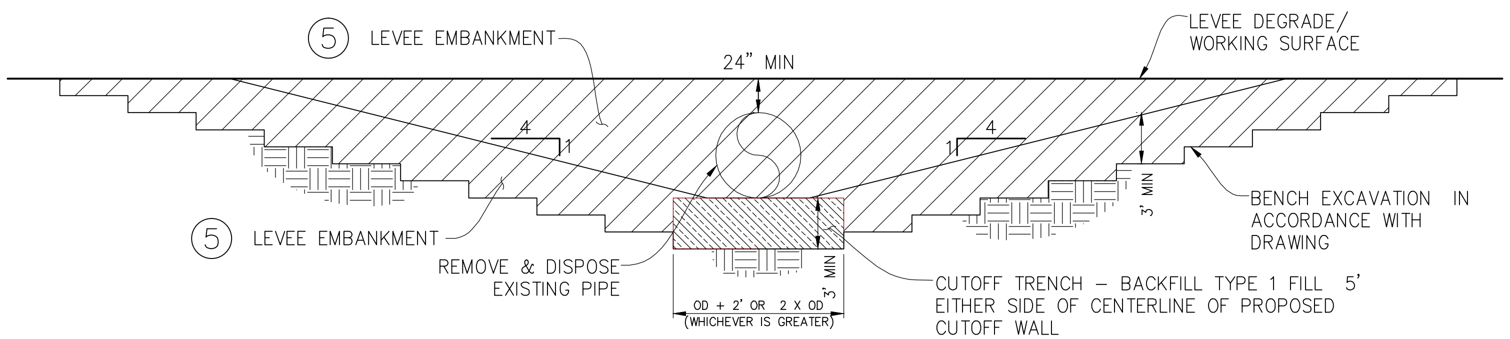


PLATE G-3F: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE ADJACENT TO CANAL (TYPE 3B)

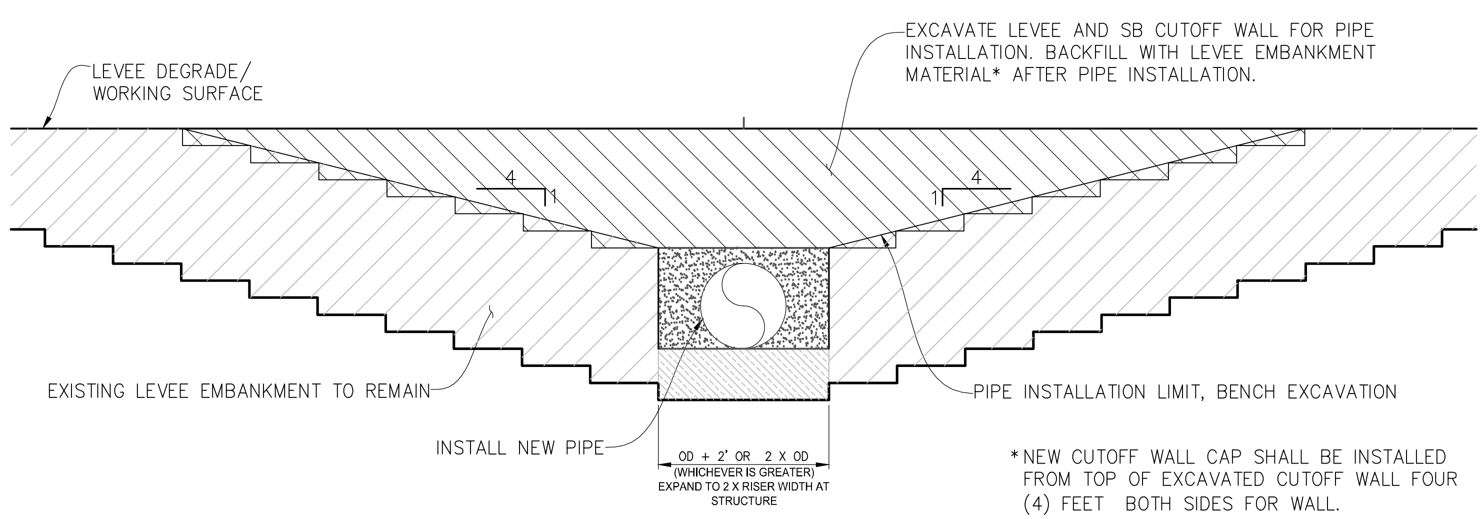
SCALE: NONE

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



*NEW CUTOFF WALL CAP SHALL BE INSTALLED FROM TOP OF EXCAVATED CUTOFF WALL FOUR (4) FEET BOTH SIDES FOR WALL.

SECTION E
SCALE: NONE

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PLATE G-3F
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE ADJACENT TO CANAL

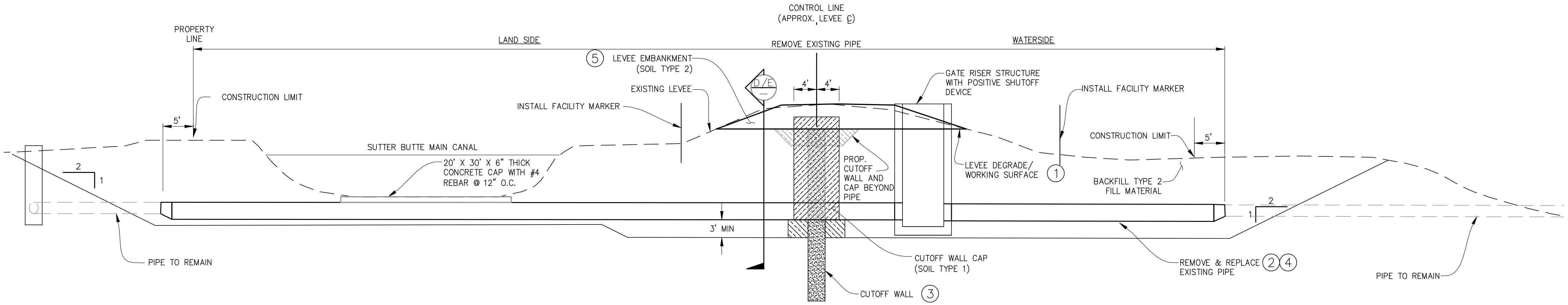
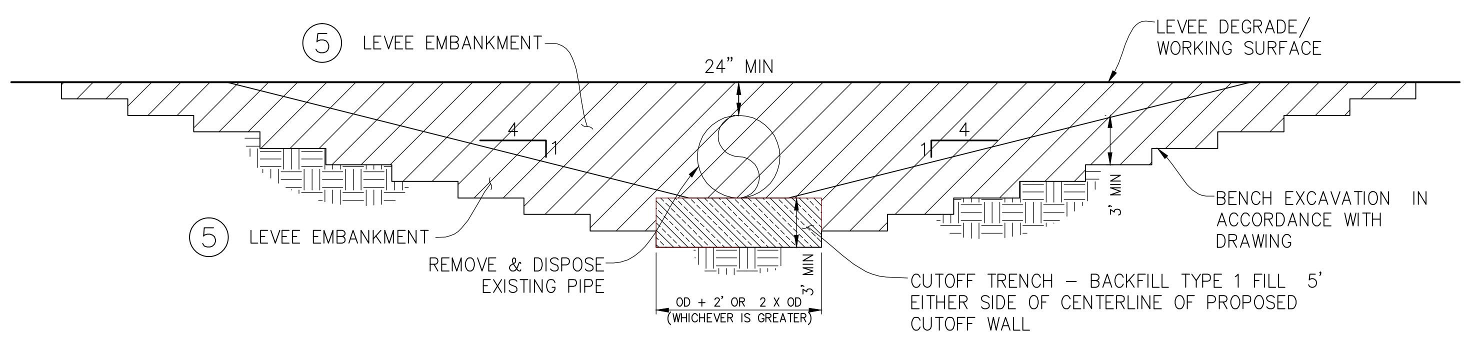


PLATE G-3G1: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL (TYPE 3C1)

SCALE: NONE

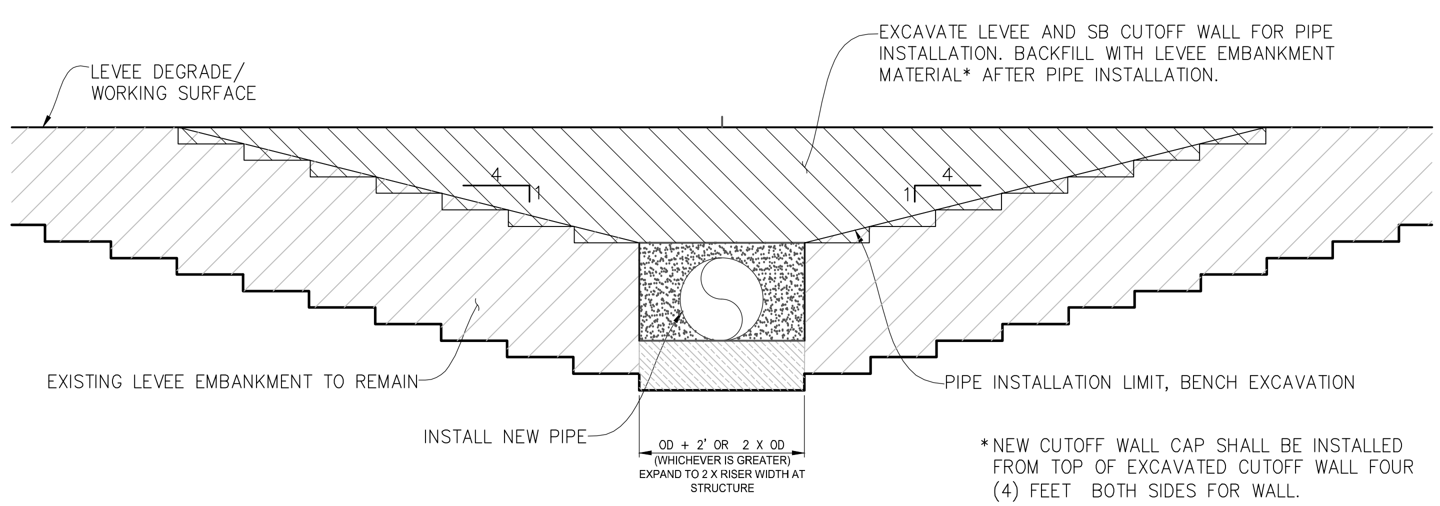
CONSTRUCTION SEQUENCE:

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

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

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D3	DESCRIPTION3	DATE3	APPROVAL3
D4	DESCRIPTION4	DATE4	APPROVAL4
D5	DESCRIPTION5	DATE5	APPROVAL5
D6	DESCRIPTION6	DATE6	APPROVAL6
D7	DESCRIPTION7	DATE7	APPROVAL7
D8	DESCRIPTION8	DATE8	APPROVAL8

Designed by: – | Date: – | Rev.: –
Dwn by: – | Spec No.: – | Design file no: –
Reviewed by: – | Drawing Code: –
Submitted by: – | File name: $$$$cnrs$$$$ | Plot date: – | Plot scale: –
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PLATE G-3G1

TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE UDNER CANAL

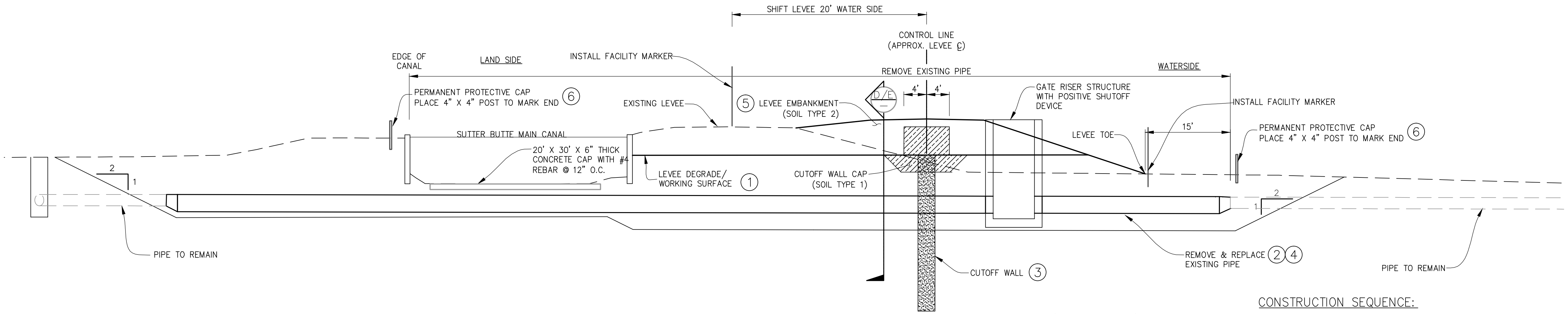
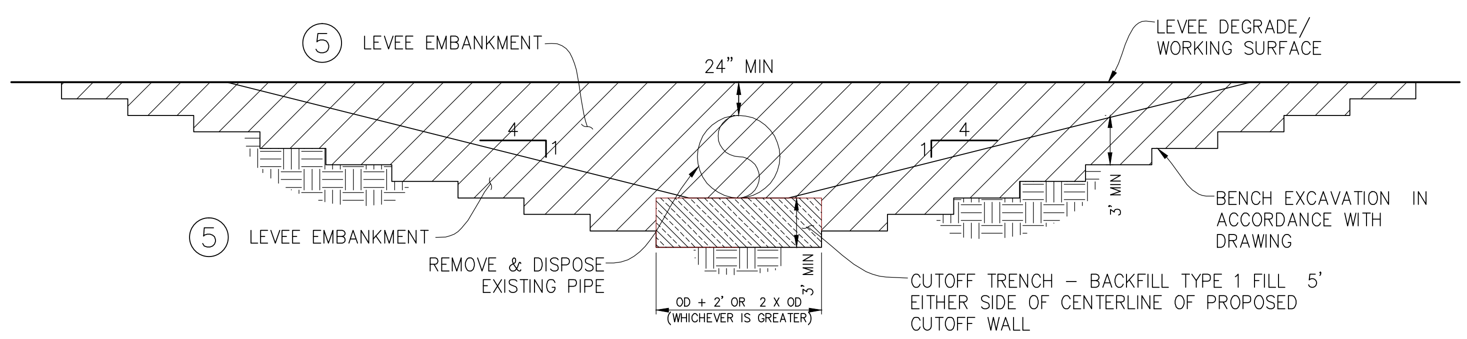


PLATE G-3G2: TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL WITH LEVEE RELOCATION (TYPE 3C2)

SCALE: NONE

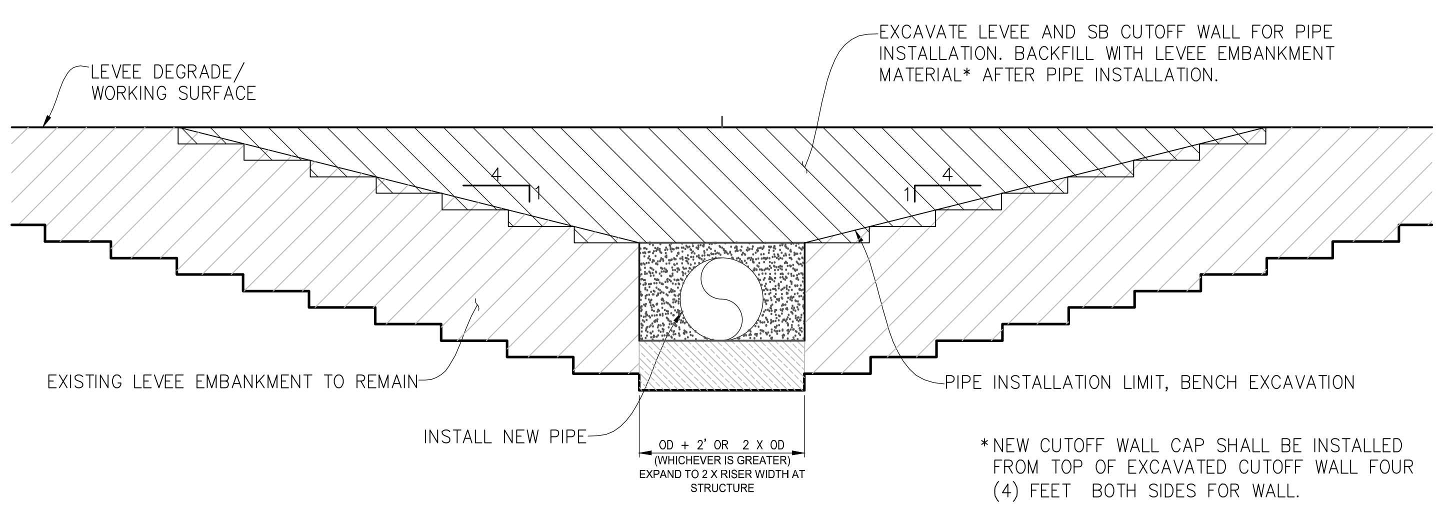
CONSTRUCTION SEQUENCE:

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

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

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX
PLATE G-3G2
TYPICAL UTILITY IMPROVEMENT - REMOVAL AND REPLACEMENT OF THROUGH PIPE UNDER CANAL W/LEVEE RELOCATION

SUTTER & BUTTE COUNTIES, CA

SUTTER BASIN PILOT FEASIBILITY STUDY

DRAFT REPORT

ALTERNATIVE SB-7 STATION 180+00 TO STATION 1483+33
ALTERNATIVE SB-8 STATION 1483+83 TO STATION 2368+00

LOCATION MAP
NTS

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
COVER SHEET

Sheet reference number:
G-1

NOT FOR CONSTRUCTION

DWG NO.	SHT NO.	DESCRIPTION
		GENERAL
G-1	1	TITLE SHEET AND LOCATION MAP
G-2	2	SHEET INDEX
G-3	3	BASIN MAP
G-4	4	VICINITY MAP
G-5	5	PROJECT FEATURES, BORROW SITES AND HAUL ROUTES
G-6	6	GENERAL ABBREVIATIONS, LEGEND AND SYMBOLS
G-7	7	GENERAL NOTES
G-8	8	OVERALL SITE PLAN AND KEY MAP
		PLAN VIEW SHEETS
C-101	9	PLAN VIEW STA: 175+00 TO 225+00
C-102	10	PLAN VIEW STA: 225+00 TO 275+00
C-103	11	PLAN VIEW STA: 275+00 TO 325+00
C-104	12	PLAN VIEW STA: 325+00 TO 375+00
C-105	13	PLAN VIEW STA: 375+00 TO 425+00
C-106	14	PLAN VIEW STA: 425+00 TO 478+68
C-107	15	PLAN VIEW STA: 478+68 TO 512+00 (STAR BEND FIX IN PLACE)
C-108	16	PLAN VIEW STA: 512+00 TO 575+00
C-109	17	PLAN VIEW STA: 575+00 TO 625+00
C-110	18	PLAN VIEW STA: 625+00 TO 675+00
C-111	19	PLAN VIEW STA: 675+00 TO 725+00
C-112	20	PLAN VIEW STA: 725+00 TO 775+00
C-113	21	PLAN VIEW STA: 775+00 TO 825+00
C-114	22	PLAN VIEW STA: 825+00 TO 875+00
C-115	23	PLAN VIEW STA: 875+00 TO 925+00
C-116	24	PLAN VIEW STA: 925+00 TO 975+00
C-117	25	PLAN VIEW STA: 975+00 TO 1025+00
C-118	26	PLAN VIEW STA: 1025+00 TO 1075+00
C-119	27	PLAN VIEW STA: 1075+00 TO 1125+00
C-120	28	PLAN VIEW STA: 1125+00 TO 1175+00
C-121	29	PLAN VIEW STA: 1175+00 TO 1225+00
C-122	30	PLAN VIEW STA: 1225+00 TO 1275+00
C-123	31	PLAN VIEW STA: 1275+00 TO 1325+00
C-124	32	PLAN VIEW STA: 1325+00 TO 1375+00
C-125	22	PLAN VIEW STA: 1375+00 TO 1433+83
C-126	34	PLAN VIEW STA: 1433+83 TO 1475+00
C-127	35	PLAN VIEW STA: 1475+00 TO 1525+00
C-128	36	PLAN VIEW STA: 1525+00 TO 1575+00
C-129	37	PLAN VIEW STA: 1575+00 TO 1625+00
C-130	38	PLAN VIEW STA: 1625+00 TO 1675+00
C-131	39	PLAN VIEW STA: 1675+00 TO 1725+00
C-132	40	PLAN VIEW STA: 1725+00 TO 1775+00
C-133	41	PLAN VIEW STA: 1775+00 TO 1825+00
C-134	42	PLAN VIEW STA: 1825+00 TO 1875+00
C-135	43	PLAN VIEW STA: 1875+00 TO 1925+00
C-136	44	PLAN VIEW STA: 1925+00 TO 1975+00
C-137	45	PLAN VIEW STA: 1975+00 TO 2025+00
C-138	46	PLAN VIEW STA: 2025+00 TO 2075+00
C-139	47	PLAN VIEW STA: 2075+00 TO 2125+00
C-140	48	PLAN VIEW STA: 2125+00 TO 2175+00
C-141	49	PLAN VIEW STA: 2175+00 TO 2225+00
C-142	50	PLAN VIEW STA: 2225+00 TO 2275+00
C-143	51	PLAN VIEW STA: 2275+00 TO 2325+00
C-144	52	PLAN VIEW STA: 2325+00 TO 2368+00
C-145	53	PLAN VIEW STA: 478+68 TO 512+00 (STAR BEND SETBACK)

DWG NO.	SHT NO.	DESCRIPTION
		PROFILE VIEW SHEETS
C-201	54	PROFILE VIEW STA: 175+00 TO 225+00
C-202	55	PROFILE VIEW STA: 225+00 TO 275+00
C-203	56	PROFILE VIEW STA: 275+00 TO 325+00
C-204	57	PROFILE VIEW STA: 325+00 TO 375+00
C-205	58	PROFILE VIEW STA: 375+00 TO 425+00
C-206	59	PROFILE VIEW STA: 425+00 TO 478+68
C-207	60	PROFILE VIEW STA: 478+68 TO 512+00 (STAR BEND FIX IN PLACE)
C-208	61	PROFILE VIEW STA: 512+00 TO 575+00
C-209	62	PROFILE VIEW STA: 575+00 TO 625+00
C-210	63	PROFILE VIEW STA: 625+00 TO 675+00
C-211	64	PROFILE VIEW STA: 675+00 TO 725+00
C-212	65	PROFILE VIEW STA: 725+00 TO 775+00
C-213	66	PROFILE VIEW STA: 775+00 TO 825+00
C-214	67	PROFILE VIEW STA: 825+00 TO 875+00
C-215	68	PROFILE VIEW STA: 875+00 TO 925+00
C-216	69	PROFILE VIEW STA: 925+00 TO 975+00
C-217	70	PROFILE VIEW STA: 975+00 TO 1025+00
C-218	71	PROFILE VIEW STA: 1025+00 TO 1075+00
C-219	72	PROFILE VIEW STA: 1075+00 TO 1125+00
C-220	73	PROFILE VIEW STA: 1125+00 TO 1175+00
C-221	74	PROFILE VIEW STA: 1175+00 TO 1225+00
C-222	75	PROFILE VIEW STA: 1225+00 TO 1275+00
C-223	76	PROFILE VIEW STA: 1275+00 TO 1325+00
C-224	77	PROFILE VIEW STA: 1325+00 TO 1375+00
C-225	78	PROFILE VIEW STA: 1375+00 TO 1433+83
C-226	79	PROFILE VIEW STA: 1433+83 TO 1475+00
C-227	80	PROFILE VIEW STA: 1475+00 TO 1525+00
C-228	81	PROFILE VIEW STA: 1525+00 TO 1575+00
C-229	82	PROFILE VIEW STA: 1575+00 TO 1625+00
C-230	83	PROFILE VIEW STA: 1625+00 TO 1675+00
C-231	84	PROFILE VIEW STA: 1675+00 TO 1725+00
C-232	85	PROFILE VIEW STA: 1725+00 TO 1775+00
C-233	86	PROFILE VIEW STA: 1775+00 TO 1825+00
C-234	87	PROFILE VIEW STA: 1825+00 TO 1875+00
C-235	88	PROFILE VIEW STA: 1875+00 TO 1925+00
C-236	89	PROFILE VIEW STA: 1925+00 TO 1975+00
C-237	90	PROFILE VIEW STA: 1975+00 TO 2025+00
C-238	91	PROFILE VIEW STA: 2025+00 TO 2075+00
C-239	92	PROFILE VIEW STA: 2075+00 TO 2125+00
C-240	93	PROFILE VIEW STA: 2125+00 TO 2175+00
C-241	94	PROFILE VIEW STA: 2175+00 TO 2225+00
C-242	95	PROFILE VIEW STA: 2225+00 TO 2275+00
C-243	96	PROFILE VIEW STA: 2275+00 TO 2325+00
C-244	97	PROFILE VIEW STA: 2325+00 TO 2368+00
C-245	98	PROFILE VIEW STA: 478+68 TO 512+00 (STAR BEND SETBACK)

DWG NO.	SHT NO.	DESCRIPTION
		TYPICAL LEVEE IMPROVEMENT SECTIONS AND DETAILS
C-301	99	TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL
C-302	100	TYPICAL LEVEE IMPROVEMENT – SEEPAGE BERM
C-303	101	TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH SEEPAGE BERM OR RELIEF WELLS
C-304	102	TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH FULL LEVEE DEGRADE AND RELIEF WELLS
C-305	103	TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH LEVEE RELOCATION
C-306	104	TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH CANAL RELOCATION
C-307	105	TYPICAL LEVEE IMPROVEMENT – TYPICAL CUTOFF WALL WITH LANDSIDE TOE FILL
C-308	106	TYPICAL LEVEE IMPROVEMENT – NEW LEVEE WITH CUTOFF WALL
C-309	107	TYPICAL LEVEE IMPROVEMENT – MISC. DETAILS
C-310	108	TYPICAL LEVEE IMPROVEMENT – STOP LOG STRUCTURE
		TYPICAL UTILITY IMPROVEMENT SECTIONS AND DETAILS
C-401	109	TYPICAL UTILITY IMPROVEMENT – REMOVAL & DISPOSAL OF ABANDONED RAISED PIPE
C-402	110	TYPICAL UTILITY IMPROVEMENT – REMOVAL & DISPOSAL OF ABANDONED THROUGH PIPE
C-403	111	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACMENT OF RAISED PIPE
C-404	112	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF THROUGH PIPE
C-406	113	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF THROUGH PIPE WITH CANAL RELOCATION
C-405	114	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF RAISED PIPE W/CANAL RELOCATION
C-407	115	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF THROUGH PIPE ADJACENT TO CANAL
C-408	116	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL
C-409	117	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL WITH LEVEE RELOCATION

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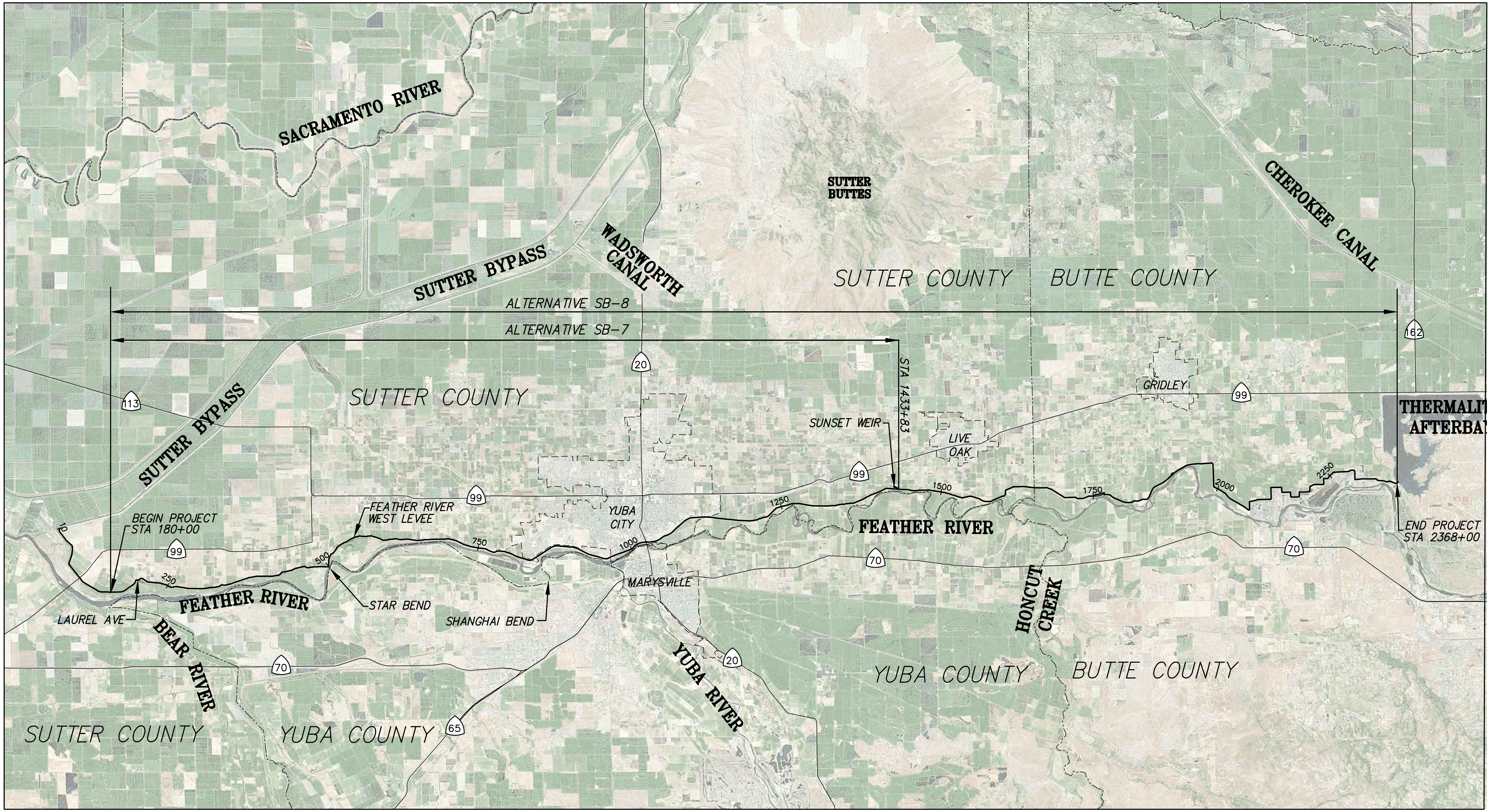
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
SHEET INDEX

Sheet reference number:
G-2

SUTTER BASIN PILOT FEASIBILITY STUDY

DRAFT REPORT



N

8000 4000 0 8000 16000

SCALE: 1"=8000'

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Symbol	Description	Date	Approved
D1	DESCRIPTION1	DATE1	APPROVAL1
D2	DESCRIPTION2	DATE2	APPROVAL2
D3	DESCRIPTION3	DATE3	APPROVAL3
D4	DESCRIPTION4	DATE4	APPROVAL4
D5	DESCRIPTION5	DATE5	APPROVAL5
D6	DESCRIPTION6	DATE6	APPROVAL6
D7	DESCRIPTION7	DATE7	APPROVAL7
D8	DESCRIPTION8	DATE8	APPROVAL8

Designed by: - | Date: - | Rev.: -
Dwn by: - | Spec No.: - | Design file no: -
Reviewed by: - | Drawing Code: -
Submitted by: - | File name: - | Plot date: $$$$date$$$$ | Plot scale: -

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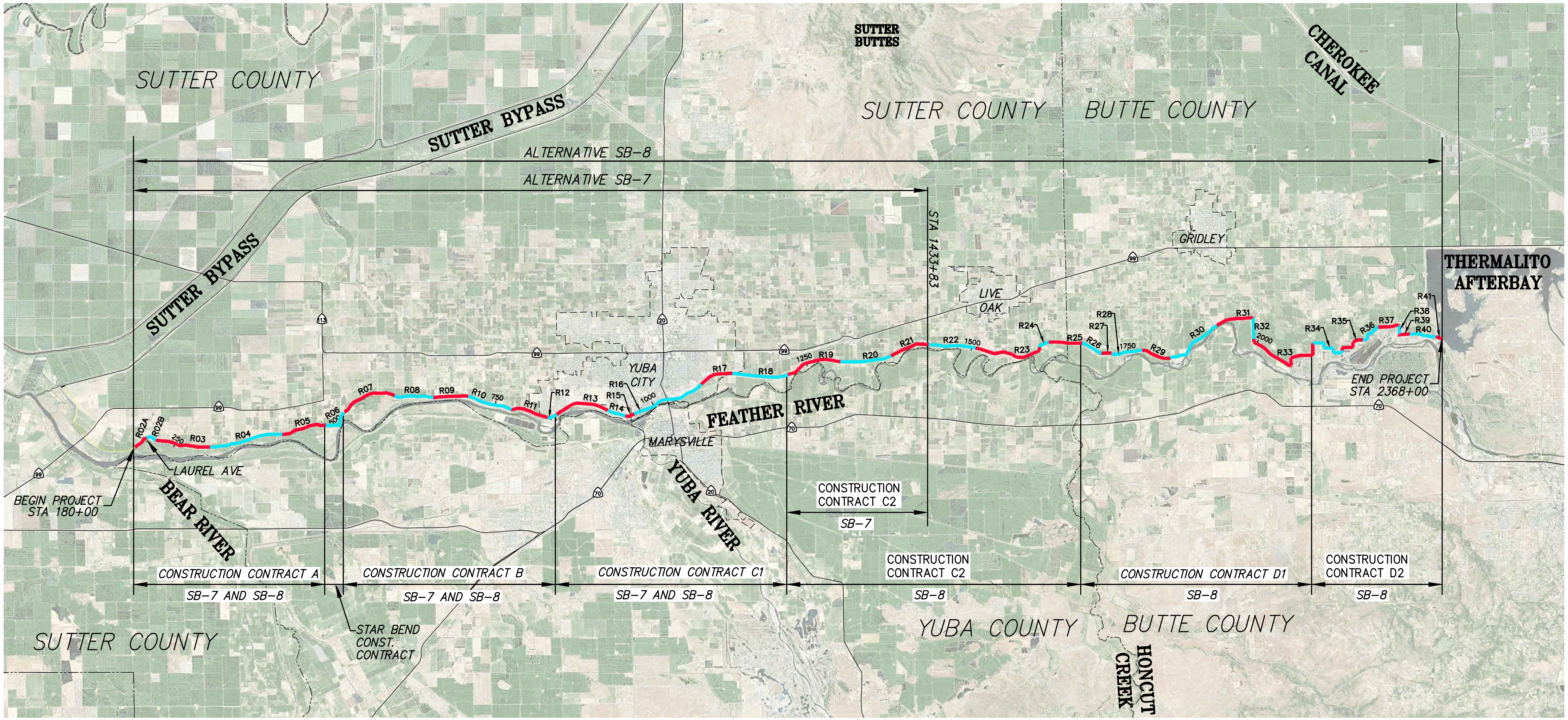
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
BASIN MAP

Sheet reference number:
G-3

SUTTER BASIN PILOT FEASIBILITY STUDY

DRAFT REPORT



REACH LEGEND

R09 REACH NAME

EVEN REACHES

ODD REACHES (EXCEPT REACH R02A)

SCALE: 1"=8000'

8000 4000 0 8000 16000

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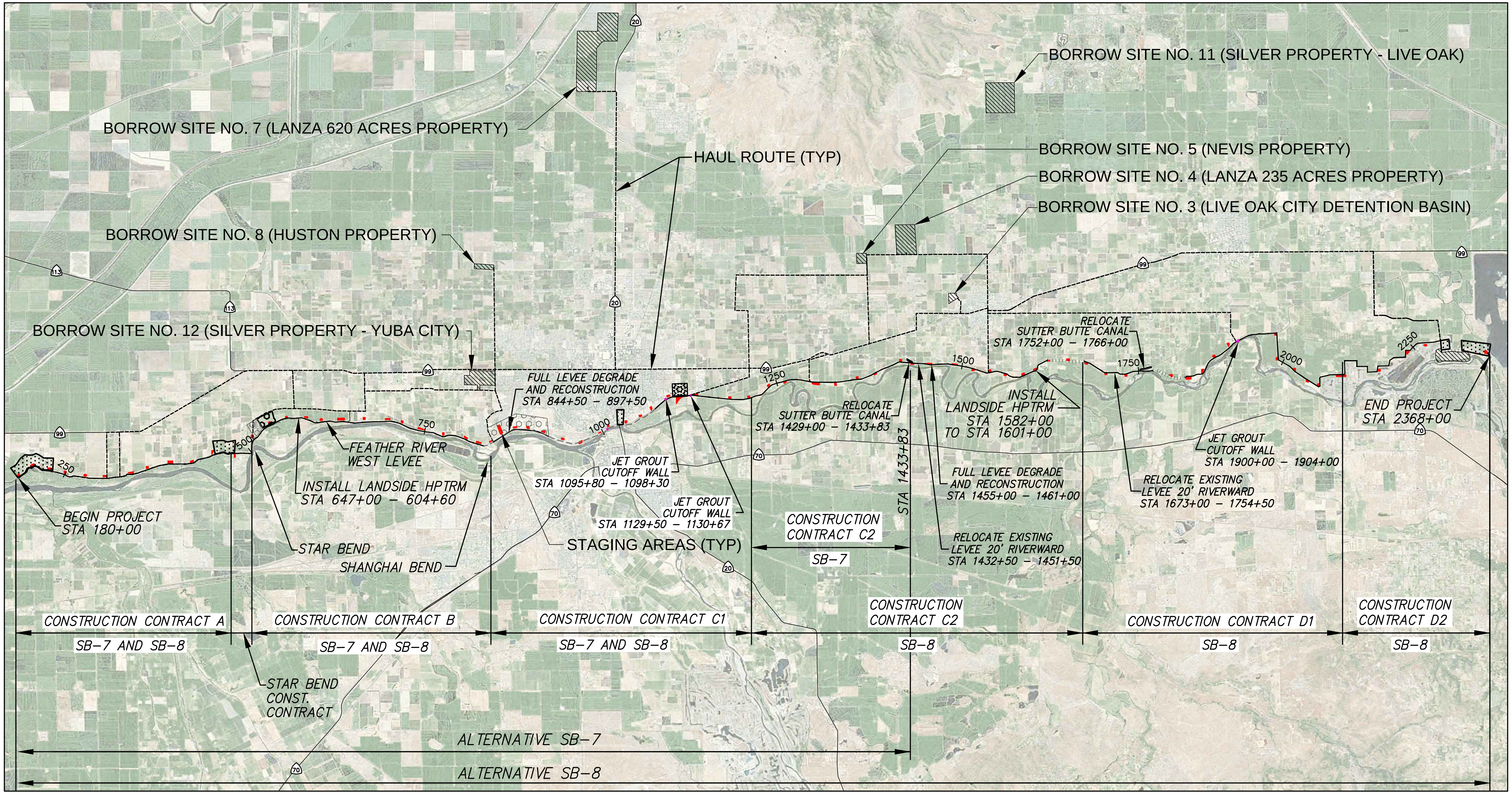
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
VICINITY MAP

Sheet reference number:
G-4

SUTTER BASIN PILOT FEASIBILITY STUDY

DRAFT REPORT



LEVEE IMPROVEMENT LEGEND

- PROP. CUTOFF WALL
- EX. CUTOFF WALL
- NO REHABILITATION REQUIRED
- PROP. LANDSIDE SEEPAGE BERM
- EX. RELIEF WELLS TO REMAIN (STA 512+00 - 545+00 & 844+50 - 923+75)
- PROP. RELIEF WELLS (STA 545+00 - 570+00)
- PROP. LANDSIDE TOE FILL

HAUL ROUTE AND STAGING LEGEND

- BORROW AREA
- STAGING AREA
- HAUL ROUTE

8000 4000 0 8000 16000

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DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROJECT FEATURES, BORROW SITES
AND HAUL ROUTES

Sheet reference number:
G-5

ABBREVIATIONS

APPROX	APPROXIMATE
ATOL	AUTHORIZED TOP OF LEVEE
AVE	AVENUE
AVG	AVERAGE
BLVD	BOULEVARD
BM	BENCHMARK
CL	CENTERLINE
CMP	CORREGATED METAL PIPE
CONST	CONSTRUCTION
DEMO	DEMOLITION
DIA	DIAMETER
DIST	DISTANCE
E	EASTING
EA	EACH
ELEV, EL	ELEVATION
ENGR	ENGINEER
EX	EXISTING
HPTRM	HIGH PERFORMANCE TURF REINFORCING MAT
IRR	IRRIGATION
MAX	MAXIMUM
MH	MANHOLE
MIN	MINIMUM
MISC	MISCELLANEOUS
MW	MONITORING WELL
NGS	NATIONAL GEODETIC SURVEY
NGVD	NATIONAL GEODETIC VERTICAL DATUM
NTS	NOT TO SCALE
OH	OVERHEAD
O&M	OPERATION AND MAINTENANCE
PL	PROPERTY LINE
PP	POWER POLE
PROP	PROPOSED
PS	PUMP STATION
QTY	QUANTITY
R/W, ROW	RIGHT OF WAY
RCP	REINFORCED CONCRETE PIPE
RD	ROAD
RM	RIVER MILE
RR	RAILROAD
RSP	ROCK SLOPE PROTECTION
RT	RELIEF WELL
ST	STREET
STA	STATION
STD	STANDARD
TEMP	TEMPORARY
TOPO	TOPOGRAPHY
TYP	TYPICAL
UTIL	UTILITY
VFZ	VEGETATION FREE ZONE
WSE	WATER SURFACE ELEVATION
WY	WAY

LEGEND AND SYMBOLS

EXISTING FEATURES		PROPOSED FEATURES
	CENTERLINE	
	PROPERTY LINE	N/A
	RIGHT OF WAY	N/A
N/A	O&M/VFZ/CONSTRUCTION LIMIT	
N/A	JET GROUT WALL (PLAN VIEW)	
N/A	JET GROUT WALL (PROFILE VIEW)	
	CUTOFF WALL (PLAN VIEW)	
	CUTOFF WALL (PROFILE VIEW)	
N/A	LEVEE DEGRADE/WORKING SURFACE	
	LEVEE/BERM TOE	
N/A	LEVEE CREST	
N/A	BERM TOP	
	1957 ATOL	N/A
N/A	STAGING AREA	
N/A	HIGH PERFORMANCE TURF REINFORCING MAT	
N/A	EARTH SLOPE	TOP TOE
N/A	CONTROL LINE W/STATION	48+00
N/A	LEVEE EMBANKMENT FILL (SOIL TYPE 1)	
N/A	RANDOM FILL AREA	
	EXISTING STRUCTURE FOR DEMOLITION	N/A

NOTES:

1. THIS SHEET APPLIES TO THE ENTIRE SET OF DRAWINGS. THIS IS A STANDARD DRAWING LISTING SHOWING ABBREVIATIONS AND SYMBOLOGY. ALL ABBREVIATIONS AND SYMBOLOGY ARE NOT NECESSARILY USED ON THIS PROJECT.
2. SCREENING OR SHADING OF WORK IS USED TO INDICATE EXISTING COMPONENTS OR TO DE-EMPHASIZE PROPOSED IMPROVEMENTS TO HIGHLIGHT SELECTED TRADE WORK. REFER TO CONTEXT OF EACH DRAWING FOR USACE.

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
GENERAL ABBREVIATIONS, LEGEND AND SYMBOLS

Sheet reference number:
G-6

ALTERNATIVE SB7

Measure	Typical Section (Sheet)	Segment	Contract	Beg. STA of Measure	End. STA of Measure	Length per Segment (LF)	Length per Contract (LF)	Length per Measure (LF)
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
Cutoff Wall Only	C-301	1	A	231+00	453+00	22,200	22,200	
Cutoff Wall Only	C-301	2	SBFIP	478+68	512+00	3,332	3,340	
Cutoff Wall Only	C-301	3	B	570+00	831+50	26,150	26,150	
Cutoff Wall Only	C-301	4	C1	1078+00	1096+00	1,800		
Cutoff Wall Only	C-301	5	C1	1098+10	1107+00	890		
Cutoff Wall Only	C-301	6	C1	1125+70	1129+99	429		
Cutoff Wall Only	C-301	7	C1	1130+20	1213+85	8,365	11,490	
Cutoff Wall Only	C-301	7	C2	1213+85	1429+00	21,515	21,520	84,700
Jet Grouting Cutoff Wall Only	C-301	1	C1	1006+04	1007+90	186		
Jet Grouting Cutoff Wall Only	C-301	2	C1	1095+80	1098+30	250		
Jet Grouting Cutoff Wall Only	C-301	3	C1	1129+50	1130+67	117	560	560
Seepage Berm Only	C-302	1	C1	1024+00	1027+50	350	350	350
Cutoff Wall with Full Levee Degrade and Existing Relief Wells	C-304	1	C1	844+50	897+50	5,300	5,300	5,300
Cutoff Wall with Full Levee Degrade	C-304	-	-	0+00	0+00	0	0	0
Cutoff Wall with Existing Relief Wells	C-303	1	B	512+00	545+00	3,300	3,300	
Cutoff Wall with Existing Relief Wells	C-303	3	C1	897+50	923+75	2,625	2,630	5,930
Cutoff Wall with New Relief Wells	C-303	2	B	545+00	570+00	2,500	2,500	2,500
Cutoff Wall with Seepage Berm	C-303	1	A	180+00	231+00	5,100		
Cutoff Wall with Seepage Berm	C-303	2	A	453+00	478+68	2,568	7,670	7,670
Cutoff Wall with Levee Relocation	C-305	-	-	0+00	0+00	0	0	0
Cutoff Wall with Sutter Butte Canal Relocation	C-306	1	C2	1429+00	1432+70	370	370	370
Cutoff Wall with Landside Toe Fill	C-307	1	C1	1107+00	1125+70	1,870	1,870	1,870
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	1	A	230+00	250+00	2,000	2,000	
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	2	C1	1125+00	1129+99	499		
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	3	C1	1130+20	1151+50	2,130	2,630	
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	4	C2	1224+00	1248+00	2,400	2,400	7,030
Erosion Protection	-	1	B	547+00	604+60	5,760	5,760	5,760
Closure Structure (Stop Log)	-	1	C1	1130+00	1130+00	-	-	-

ALTERNATIVE SB8

Measure	Typical Section (Sheet)	Segment	Contract	Beg. STA of Measure	End. STA of Measure	Length per Segment (LF)	Length per Contract (LF)	Length per Measure (LF)
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
Cutoff Wall Only	C-301	1	A	231+00	453+00	22,200	22,200	
Cutoff Wall Only	C-301	2	SBFIP	478+68	512+00	3,332	3,340	
Cutoff Wall Only	C-301	3	B	570+00	831+50	26,150	26,150	
Cutoff Wall Only	C-301	4	C1	1078+00	1096+00	1,800		
Cutoff Wall Only	C-301	5	C1	1098+10	1107+00	890		
Cutoff Wall Only	C-301	6	C1	1125+70	1129+99	429		
Cutoff Wall Only	C-301	7	C1	1130+20	1213+85	8,365	11,490	
Cutoff Wall Only	C-301	7	C2	1213+85	1429+00	21,515		
Cutoff Wall Only	C-301	8	C2	1451+50	1455+00	350		
Cutoff Wall Only	C-301	9	C2	1461+00	1608+50	14,750		
Cutoff Wall Only	C 301	10	C2	1624+70	1625+00	30		
Cutoff Wall Only	C 301	11	C2	1673+00	1673+30	30	36,680	
Cutoff Wall Only	C-301	12	D1	1766+00	1769+40	340		
Cutoff Wall Only	C-301	13	D1	1813+30	1900+50	8,720		
Cutoff Wall Only	C-301	14	D1	1903+50	2122+00	21,850	30,910	
Cutoff Wall Only	C-301	14	D2	2122+00	2290+00	16,800	16,800	147,570
Jet Grouting Cutoff Wall Only	C-301	1	C1	1006+04	1007+90	186		
Jet Grouting Cutoff Wall Only	C-301	2	C1	1095+80	1098+30	250		
Jet Grouting Cutoff Wall Only	C-301	3	C1	1129+50	1130+67	117	560	
Jet Grouting Cutoff Wall Only	C-301	4	D1	1900+00	1904+00	400	400	960
Seepage Berm Only	C-302	1	C1	1024+00	1027+50	350	350	
Seepage Berm Only	C-302	2	D2	2290+00	2303+00	1,300		
Seepage Berm Only	C-302	3	D2	2331+00	2368+00	3,700	5,000	5,350
Cutoff Wall with Full Levee Degrade and Existing Relief Wells	C 304	1	C1	844+50	897+50	5,300	5,300	5,300
Cutoff Wall with Full Levee Degrade	C 304	2	C2	1455+00	1461+00	600	600	600
Cutoff Wall with Existing Relief Wells	C-303	1	B	512+00	545+00	3,300	3,300	
Cutoff Wall with Existing Relief Wells	C-303	3	C1	897+50	923+75	2,625	2,630	5,930
Cutoff Wall with New Relief Wells	C-303	2	B	545+00	570+00	2,500	2,500	2,500
Cutoff Wall with Seepage Berm	C-303	1	A	180+00	231+00	5,100		
Cutoff Wall with Seepage Berm	C-303	2	A	453+00	478+68	2,568	7,670	7,670
Cutoff Wall with Levee Relocation	C-305	1	C2	1432+70	1451+50	1,880		
Cutoff Wall with Levee Relocation	C-305	2	C2	1608+50	1624+70	1,620		
Cutoff Wall with Levee Relocation	C-305	3	C2	1673+30	1674+37	107	3,610	
Cutoff Wall with Levee Relocation	C-305	3	D1	1674+37	1754+30	7,993	8,000	11,610
Cutoff Wall with Sutter Butte Canal Relocation	C 306	1	C2	1429+00	1432+70	370	370	
Cutoff Wall with Sutter Butte Canal Relocation	C 306	2	D1	1754+30	1766+00	1,170	1,170	1,540
Cutoff Wall with Landside Toe Fill	C-307	1	C1	1107+00	1125+70	1,870	1,870	1,870
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	1	A	230+00	250+00	2,000	2,000	
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	2	C1	1125+00	1129+99	499		
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	3	C1	1130+20	1151+50	2,130	2,630	
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	4	C2	1224+00	1248+00	2,400	2,400	
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	5	D1	1987+25	2002+00	1,475		
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	6	D1	2016+75	2036+75	2,000		
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	7	D1	2067+00	2088+00	2,100	5,580	
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	8	D2	2137+00	2148+00	1,100		
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	9	D2	2182+00	2196+50	1,450		
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	10	D2	2245+75	2292+00	4,625	7,180	19,790
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
Closure Structure (Stop Log)	-	1	C1	1130+00	1130+00	-	-	-

NOTES REGARDING LAYOUT OF ALTERNATIVE SB-7 AND SB-8

1. SHEETS C-101 THROUGH C-125 ARE THE PLAN VIEW SHEETS FOR ALTERNATIVE SB-7; SHEETS C-201 THROUGH C-225 ARE THE PROFILE VIEW SHEETS FOR ALTERNATIVE SB-7.
2. SHEETS C-126 THROUGH C-144 ARE THE PLAN VIEW SHEETS FROM ALTERNATIVE SB-8; SHEETS C-226 THROUGH C-244 ARE THE PROFILE VIEW SHEET FOR ALTERNATIVE SB-8.
3. SHEETS C-145 AND C-245 ARE THE PLAN AND PROFILE VIEW SHEETS FOR THE STAR BEND SETBACK OPTION, RESPECTIVELY. THIS IS DONE SINCE THE FIX-IN PLACE OPTION IS THE PREFERRED PLAN INCLUDED AS THE RECOMMENDED OPTION FOR ALTERNATIVES SB-7 & SB-8.

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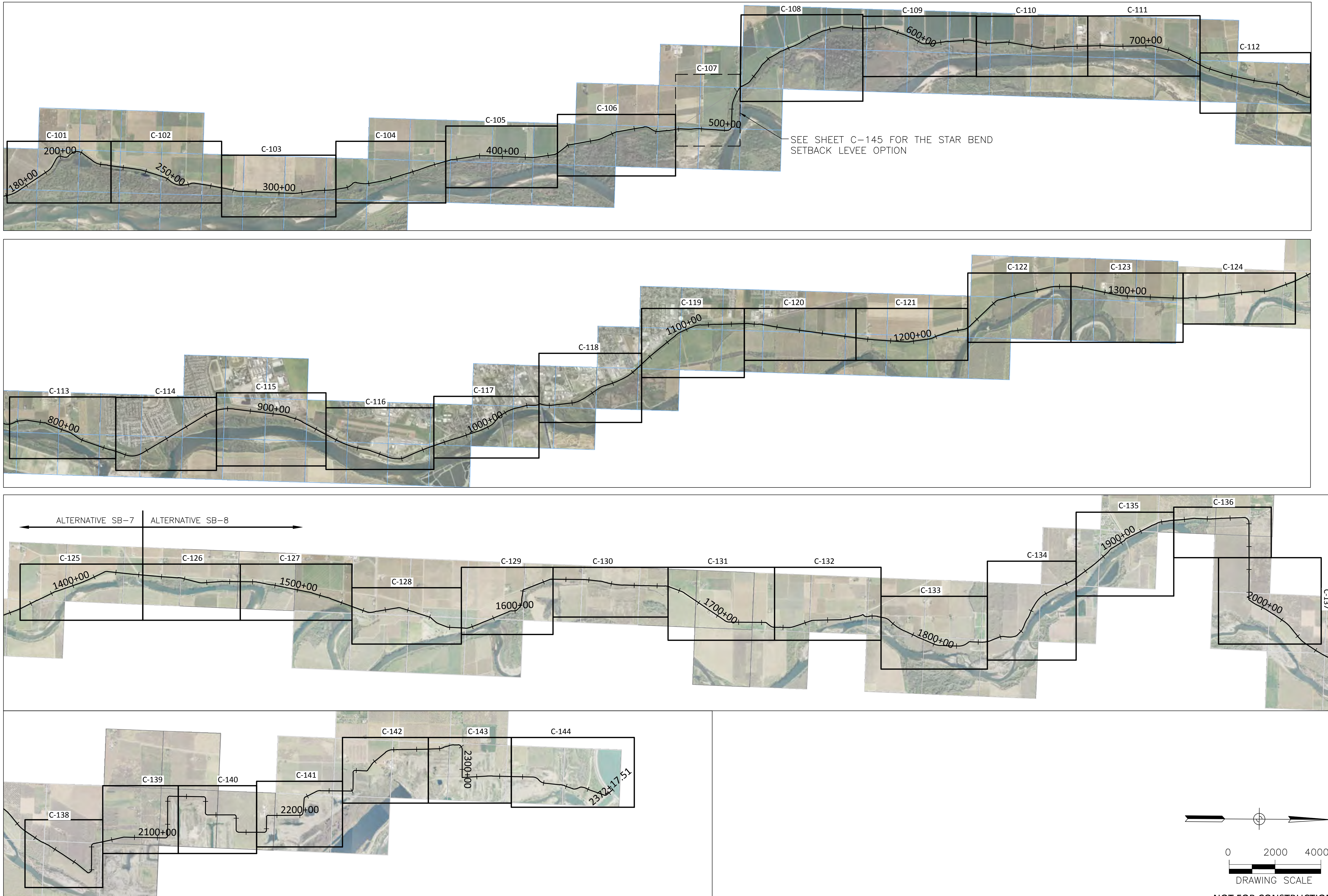
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
GENERAL NOTES

Sheet reference number:
G-7

NOT FOR CONSTRUCTION



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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
OVERALL SITE PLAN AND KEY MAP

Sheet reference number:
G-8

MATCHLINE STATION 225+00 FOR CONTINUATION SEE SHEET C-102

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 175+00 TO 225+00

Sheet reference number:
C-101

MATCHLINE STATION 225+00 FOR CONTINUATION SEE SHEET C-101

MATCHLINE STATION 275+00 FOR CONTINUATION SEE SHEET C-103

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 225+00 TO 275+00

Sheet reference number:
C-102

MATCHLINE STATION 275+00 FOR CONTINUATION SEE SHEET C-102

MATCHLINE STATION 325+00 FOR CONTINUATION SEE SHEET C-104

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

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D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

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Spec No.: –
Reviewed by: –
Submitted by: –
CHIEF, CIV ENGR DES SEC A
Date: –
Rev. –
Design file no: –
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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 275+00 TO 325+00

Sheet reference number:
C-103

HORIZONTAL DATUM

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 325+00 TO 375+00

Sheet reference number:
C-104

MATCHLINE STATION 375+00 FOR CONTINUATION SEE SHEET C-104

MATCHLINE STATION 425+00 FOR CONTINUATION SEE SHEET C-106

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 375+00 TO 425+00

Sheet reference number:
C-105

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 425+00 FOR CONTINUATION SEE SHEET C-105

MATCHLINE STATION 478+68 FOR CONTINUATION SEE SHEET C-107

SEE SHEET C-145 FOR STAR BEND SETBACK OPTION

0 200 400

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 425+00 TO 478+68

Sheet reference number:

C-106

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 478+68 FOR CONTINUATION SEE SHEET C-106

MATCHLINE STATION 512+00 FOR CONTINUATION SEE SHEET C-108

NOTE: SEE SHEET C-145 FOR STAR BEND SETBACK OPTION

0 200 400
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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA. 478+68 to STA. 512+00 (MAINLINE)

Sheet reference number:
C-107

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 512+00 FOR CONTINUATION SEE SHEET C-107
SEE SHEET C-145 FOR STAR BEND SETBACK OPTION

MATCHLINE STATION 575+00 FOR CONTINUATION SEE SHEET C-109

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D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

Designed by: –		Date: –	Rev. –
Dwn by: –	Spec No.: –	Design file no: –	
Reviewed by: –		Drawing Code: –	
Submitted by: – CHIEF, CIV ENGR DES SEC A		File name: Plot date: $$$$date$$$$ Plot scale: –	

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 512+00 TO 575+00

Sheet reference number:
C-108

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 575+00 FOR CONTINUATION SEE SHEET C-108

MATCHLINE STATION 625+00 FOR CONTINUATION SEE SHEET C-110

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 575+00 TO 625+00

Sheet reference number:
C-109

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

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MATCHLINE STATION 625+00 FOR CONTINUATION SEE SHEET C-109

MATCHLINE STATION 675+00 FOR CONTINUATION SEE SHEET C-111

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 625+00 TO 675+00

Sheet reference number:
C-110

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 675+00 FOR CONTINUATION SEE SHEET C-110

MATCHLINE STATION 725+00 FOR CONTINUATION SEE SHEET C-112

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 675+00 TO 725+00

Sheet reference number:
C-111

MATCHLINE STATION 725+00 FOR CONTINUATION SEE SHEET C-111

MATCHLINE STATION 775+00 FOR CONTINUATION SEE SHEET C-113

HORIZONTAL DATUM

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 725+00 TO 775+00

Sheet reference number:
C-112

HORIZONTAL DATUM

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MATCHLINE STATION 775+00 FOR CONTINUATION SEE SHEET C-112

MATCHLINE STATION 825+00 FOR CONTINUATION SEE SHEET C-114

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 775+00 TO 825+00

Sheet reference number:
C-113

MATCHLINE STATION 825+00 FOR CONTINUATION SEE SHEET C-113

MATCHLINE STATION 875+00 FOR CONTINUATION SEE SHEET C-115

HORIZONTAL DATUM

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DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 825+00 TO 875+00

Sheet reference number:
C-114

MATCHLINE STATION 875+00 FOR CONTINUATION SEE SHEET C-114

MATCHLINE STATION 925+00 FOR CONTINUATION SEE SHEET C-116

HORIZONTAL DATUM

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8

PLAN VIEW
STA 875+00 TO 925+00

Sheet reference number:

C-115

MATCHLINE STATION 925+00 FOR CONTINUATION SEE SHEET C-115

MATCHLINE STATION 975+00 FOR CONTINUATION SEE SHEET C-117

HORIZONTAL DATUM

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D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
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Dwn by: –	Spec No.: –	Design file no: –	
Reviewed by: –		Drawing Code: –	
Submitted by: – CHIEF, CIV ENGR DES SEC A		File name: Plot date: $$$$date$$$$ Plot scale: –	

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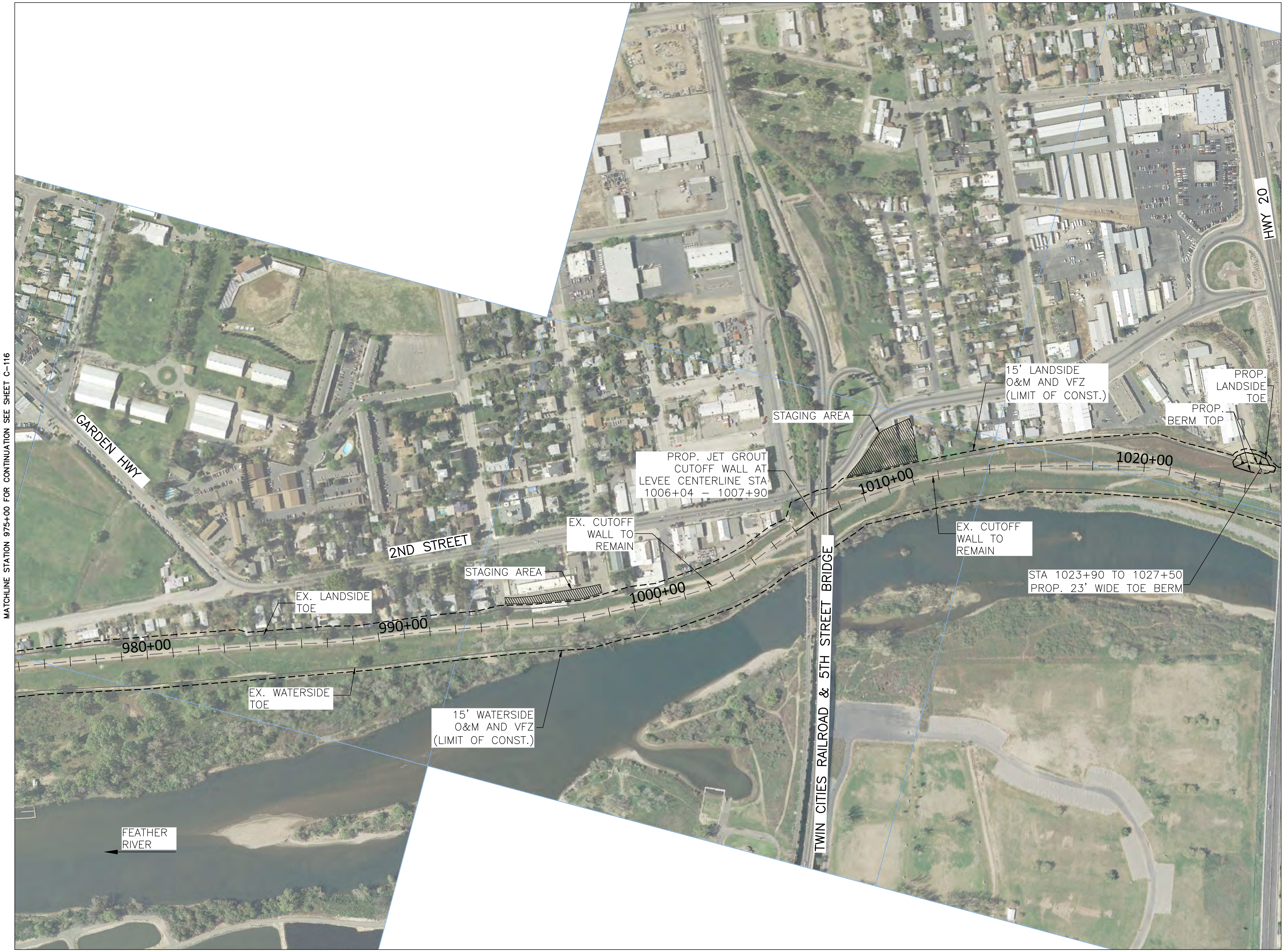
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 925+00 TO 975+00

Sheet reference number:
C-116



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D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 975+00 TO 1025+00

Sheet reference number:
C-117

HORIZONTAL DATUM

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SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1025+00 TO 1075+00

Sheet reference number:
C-118

MATCHLINE STATION 1075+00 FOR CONTINUATION SEE SHEET C-118

MATCHLINE STATION 1125+00 FOR CONTINUATION SEE SHEET C-120

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1075+00 TO 1125+00

Sheet reference number:
C-119

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 1125+00 FOR CONTINUATION SEE SHEET C-119

MATCHLINE STATION 1175+00 FOR CONTINUATION SEE SHEET C-121

N

0 200 400

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1125+00 TO 1175+00

Sheet reference number:

C-120

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 1175+00 FOR CONTINUATION SEE SHEET C-120

MATCHLINE STATION 1225+00 FOR CONTINUATION SEE SHEET C-122

0 200 400
DRAWING SCALE

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1175+00 TO 1225+00

Sheet reference number:
C-121

MATCHLINE STATION 1225+00 FOR CONTINUATION SEE SHEET C-121

MATCHLINE STATION 1275+00 FOR CONTINUATION SEE SHEET C-123

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1225+00 TO 1275+00

Sheet reference number:
C-122

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 1275+00 FOR CONTINUATION SEE SHEET C-122

MATCHLINE STATION 1325+00 FOR CONTINUATION SEE SHEET C-124

N

0 200 400
DRAWING SCALE

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Symbol	Description	Date	Approved
Δ1	DESCRIPTION1	DATE1	APPROVAL1
Δ2	DESCRIPTION2	DATE2	APPROVAL2
Δ3	DESCRIPTION3	DATE3	APPROVAL3
Δ4	DESCRIPTION4	DATE4	APPROVAL4
Δ5	DESCRIPTION5	DATE5	APPROVAL5
Δ6	DESCRIPTION6	DATE6	APPROVAL6
Δ7	DESCRIPTION7	DATE7	APPROVAL7
Δ8	DESCRIPTION8	DATE8	APPROVAL8

Designed by: – | Date: – | Rev. –
Dwn by: – | Spec No.: – | Design file no: –
Reviewed by: – | Drawing Code: –
Submitted by: – CHIEF, CIV ENGR DES SEC A | File name: $$$$$$date$$$$ | Plot date: – | Plot scale: –

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1275+00 TO 1325+00

Sheet reference number:
C-123

4 3 2 1

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

MATCHLINE STATION 1325+00 FOR CONTINUATION SEE SHEET C-123

MATCHLINE STATION 1375+00 FOR CONTINUATION SEE SHEET C-125

0 200 400
DRAWING SCALE

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1325+00 TO 1375+00

Sheet reference number:

C-124

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

MATCHLINE STATION 1375+00 FOR CONTINUATION SEE SHEET C-124

MATCHLINE STATION 1433+83 FOR CONTINUATION SEE SHEET C-126

0 200 400
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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1375+00 TO 1433+83

Sheet reference number:
C-125

MATCHLINE STATION 1433+83 FOR CONTINUATION SEE SHEET C-125

MATCHLINE STATION 1475+00 FOR CONTINUATION SEE SHEET C-127

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

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D8	DESCRIPTION8	DATE8	APPROVAL8
D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

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Dwn by: – Spec No.: –
Reviewed by: –
Submitted by: –
CHIEF, CIV ENGR DES SEC A
Date: – Rev. –
Design file no: –
Drawing Code: –
File name:
Plot date: $$$$date$$$$
Plot scale: –

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1433+83 TO 1475+00

Sheet reference number:
C-126

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 1475+00 FOR CONTINUATION SEE SHEET C-126

MATCHLINE STATION 1525+00 FOR CONTINUATION SEE SHEET C-128

0 200 400
DRAWING SCALE

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Δ1	DESCRIPTION1	DATE1	APPROVAL1
Δ2	DESCRIPTION2	DATE2	APPROVAL2
Δ3	DESCRIPTION3	DATE3	APPROVAL3
Δ4	DESCRIPTION4	DATE4	APPROVAL4
Δ5	DESCRIPTION5	DATE5	APPROVAL5
Δ6	DESCRIPTION6	DATE6	APPROVAL6
Δ7	DESCRIPTION7	DATE7	APPROVAL7
Δ8	DESCRIPTION8	DATE8	APPROVAL8

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Dwn by: – | Spec No.: – | Design file no: –
Reviewed by: – | Drawing Code: –
Submitted by: CHIEF, CV ENGR DES SEC A | File name: | Plot date: $$$$date$$$$ | Plot scale: –

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1475+00 TO 1525+00

Sheet reference number:

C-127

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 1525+00 FOR CONTINUATION SEE SHEET C-127

MATCHLINE STATION 1575+00 FOR CONTINUATION SEE SHEET C-129

0 200 400
DRAWING SCALE

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1525+00 TO 1575+00

Sheet reference number:
C-128

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 1575+00 FOR CONTINUATION SEE SHEET C-127

MATCHLINE STATION 1625+00 FOR CONTINUATION SEE SHEET C-130

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1575+00 TO 1625+00

Sheet reference number:
C-129

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 1625+00 FOR CONTINUATION SEE SHEET C-129

MATCHLINE STATION 1675+00 FOR CONTINUATION SEE SHEET C-131

0 200 400
DRAWING SCALE

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1625+00 TO 1675+00

Sheet reference number:
C-130

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 1675+00 FOR CONTINUATION SEE SHEET C-130

MATCHLINE STATION 1725+00 FOR CONTINUATION SEE SHEET C-132

0 200 400
DRAWING SCALE

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1675+00 TO 1725+00

Sheet reference number:
C-131

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 1725+00 FOR CONTINUATION SEE SHEET C-131

MATCHLINE STATION 1775+00 FOR CONTINUATION SEE SHEET C-133

N

0 200 400
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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1725+00 TO 1775+00

Sheet reference number:
C-132

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 1775+00 FOR CONTINUATION SEE SHEET C-132

MATCHLINE STATION 1825+00 FOR CONTINUATION SEE SHEET C-134

0 200 400
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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1775+00 TO 1825+00

Sheet reference number:
C-133

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 1825+00 FOR CONTINUATION SEE SHEET C-133

MATCHLINE STATION 1875+00 FOR CONTINUATION SEE SHEET C-135

0 200 400
DRAWING SCALE

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1825+00 TO 1875+00

Sheet reference number:
C-134

MATCHLINE STATION 1875+00 FOR CONTINUATION SEE SHEET C-134

MATCHLINE STATION 1925+00 FOR CONTINUATION SEE SHEET C-136

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

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DRAWING SCALE

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Symbol	Description	Date	Approved
D8	DESCRIPTION8	DATE8	APPROVAL8
D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

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Reviewed by: – | Drawing Code: –
Submitted by: – CHIEF, CIV ENGR DES SEC A | File name: Plot date: $$$$date$$$$ Plot scale: –

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1875+00 TO 1925+00

Sheet reference number:
C-135

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 1925+00 FOR CONTINUATION SEE SHEET C-135

MATCHLINE STATION 1975+00 FOR CONTINUATION SEE SHEET C-137

0 200 400
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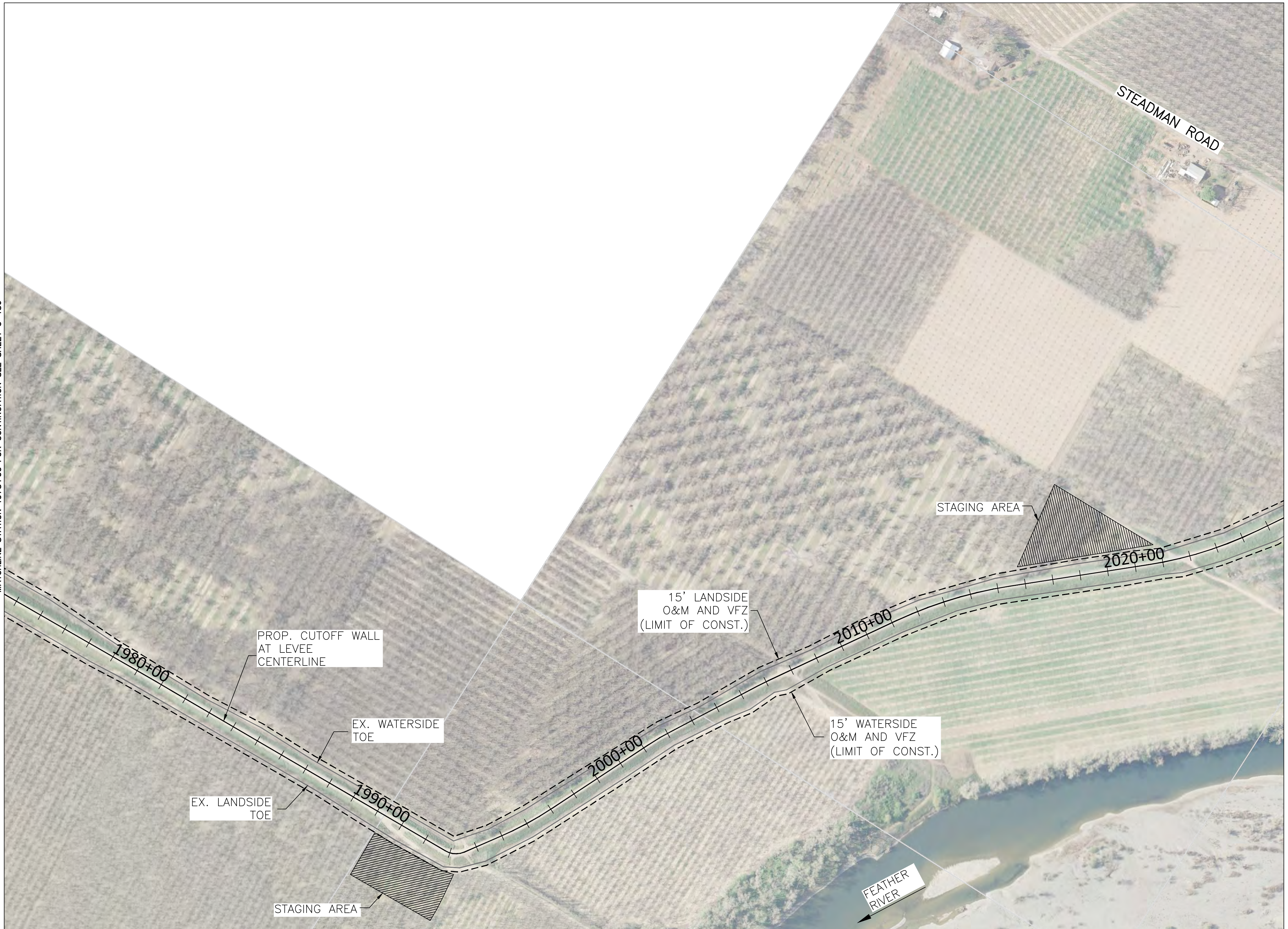
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1925+00 TO 1975+00

Sheet reference number:
C-136

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).



MATCHLINE STATION 1975+00 FOR CONTINUATION SEE SHEET C-136

MATCHLINE STATION 2025+00 FOR CONTINUATION SEE SHEET C-138

0 200 400
DRAWING SCALE

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1975+00 TO 2025+00

Sheet reference number:

C-137

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 2025+00 FOR CONTINUATION SEE SHEET C-137

MATCHLINE STATION 2075+00 FOR CONTINUATION SEE SHEET C-139

N

0 200 400
DRAWING SCALE

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Symbol	Description	Date	Approved
D8	DESCRIPTION8	DATE8	APPROVAL8
D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

Designed by: - | Date: - | Rev. -
Dwn by: - | Spec No.: - | Design file no: -
Reviewed by: - | Drawing Code: -
Submitted by: - CHIEF, CIV ENGR DES SEC A | File name: $$$$$dofo$$$$ | Plot date: - | Plot scale: -

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DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 2025+00 TO 2075+00

Sheet reference number:
C-138

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 2075+00 FOR CONTINUATION SEE SHEET C-138

MATCHLINE STATION 2125+00 FOR CONTINUATION SEE SHEET C-140

0 200 400
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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 2075+00 TO 2125+00

Sheet reference number:
C-139

MATCHLINE STATION 2125+00 FOR CONTINUATION SEE SHEET C-139

MATCHLINE STATION 2175+00 FOR CONTINUATION SEE SHEET C-141

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 2125+00 TO 2175+00

Sheet reference number:
C-140

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 2175+00 FOR CONTINUATION SEE SHEET C-140

MATCHLINE STATION 2225+00 FOR CONTINUATION SEE SHEET C-142

0 200 400
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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 2175+00 TO 2225+00

Sheet reference number:

C-141

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

MATCHLINE STATION 2225+00 FOR CONTINUATION SEE SHEET C-141

MATCHLINE STATION 2275+00 FOR CONTINUATION SEE SHEET C-143

0 200 400
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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 2225+00 TO 2275+00

Sheet reference number:
C-142

MATCHLINE STATION 2275+00 FOR CONTINUATION SEE SHEET C-142

MATCHLINE STATION 2325+00 FOR CONTINUATION SEE SHEET C-144

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

US Army Corps of Engineers® Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

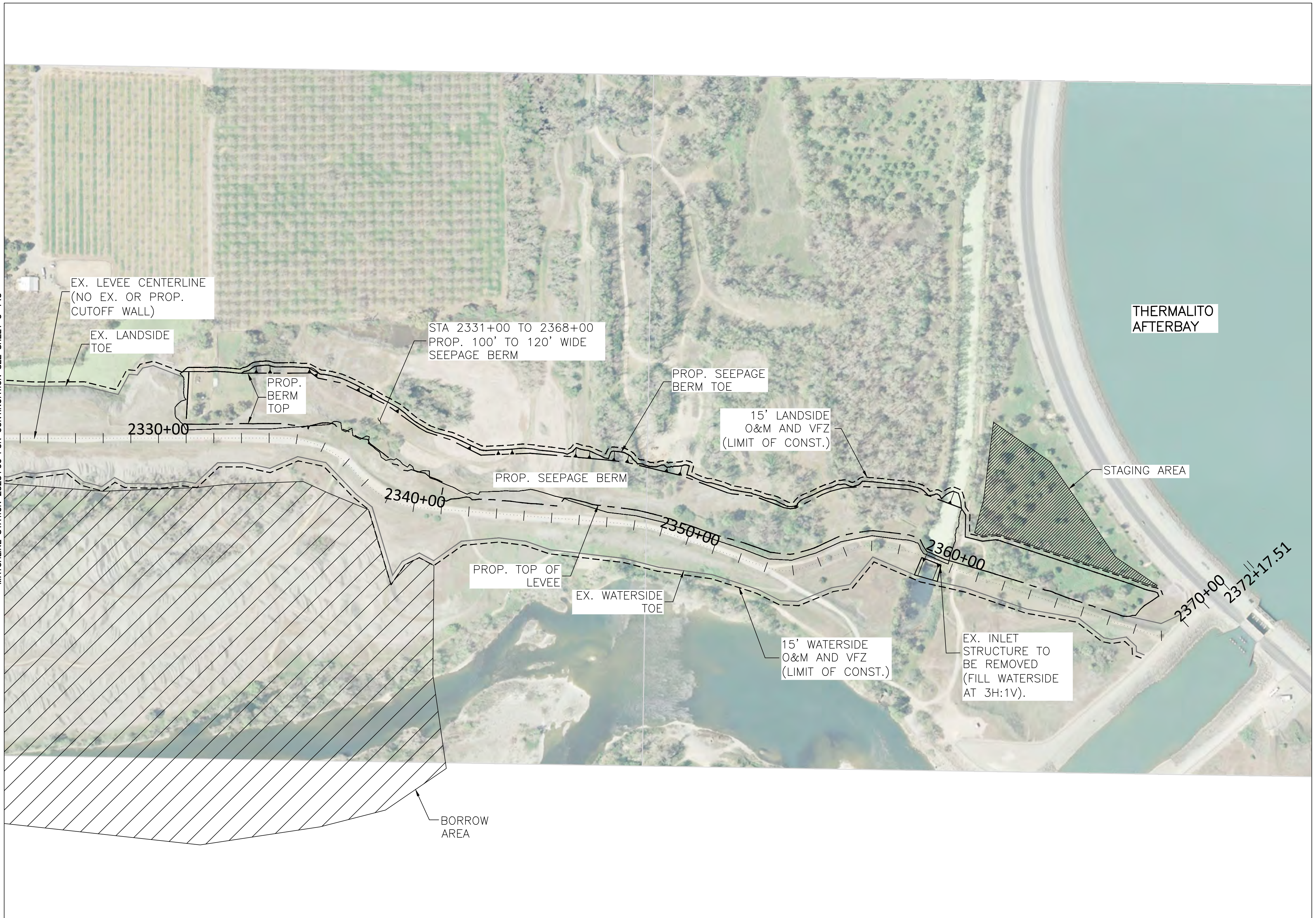
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 2275+00 TO 2325+00

Sheet reference number:
C-143

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).



0 200 400

DRAWING SCALE

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 2325+00 TO 2368+00

Sheet reference number:

C-144

MATCHLINE STATION 478+68 FOR CONTINUATION SEE SHEET C-106

MATCHLINE STATION 512+00 FOR CONTINUATION SEE SHEET C-108

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400

DRAWING SCALE

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

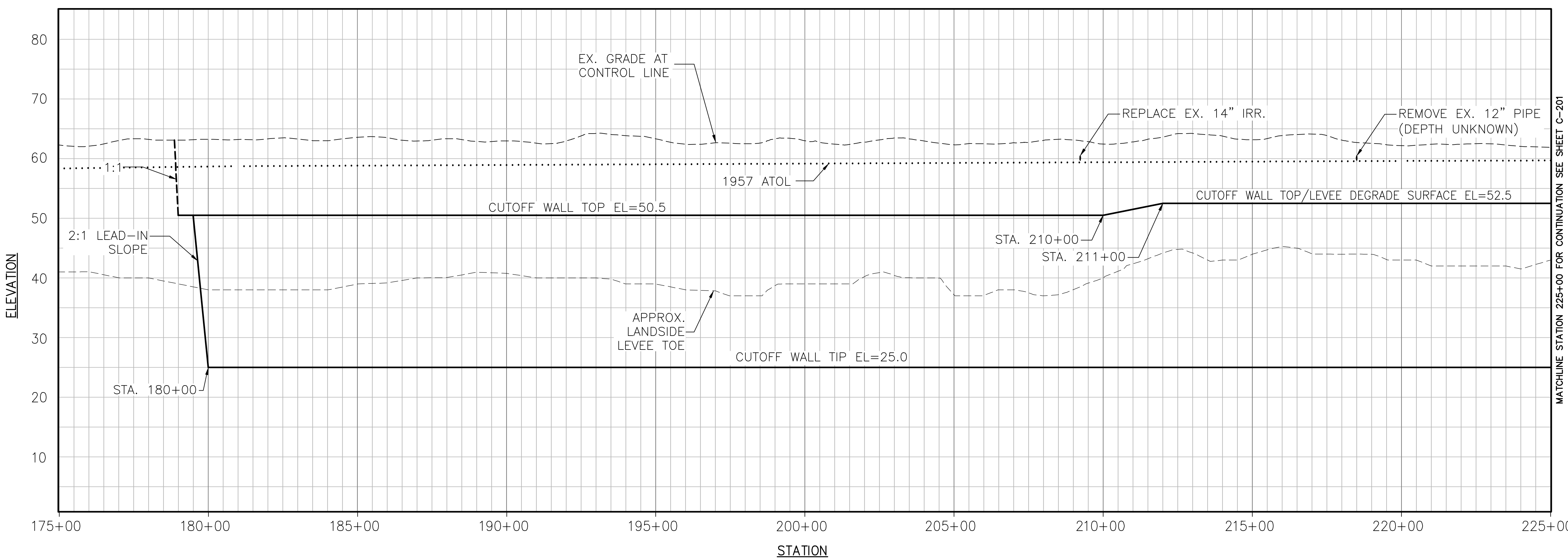
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
STAR BEND SETBACK OPTION
PLAN VIEW
STA. 478+68 to STA. 512+00

Sheet reference number:

C-145

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

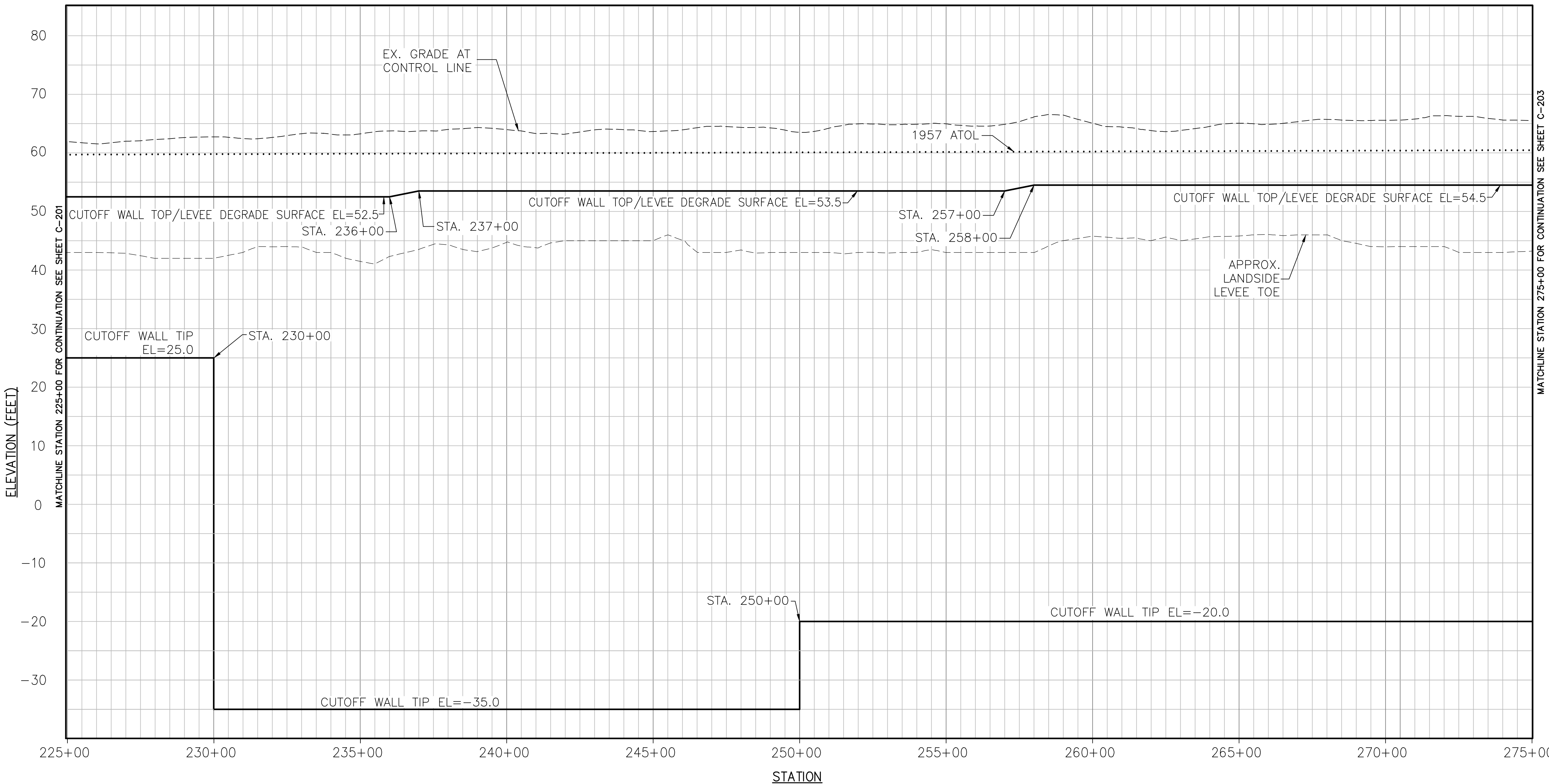
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 175+00 TO 225+00

Sheet reference number:
C-201

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

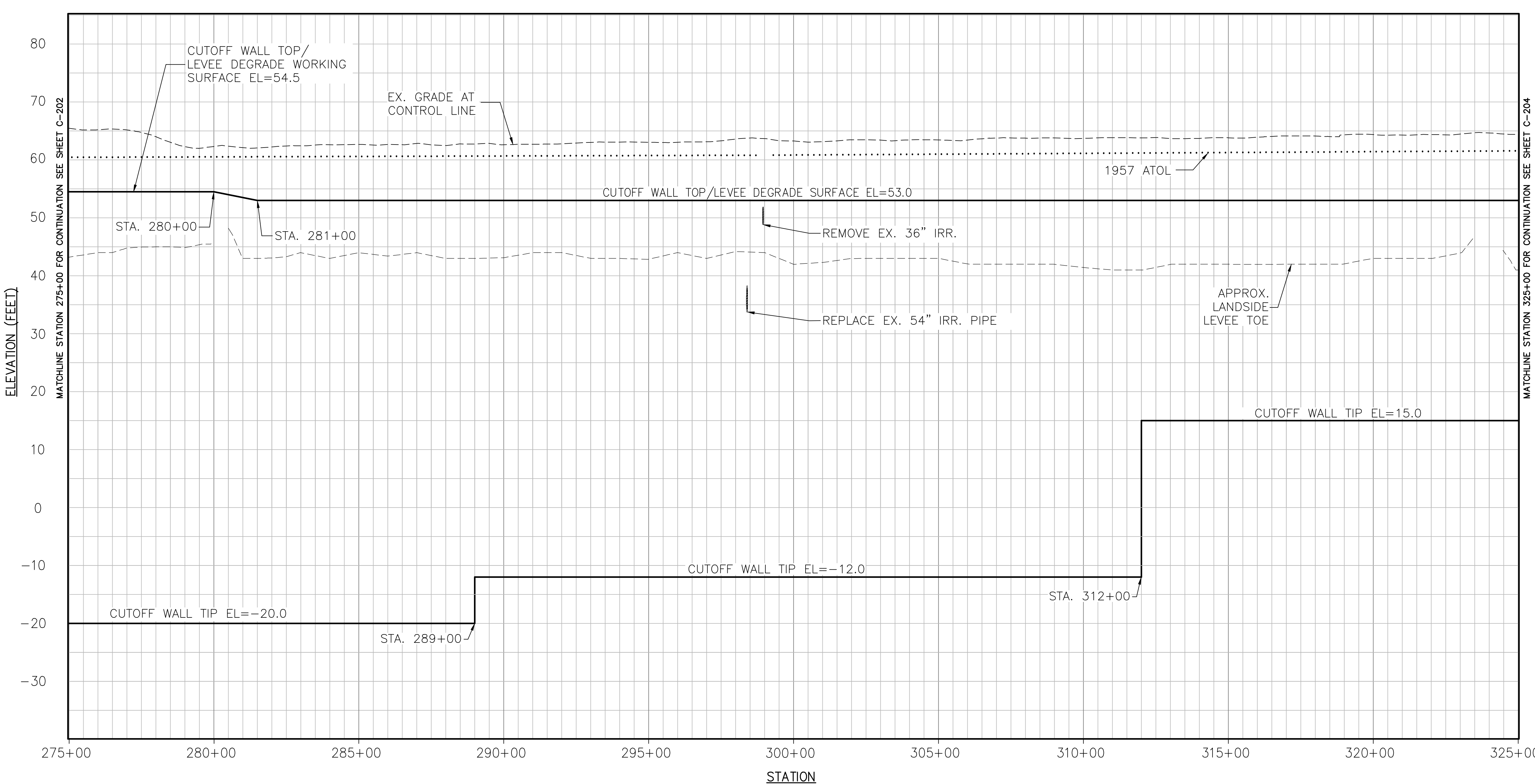
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 225+00 TO 275+00

Sheet reference number:
C-202

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

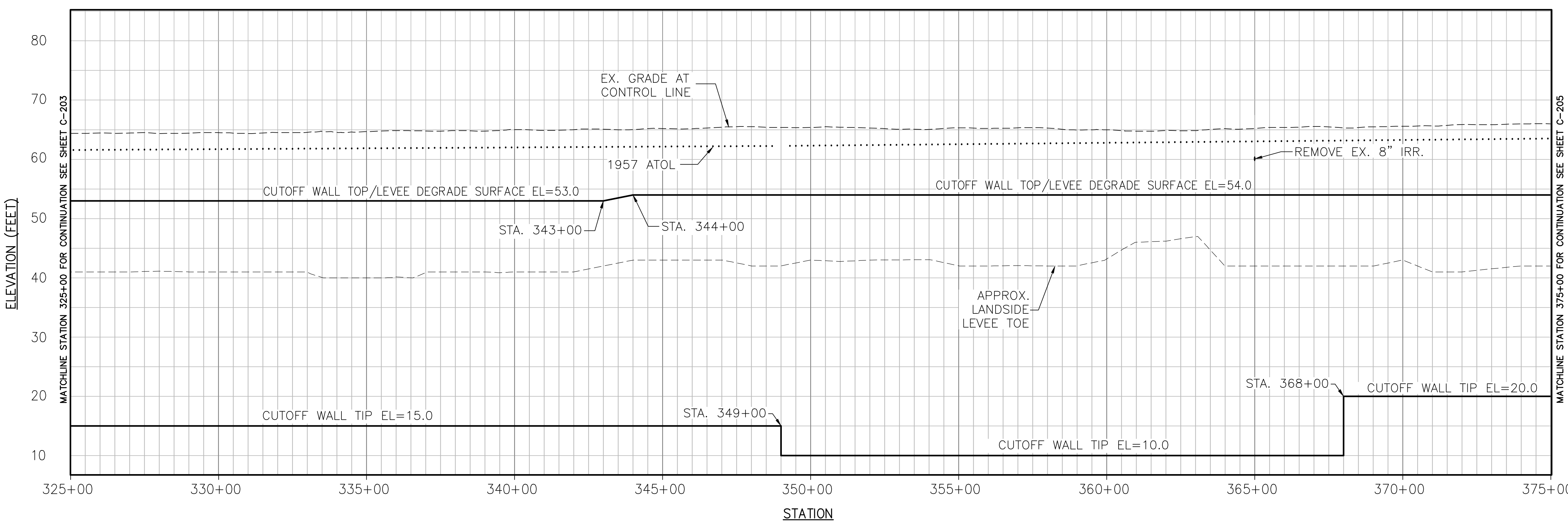
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 275+00 TO 325+00

Sheet reference number:
C-203

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'
0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

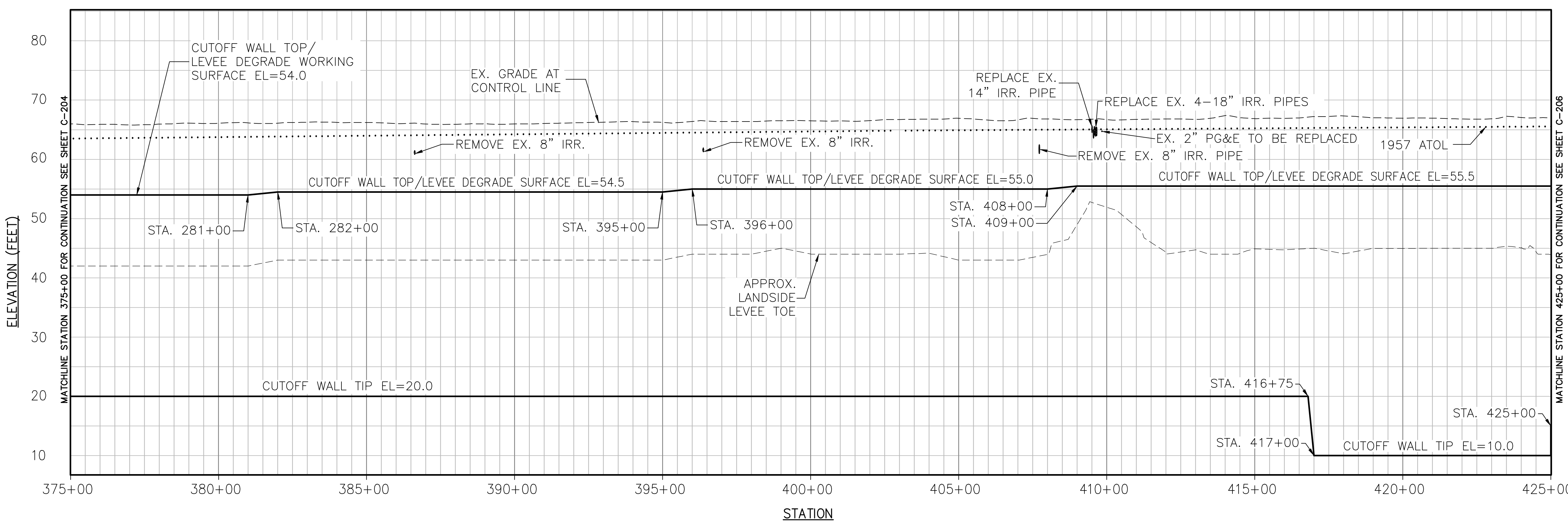
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 325+00 TO 375+00

Sheet reference number:
C-204

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

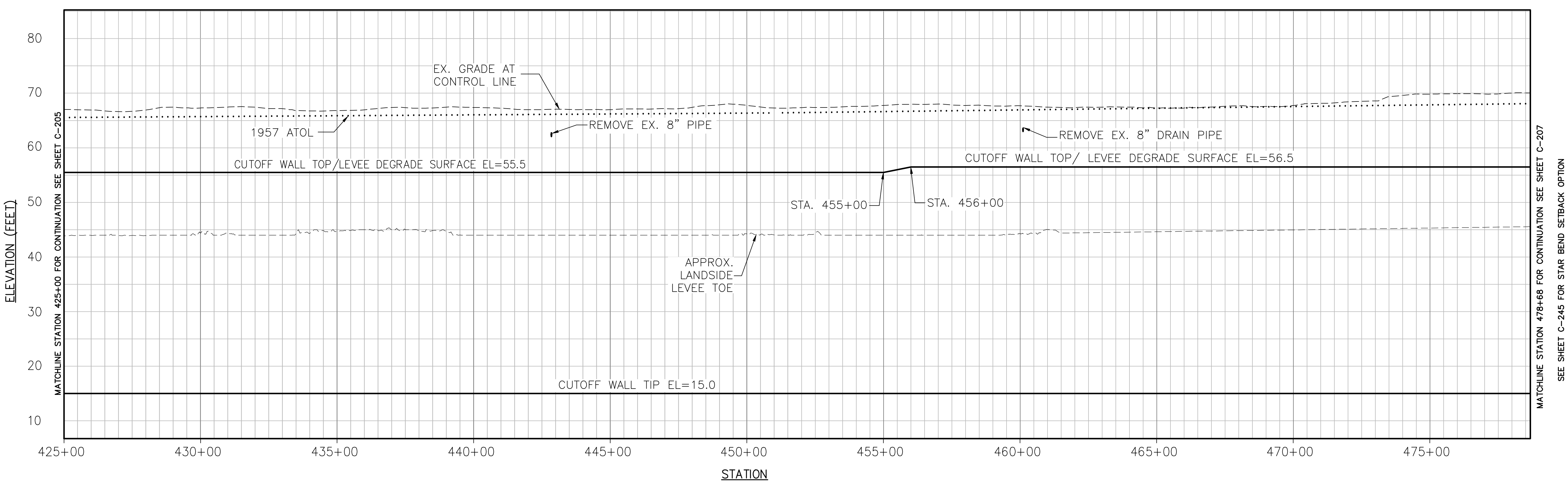
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 375+00 TO 425+00

Sheet reference number:
C-205

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

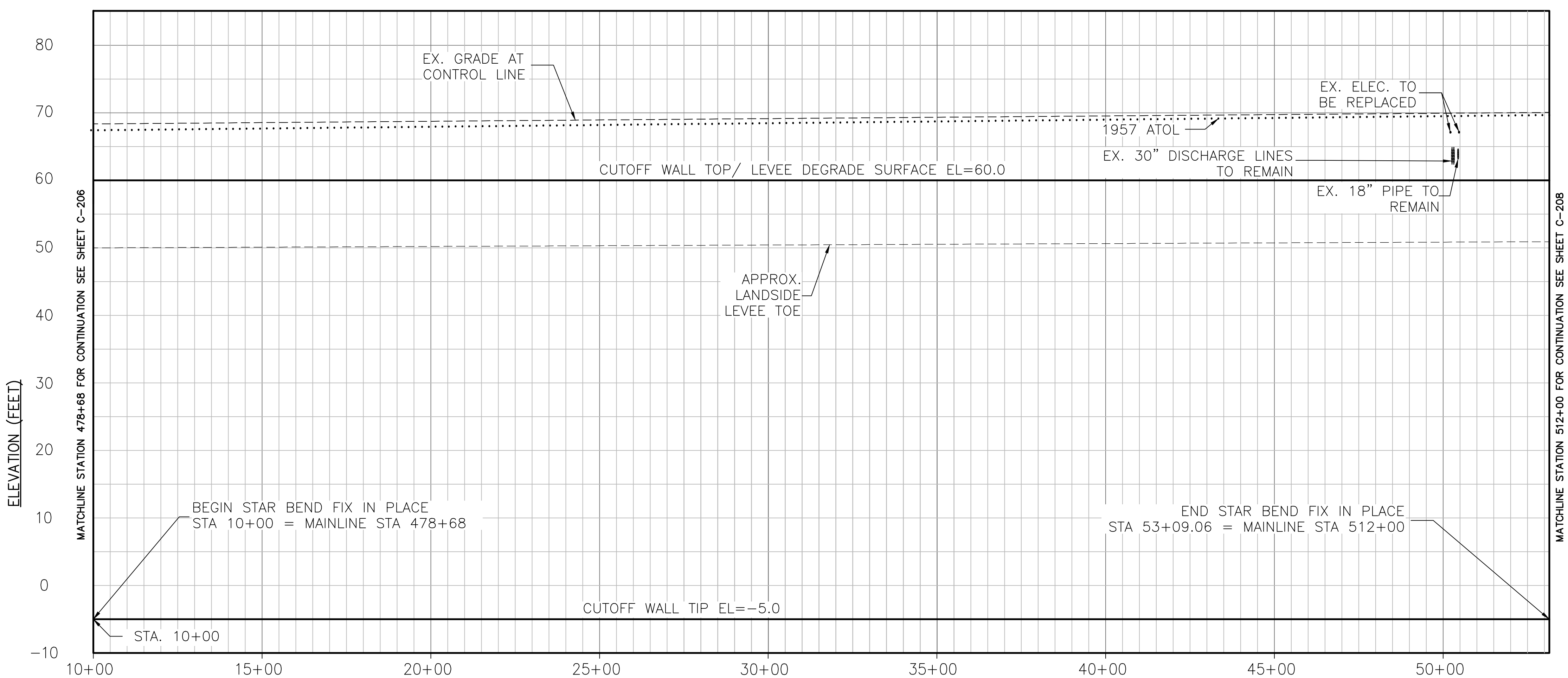
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 425+00 TO 478+68

Sheet reference number:
C-206

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



STATION

PROFILE

STATION EQUATIONS:

STAR BEND FIX−IN PLACE STA 10+00 = MAINLINE STATION 478+68
STAR BEND FIX−IN PLACE STA 53+09.06 = MAINLINE STATION 512+00

NOTE: SEE SHEET C−245 FOR STAR BEND SETBACK OPTION

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

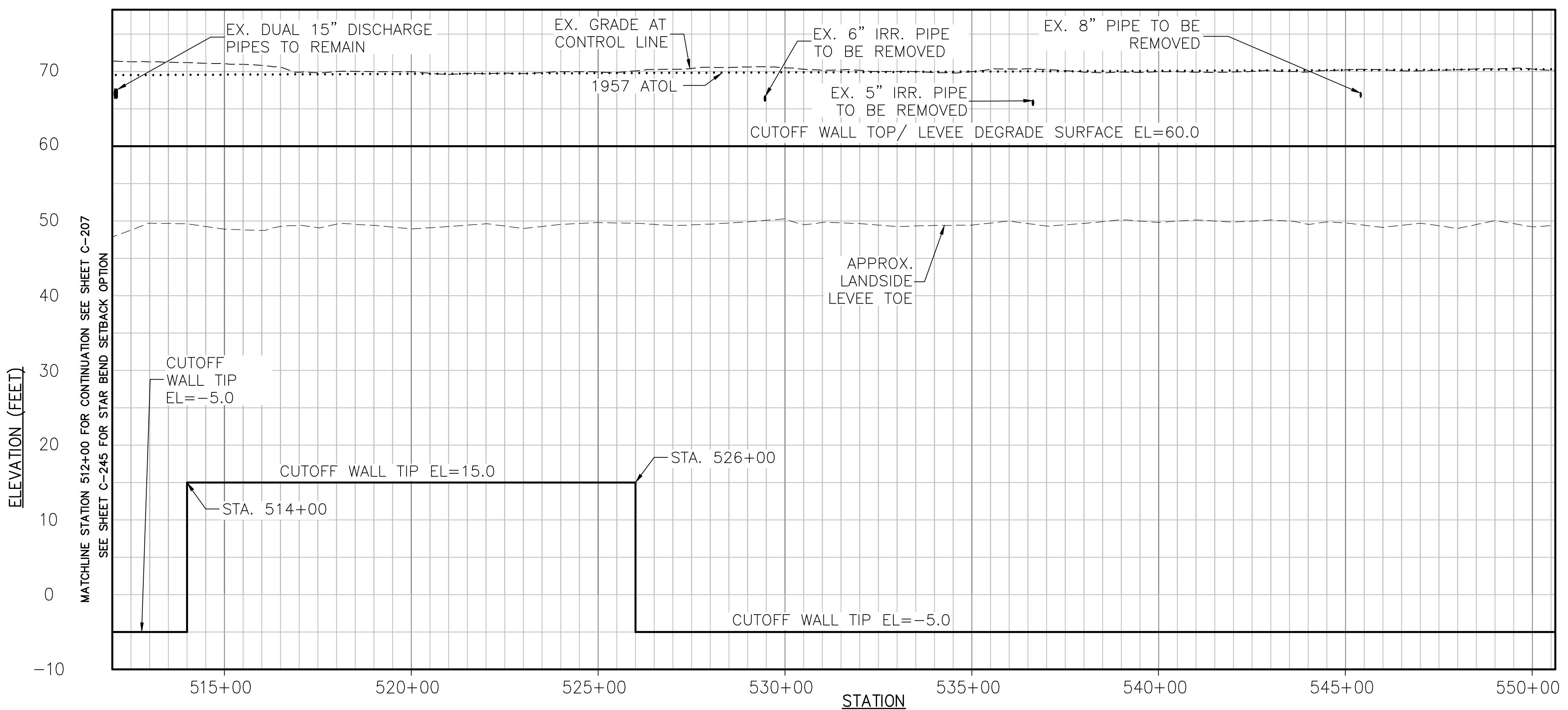
US Army Corps of Engineers®
Sacramento District

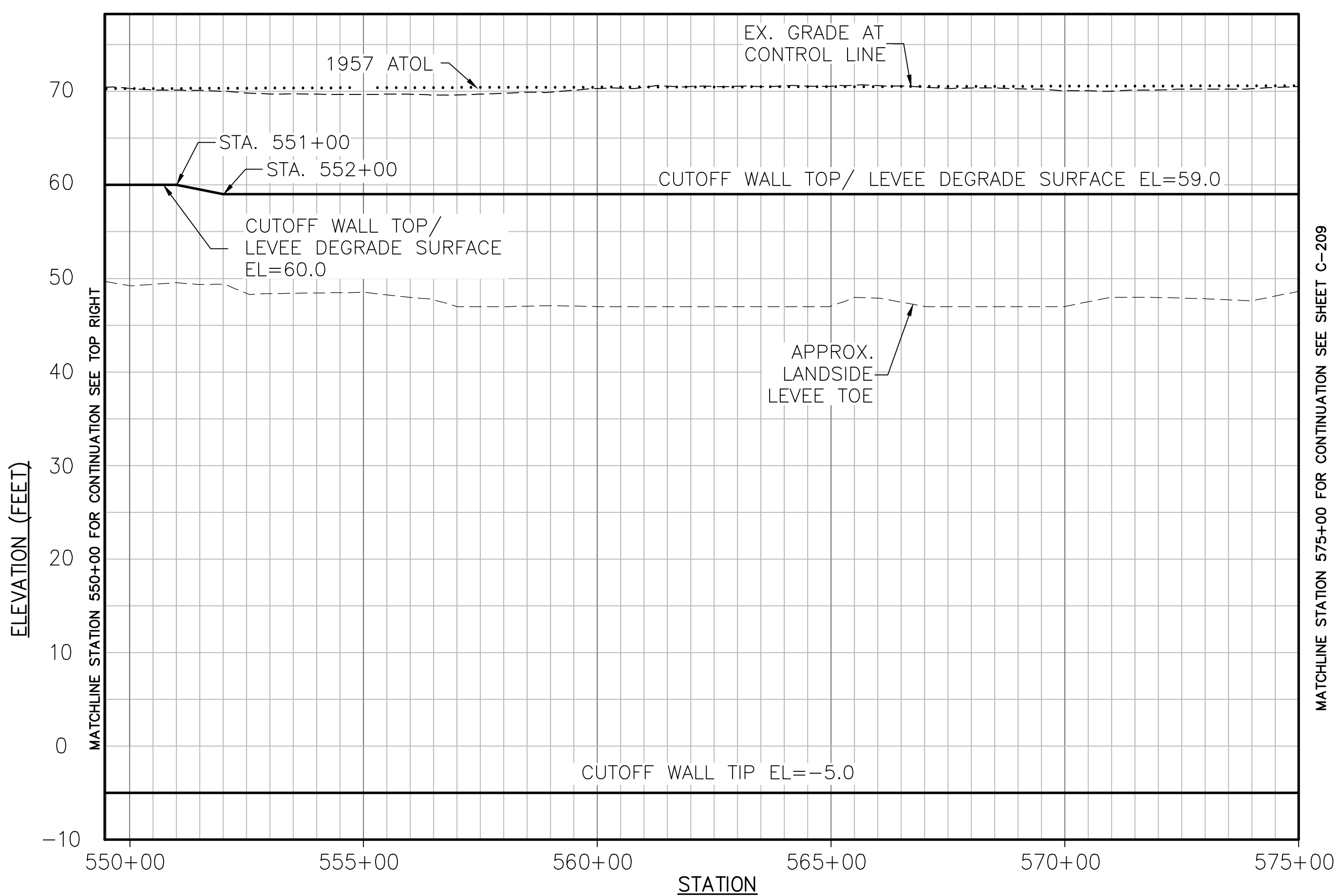
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN−HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814−2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB−7 AND SB−8
PROFILE VIEW
STA. 478+68 to STA. 512+00 (MAINLINE)

Sheet reference number:
C-207





PROFILE

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.

PROFILE
H: 1"=200'
V: 1"=10'
0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

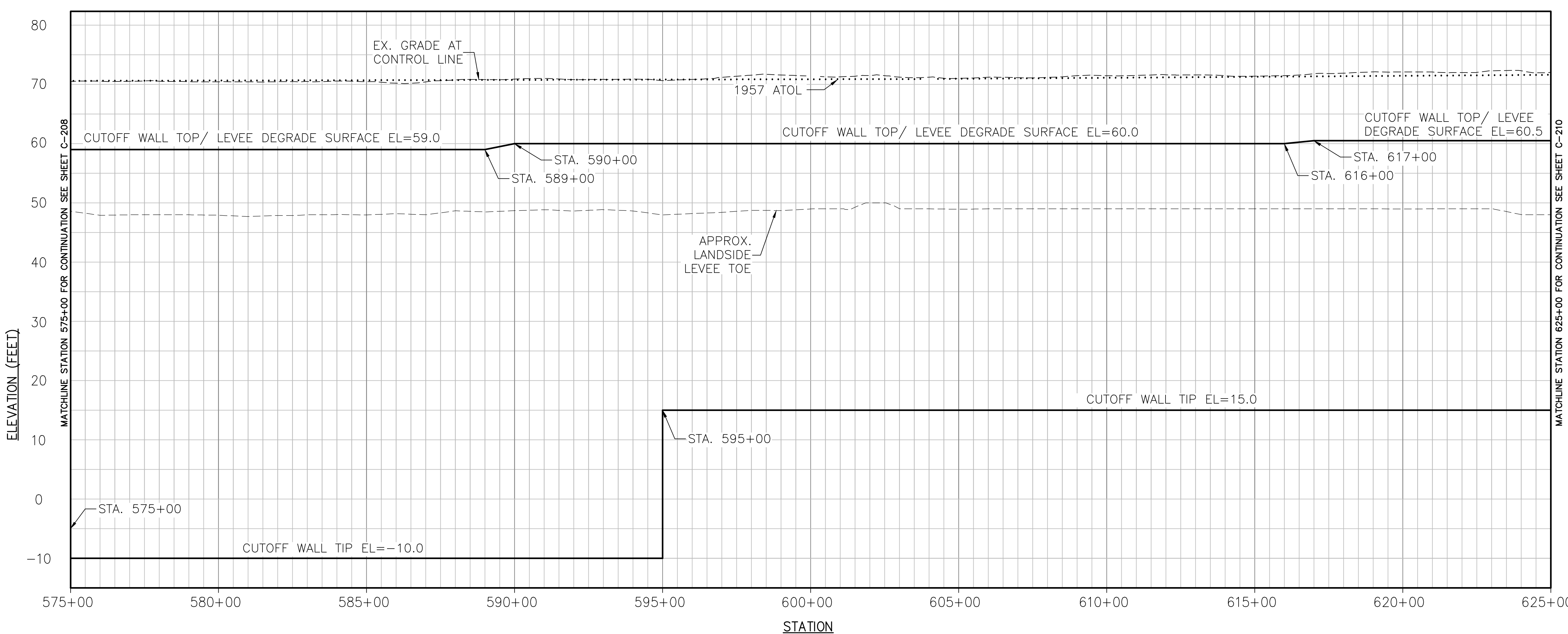
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 512+00 TO 575+00

Sheet reference number:
C-208

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

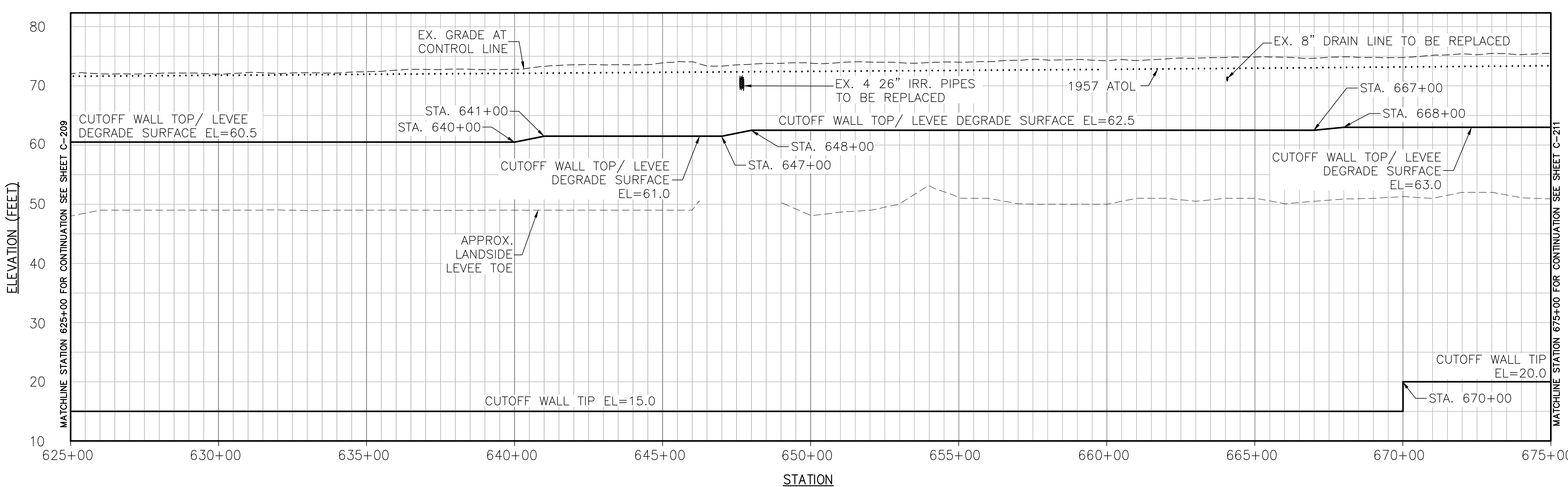
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 575+00 TO 625+00

Sheet reference number:
C-209

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

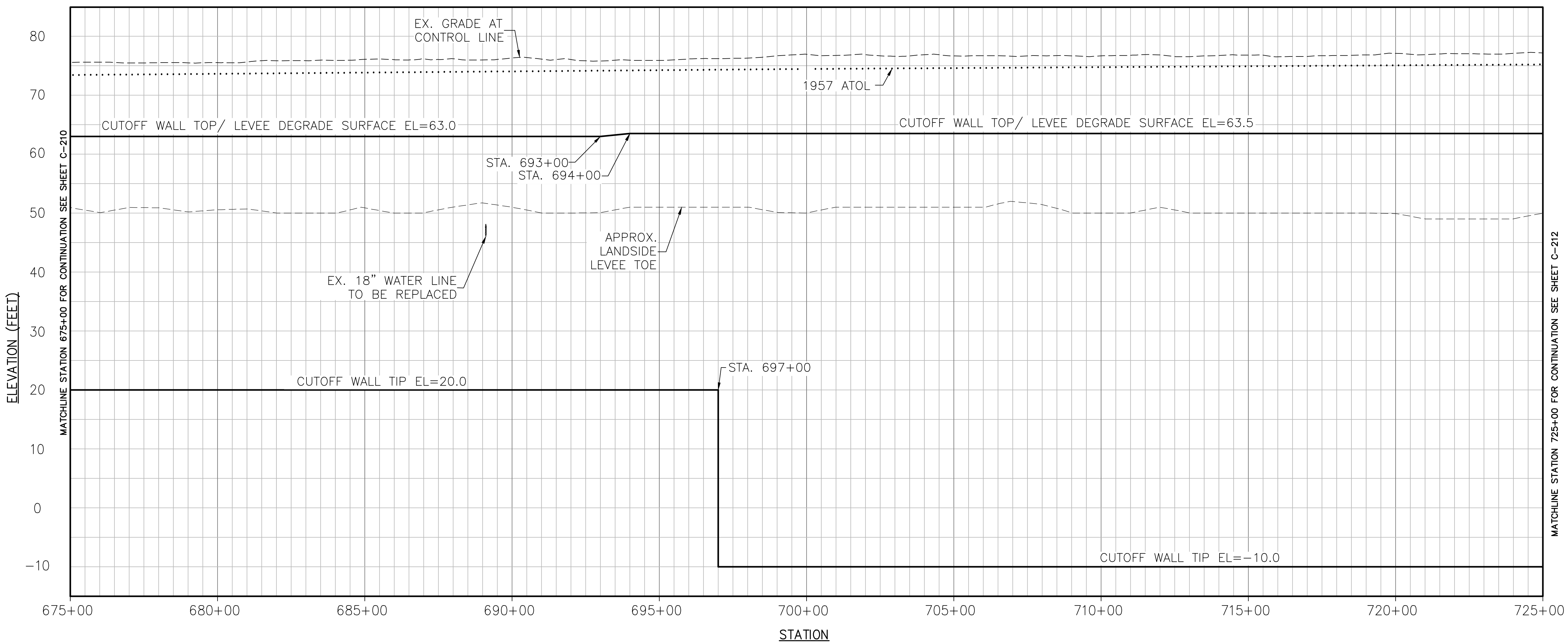
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 625+00 TO 675+00

Sheet reference number:
C-210

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'
0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

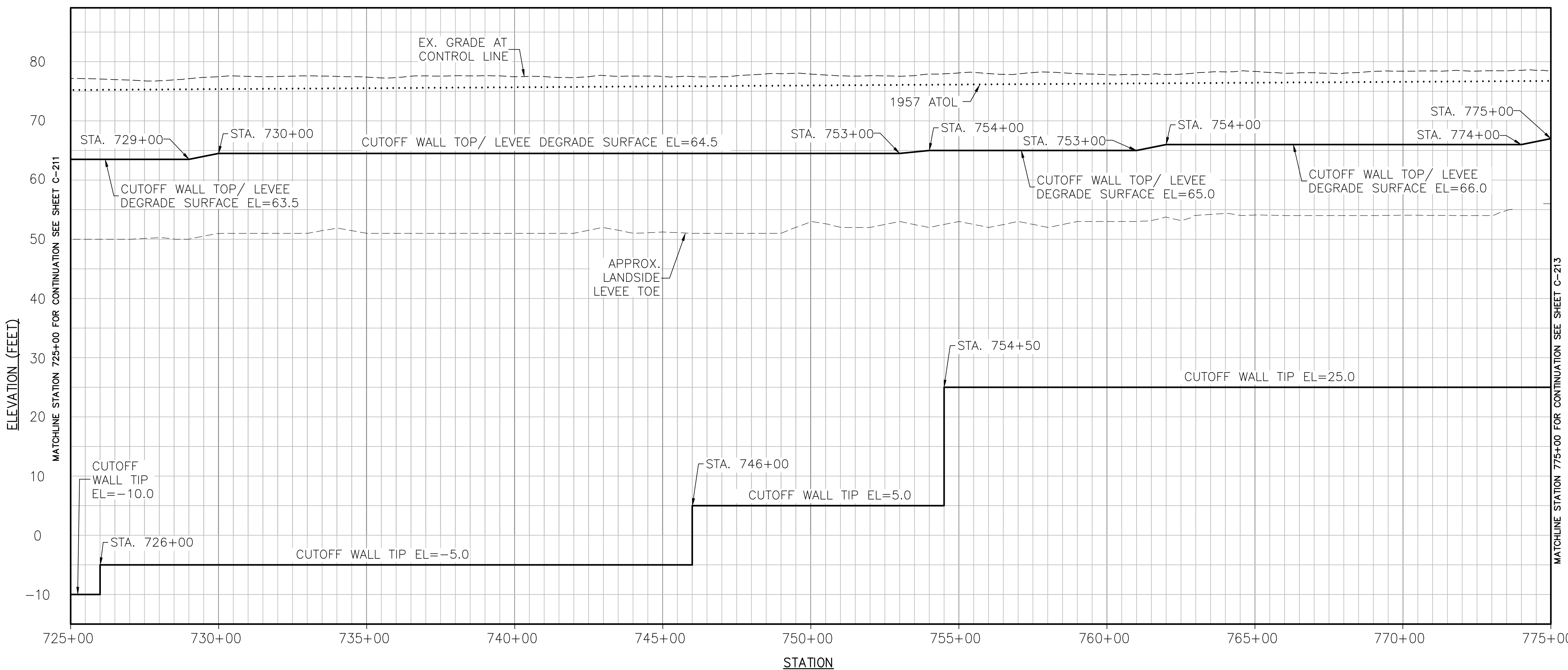
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 675+00 TO 725+00

Sheet reference number:
C-211

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

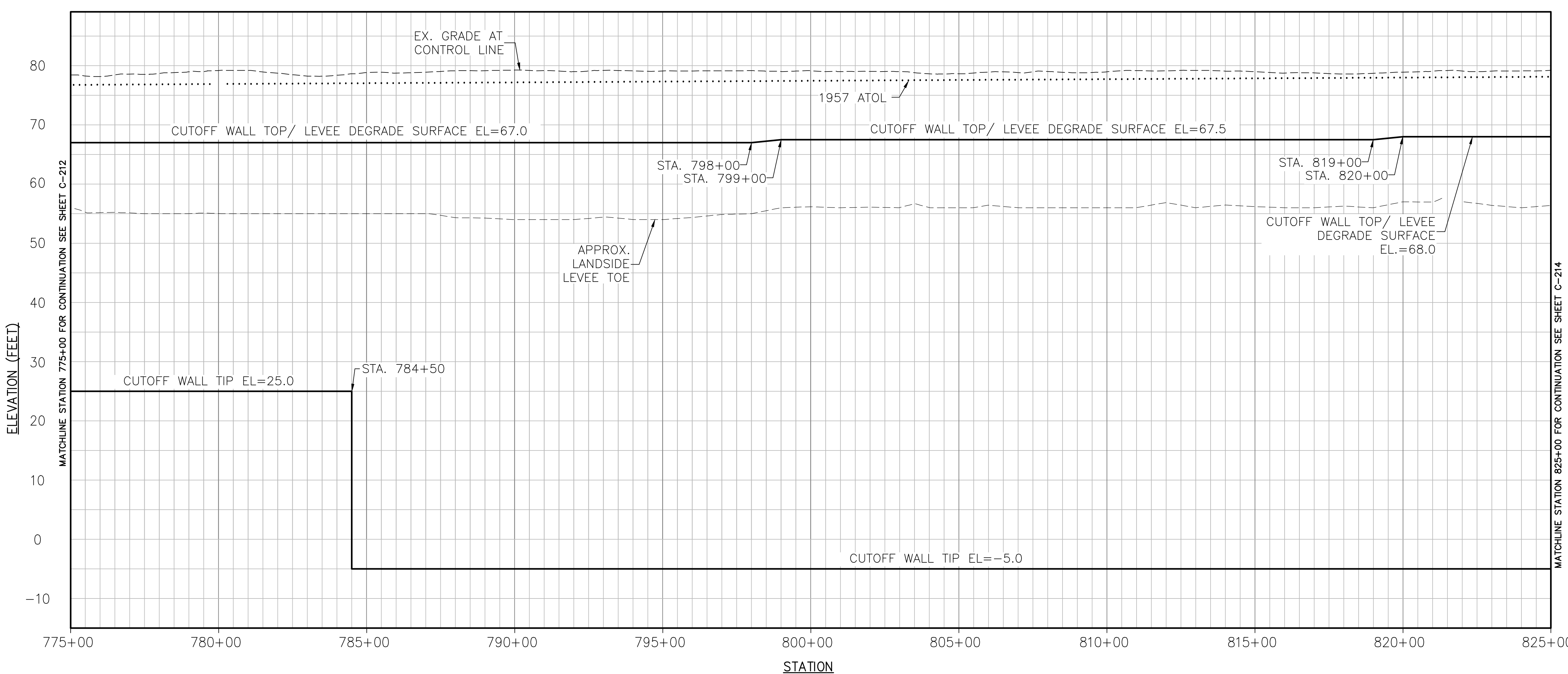
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 725+00 TO 775+00

Sheet reference number:
C-212

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

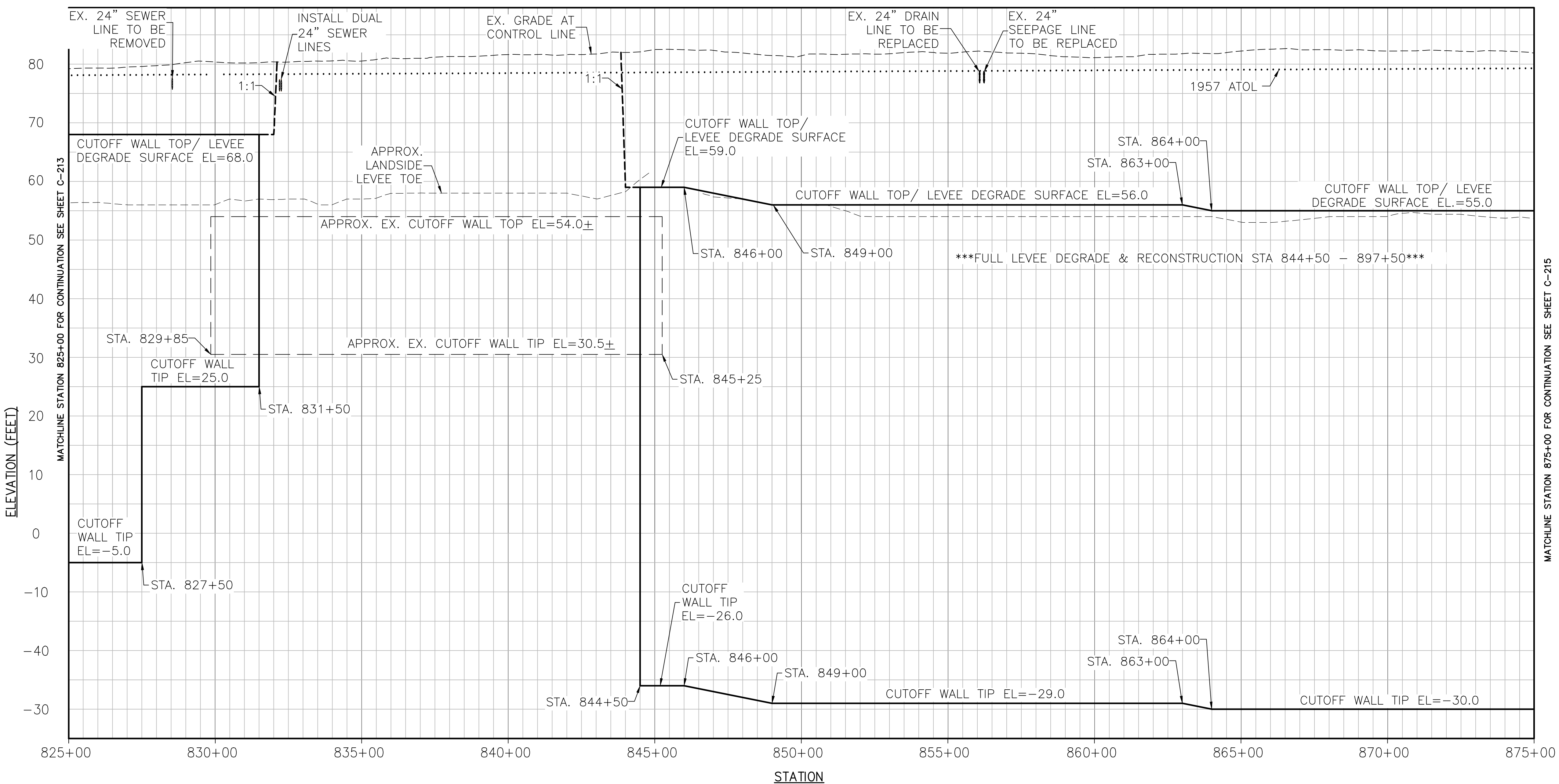
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 775+00 TO 825+00

Sheet reference number:
C-213

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

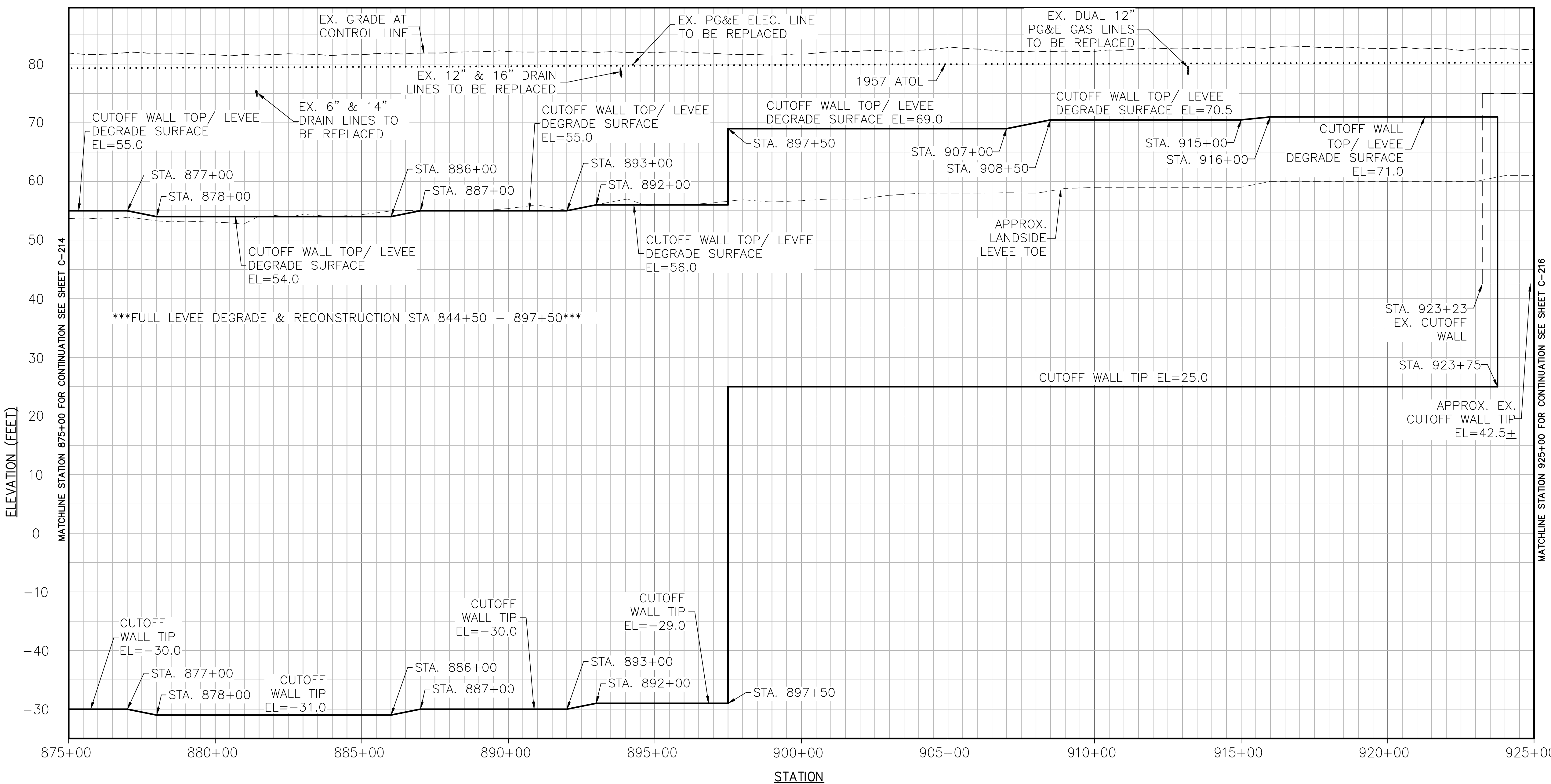
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 825+00 TO 875+00

Sheet reference number:
C-214

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

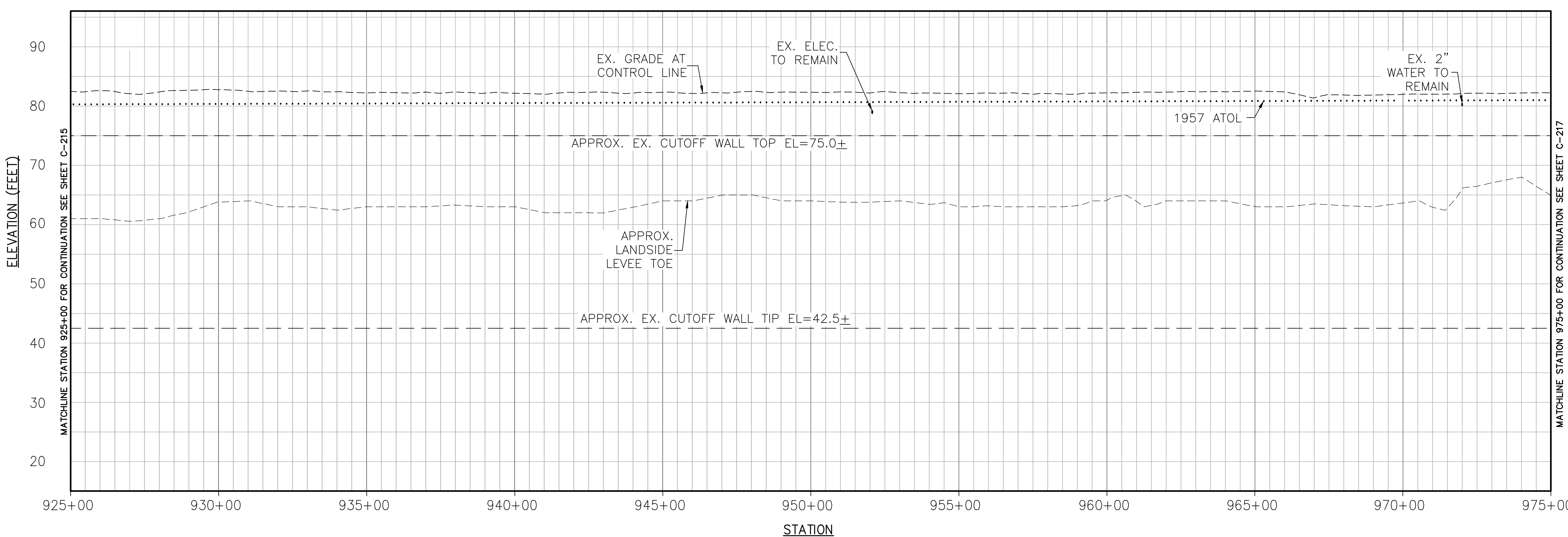
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 875+00 TO 925+00

Sheet reference number:
C-215

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

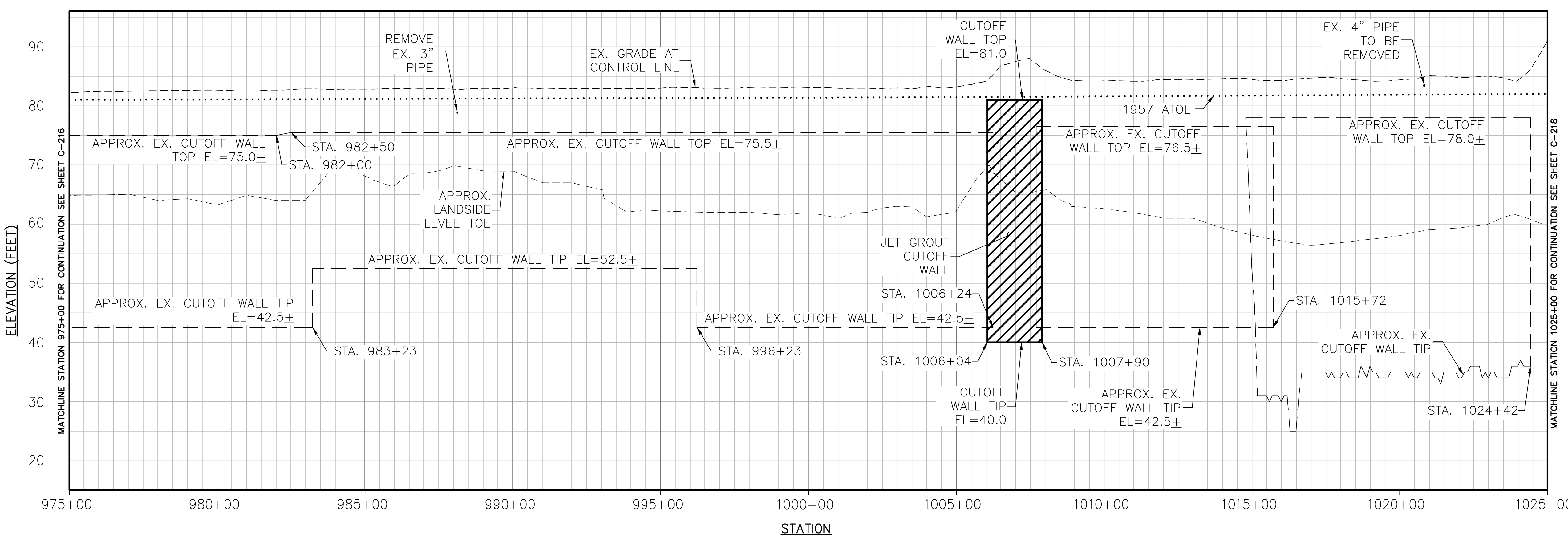
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 925+00 TO 975+00

Sheet reference number:
C-216

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

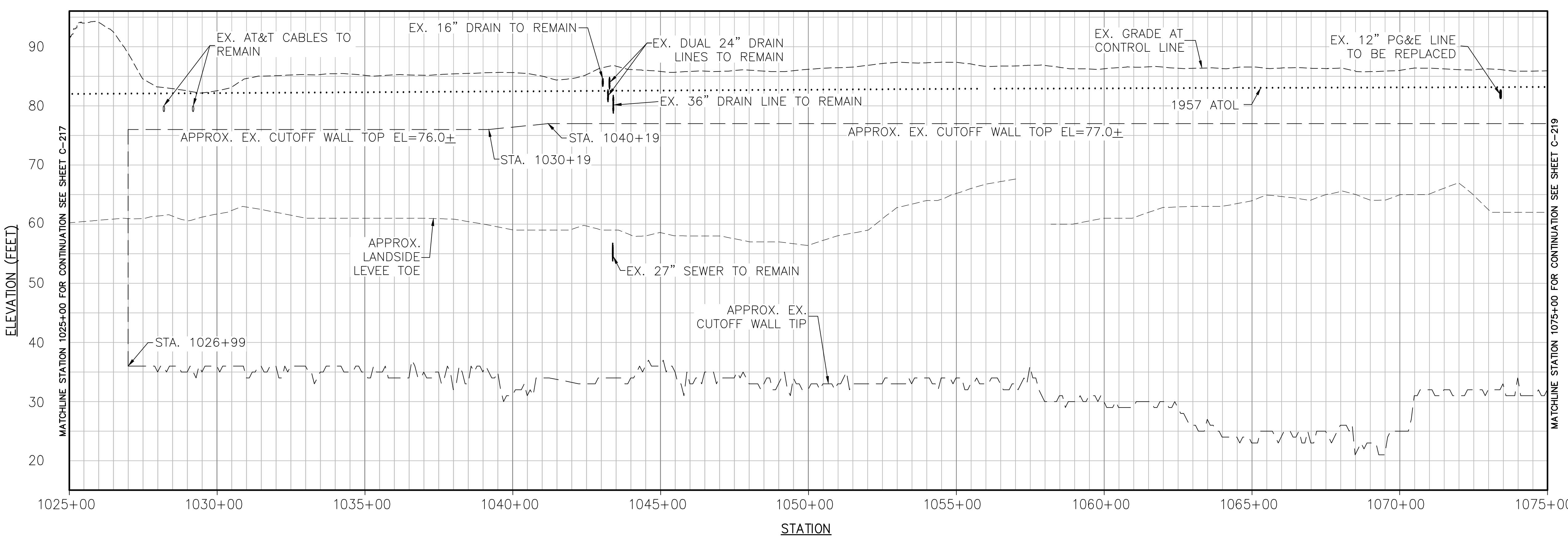
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 975+00 TO 1025+00

Sheet reference number:
C-217

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

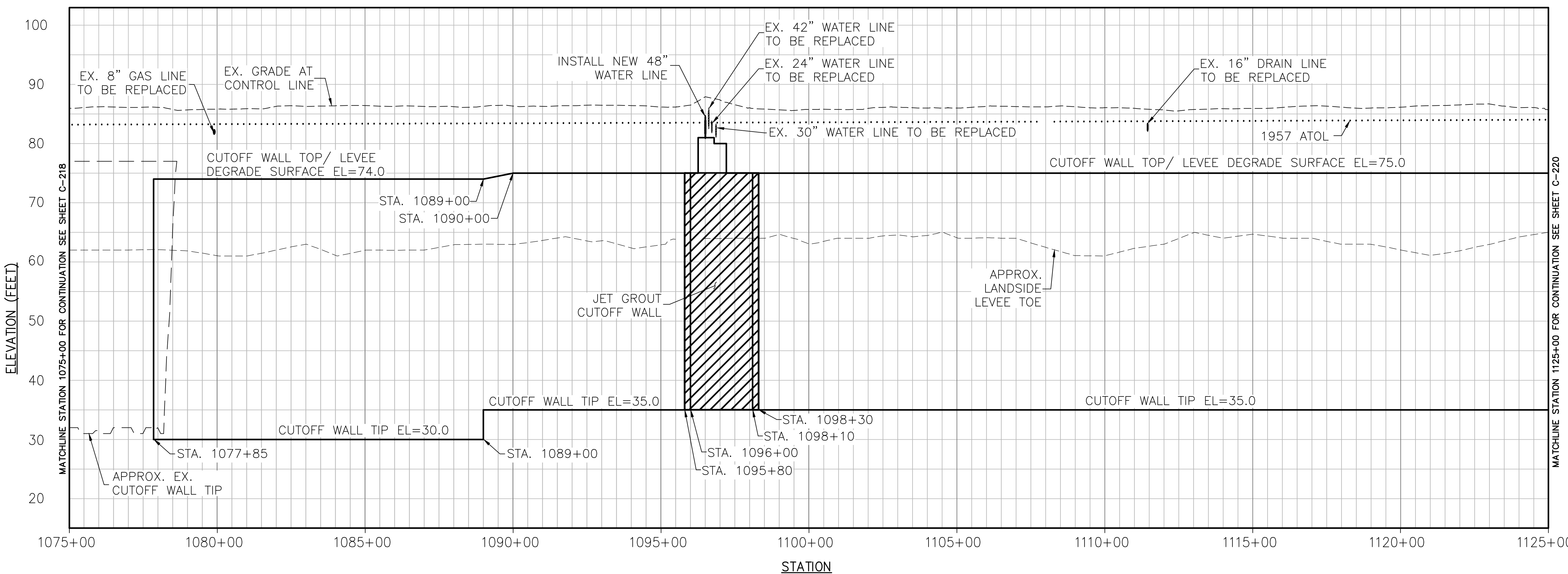
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 1025+00 TO 1075+00

Sheet reference number:
C-218

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'
0 200 400

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US Army Corps of Engineers®
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DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
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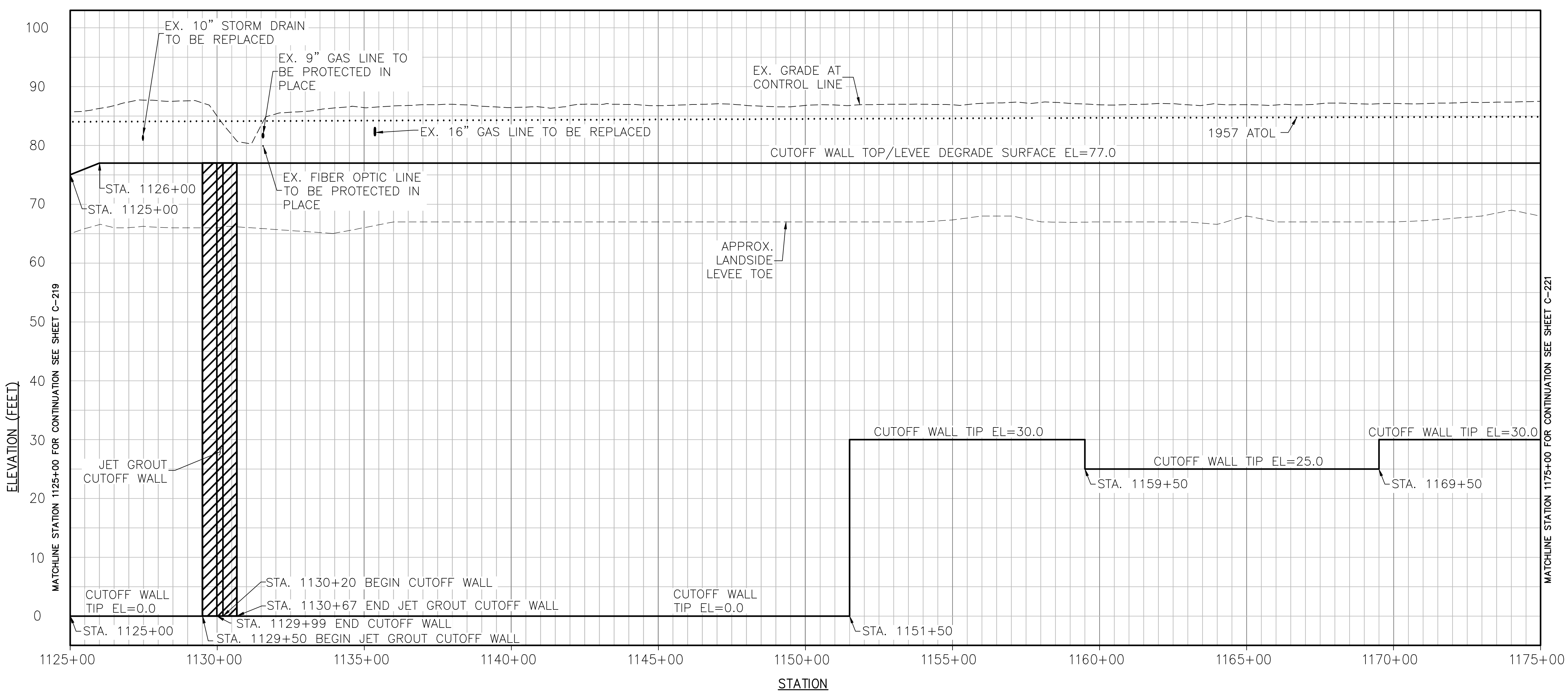
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 1075+00 TO 1125+00

Sheet reference number:
C-219

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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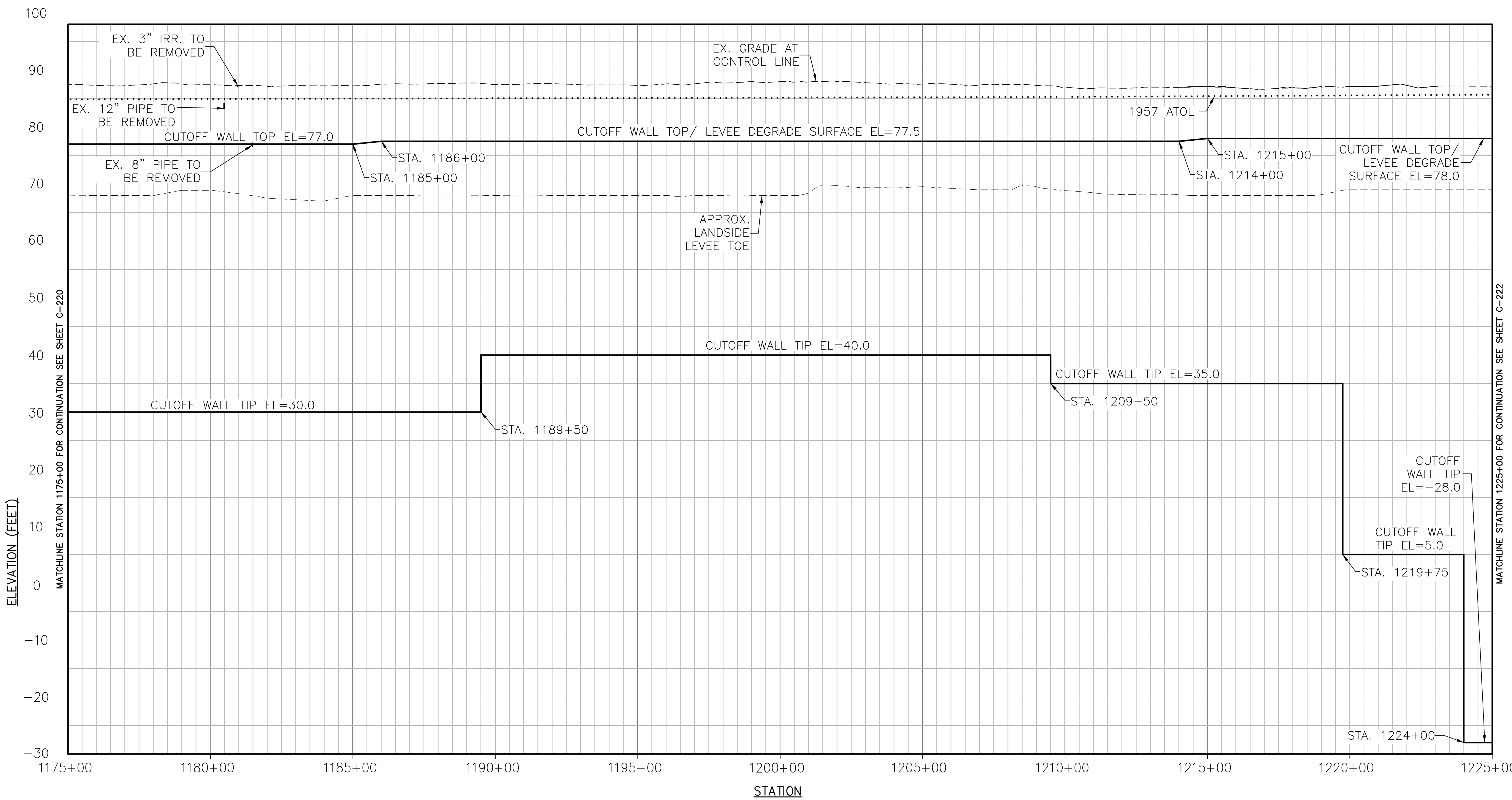
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 1125+00 TO 1175+00

Sheet reference number:
C-220

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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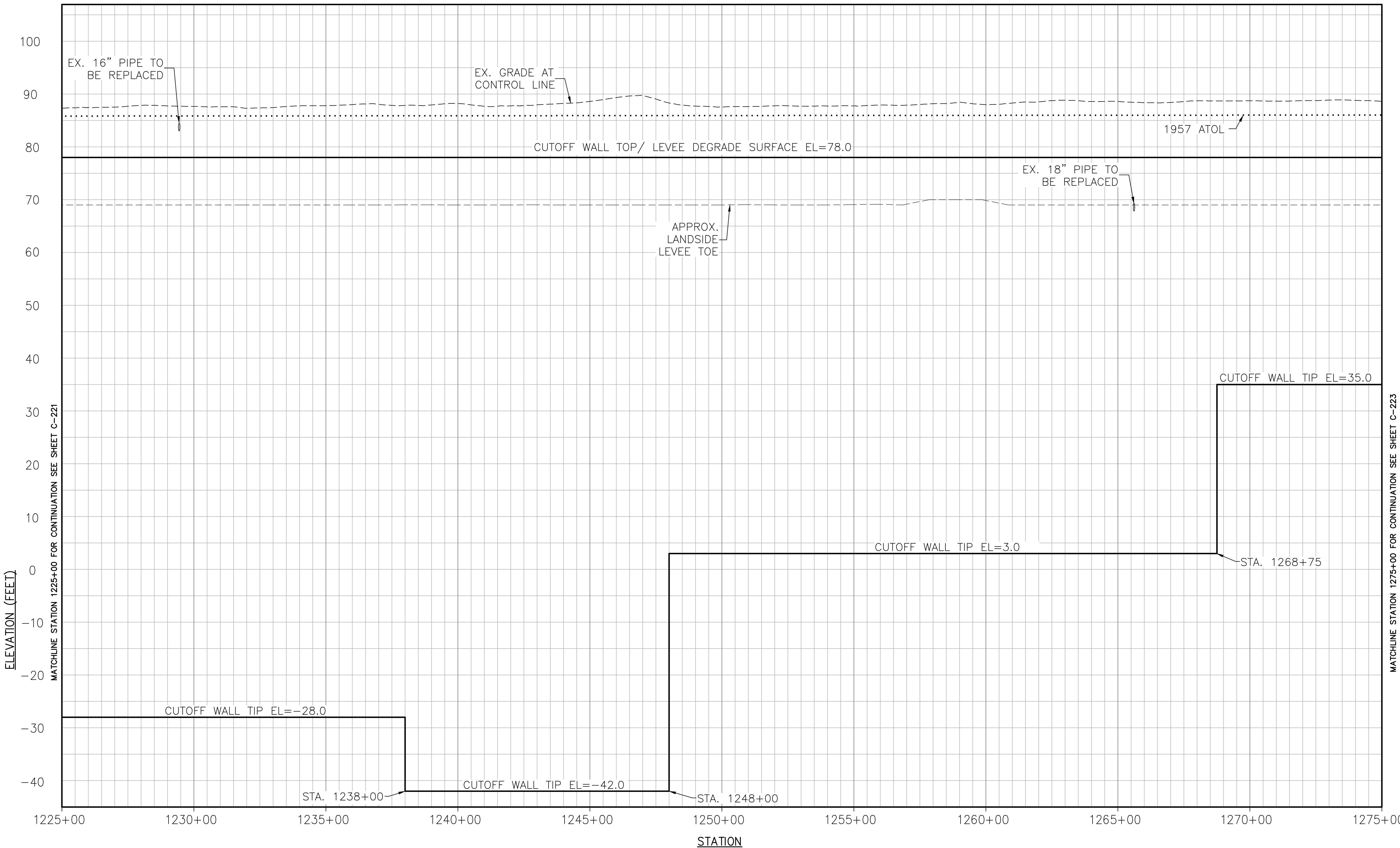
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 1175+00 TO 1225+00

Sheet reference number:
C-221

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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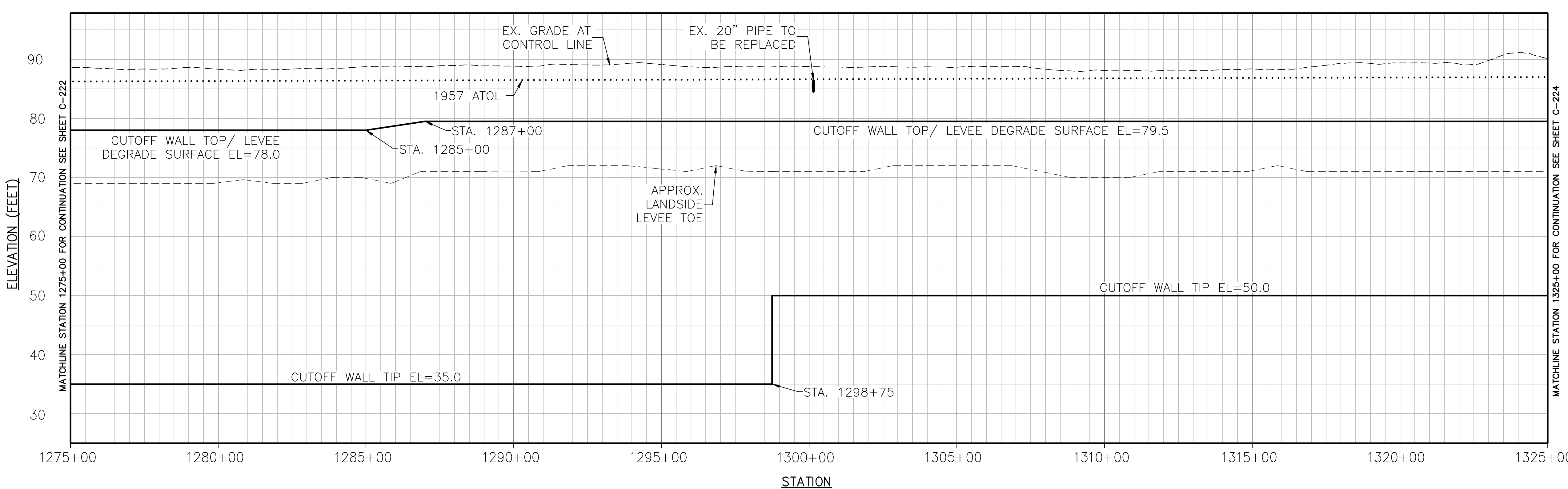
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 1225+00 TO 1275+00

Sheet reference number:
C-222

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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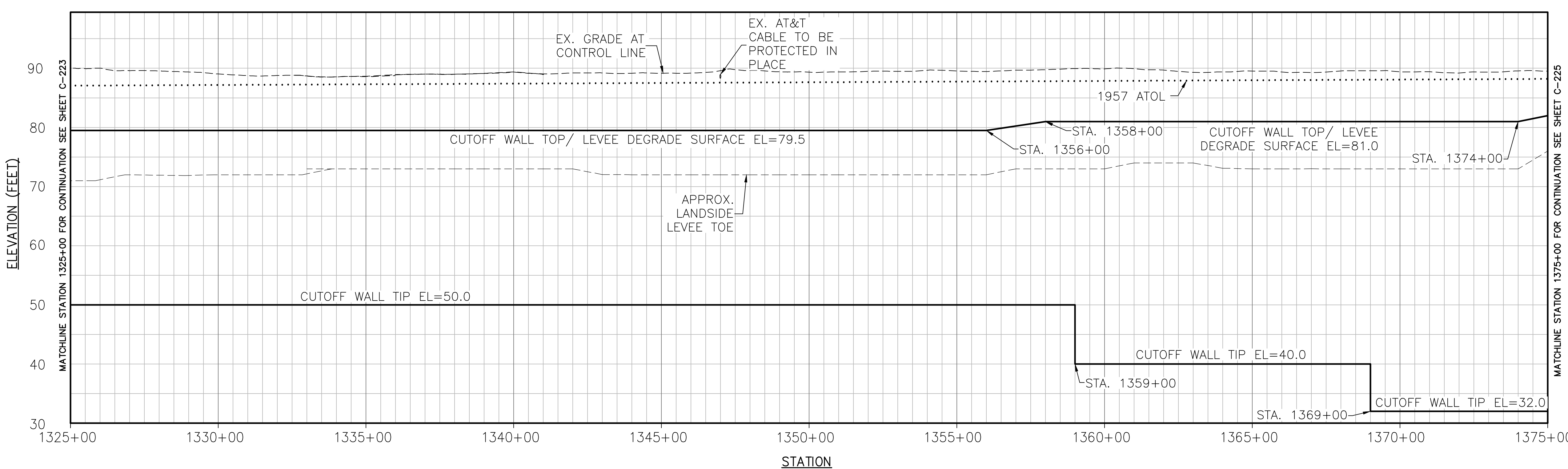
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 1275+00 TO 1325+00

Sheet reference number:
C-223

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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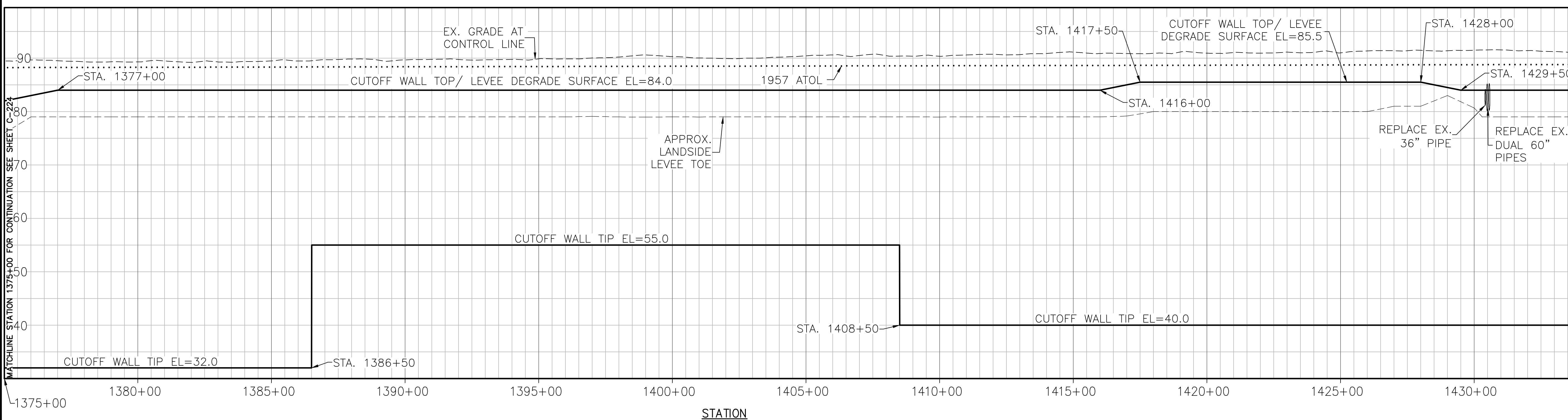
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 1325+00 TO 1375+00

Sheet reference number:
C-224

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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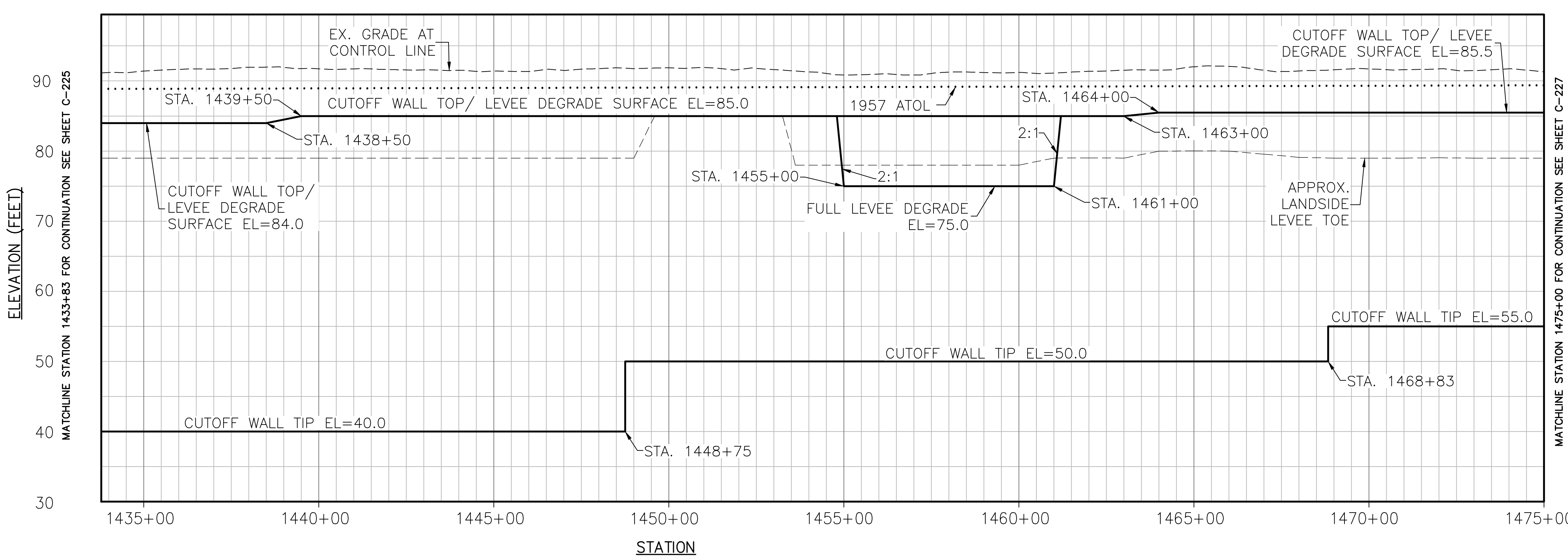
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 1375+00 TO 1433+83

Sheet reference number:
C-225

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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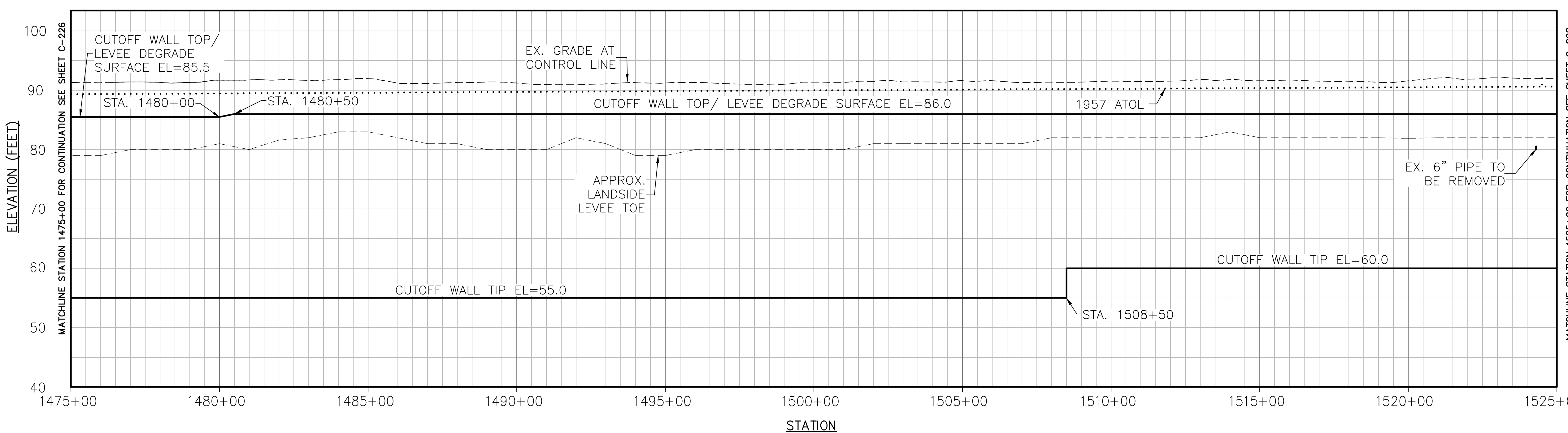
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1433+83 TO 1475+00

Sheet reference number:
C-226

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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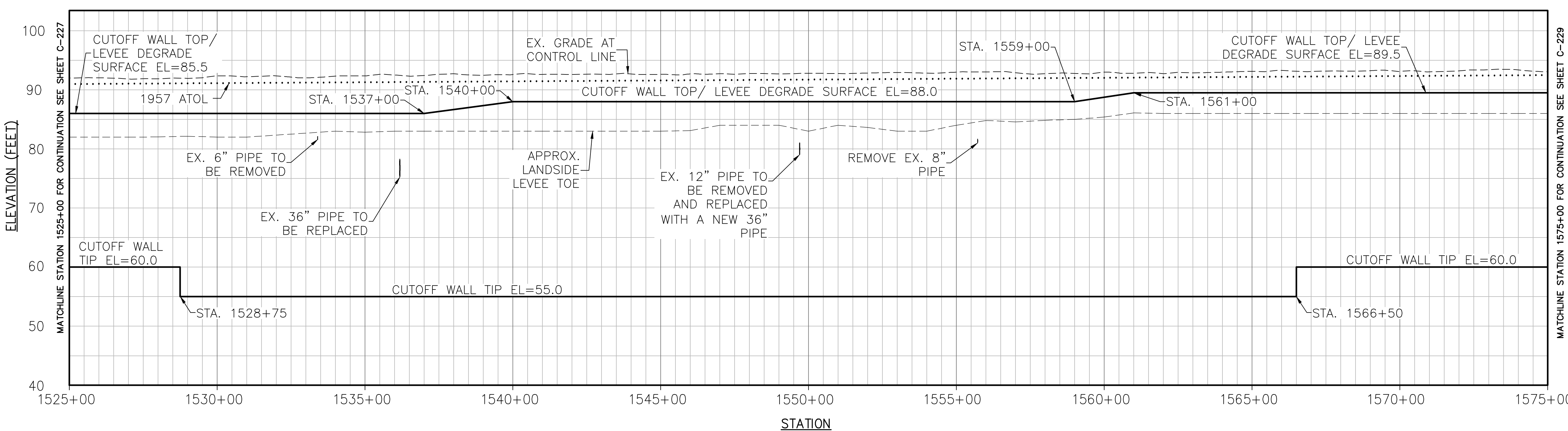
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1475+00 TO 1525+00

Sheet reference number:
C-227

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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SACRAMENTO DISTRICT
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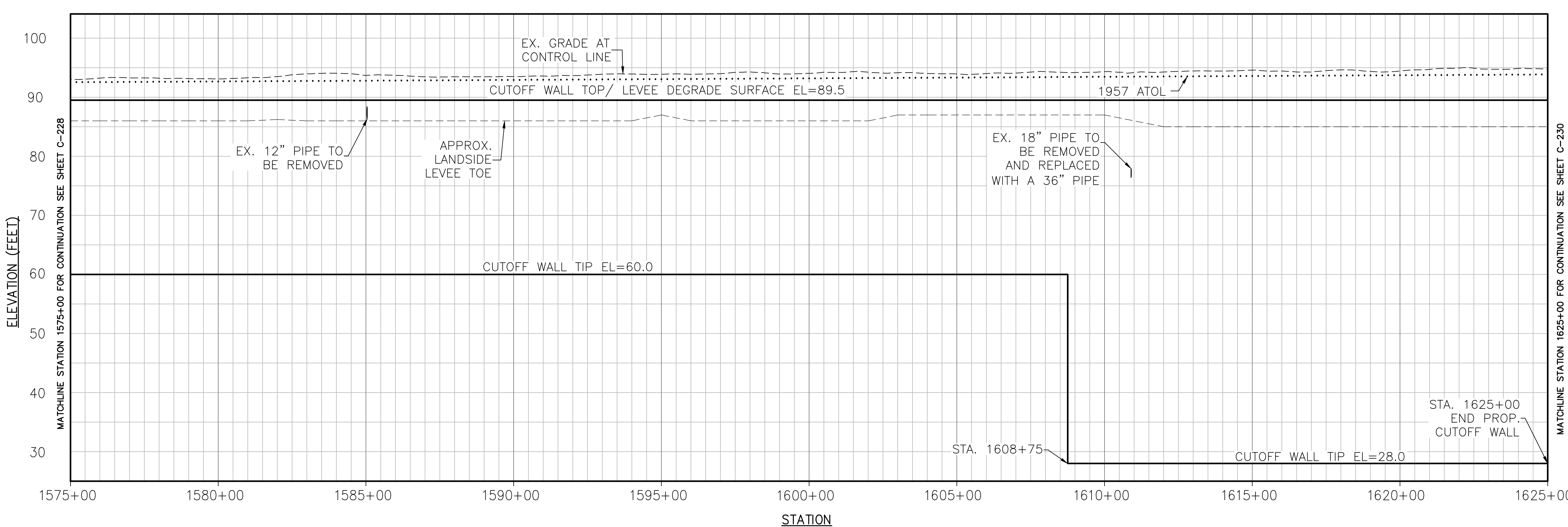
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1525+00 TO 1575+00

Sheet reference number:
C-228

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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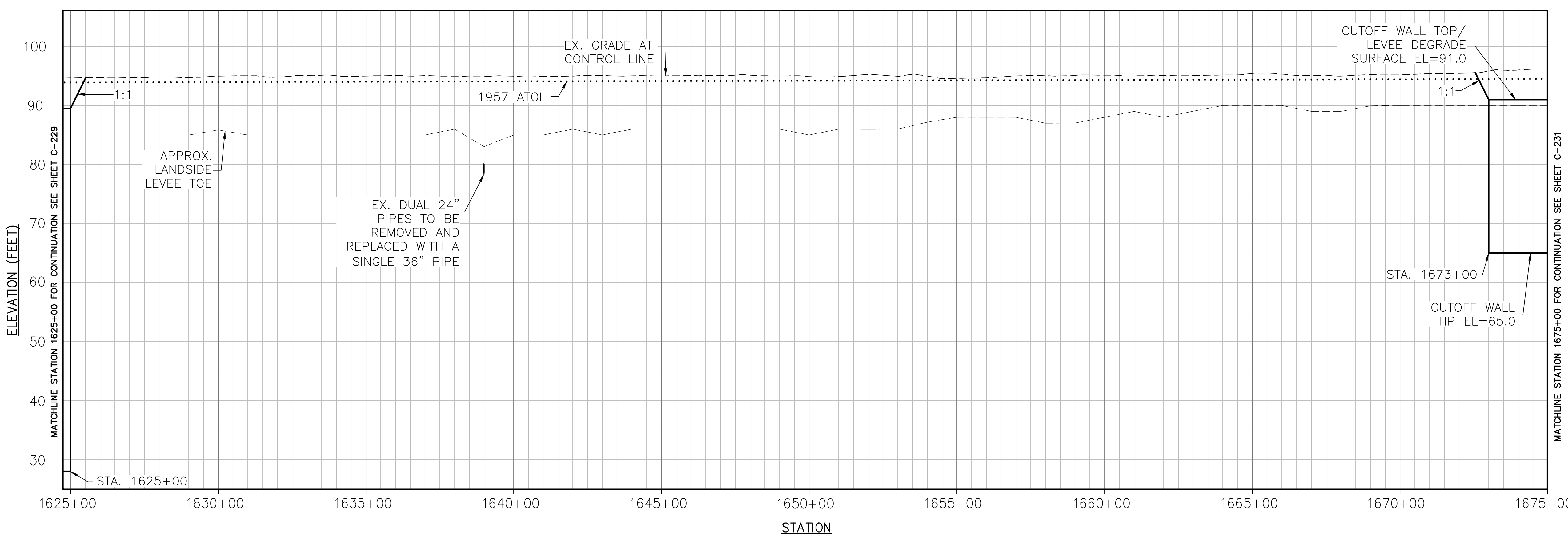
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1575+00 TO 1625+00

Sheet reference number:
C-229

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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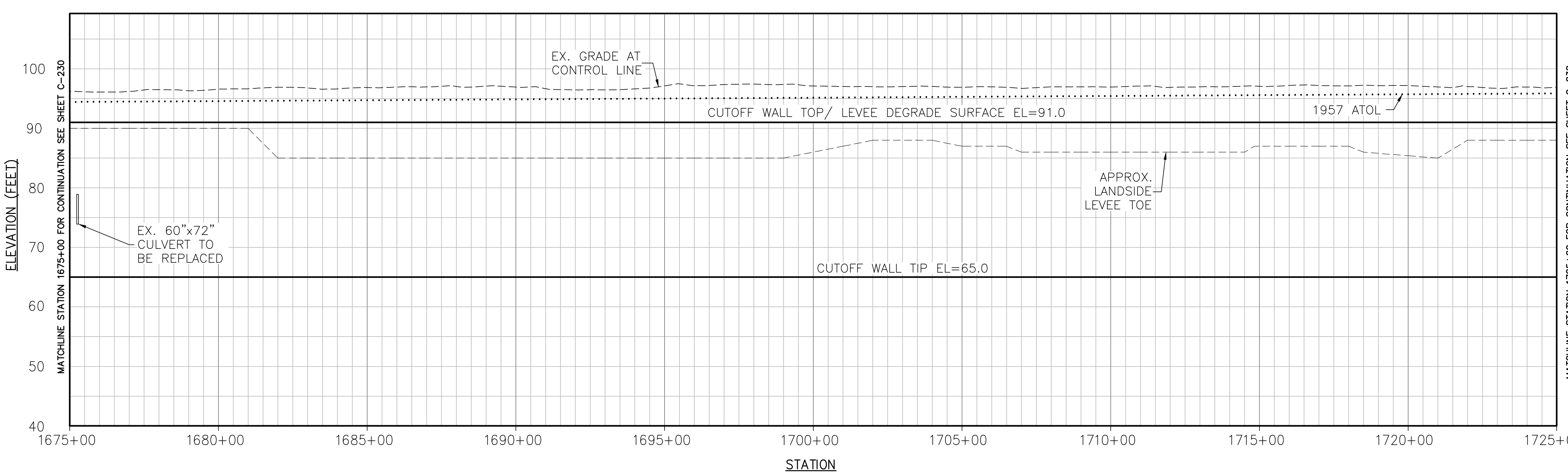
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1625+00 TO 1675+00

Sheet reference number:
C-230

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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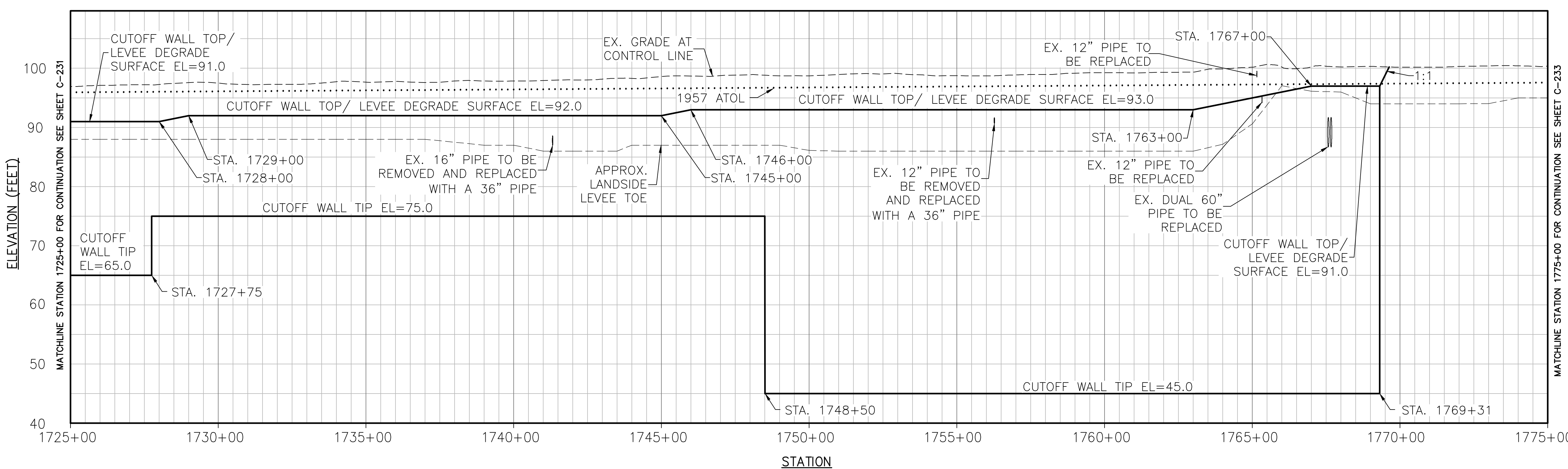
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1675+00 TO 1725+00

Sheet reference number:
C-231

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1725+00 TO 1775+00

Sheet reference number:
C-232

VERTICAL DATUM

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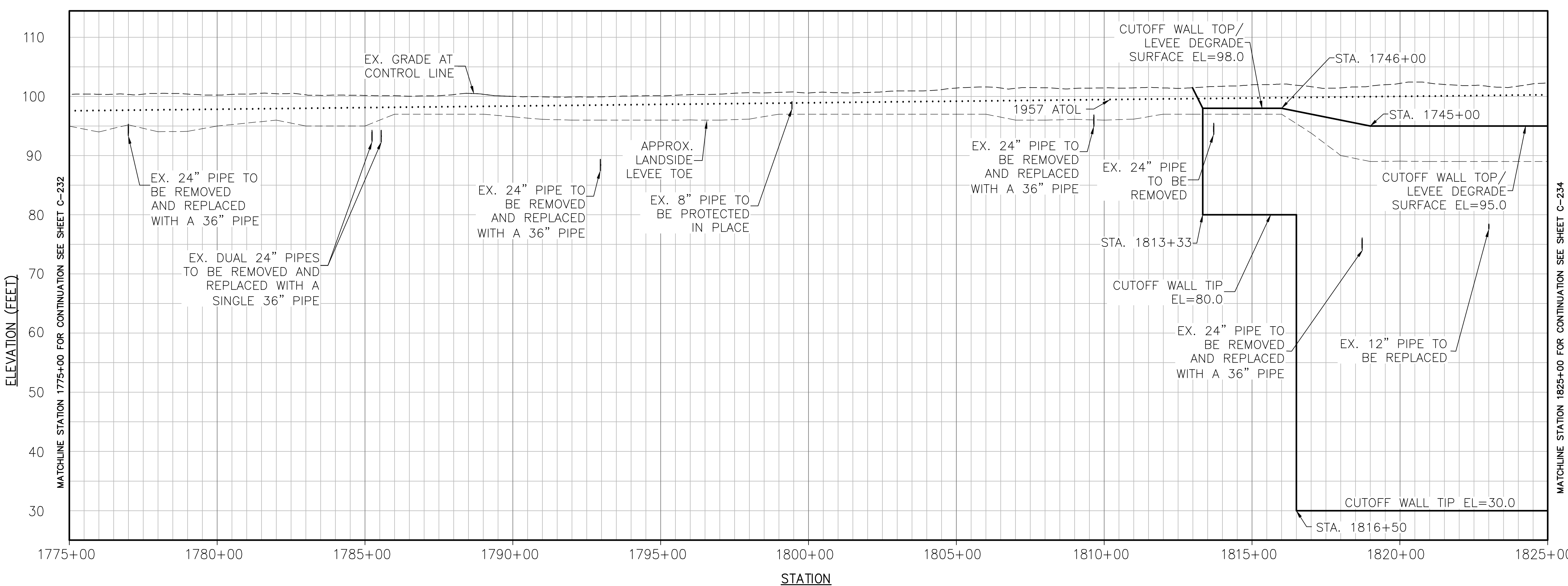

PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

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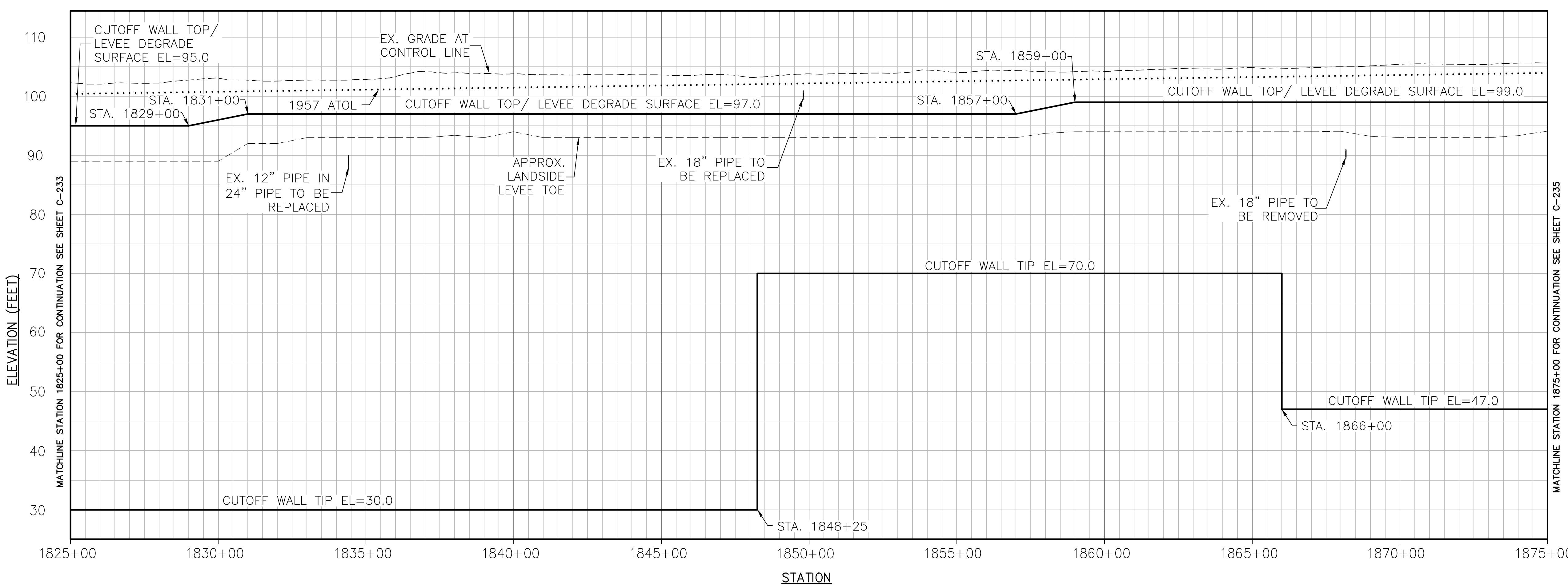
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1775+00 TO 1825+00

Sheet reference number:
C-233

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

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SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
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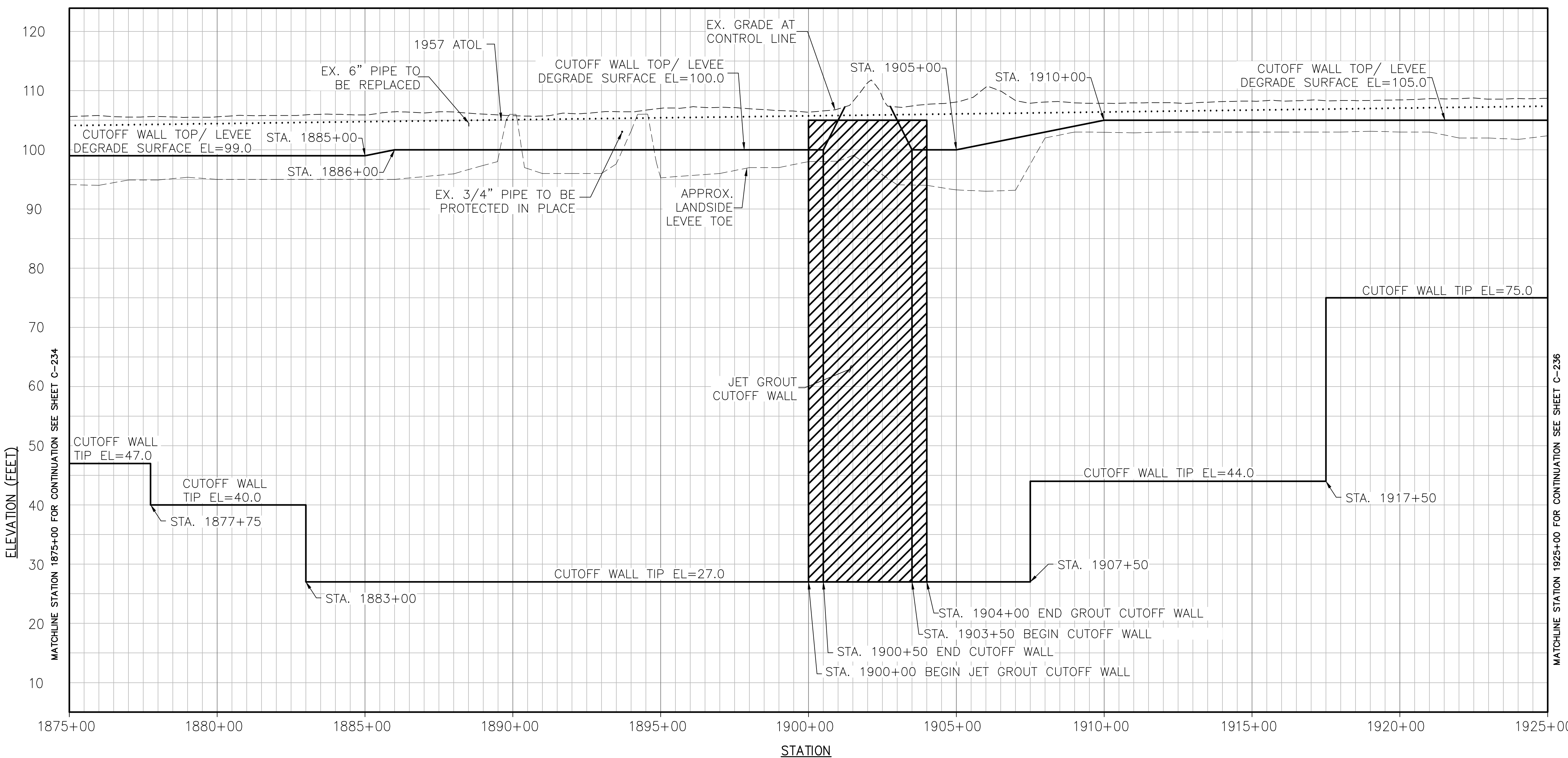
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1825+00 TO 1875+00

Sheet reference number:
C-234

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

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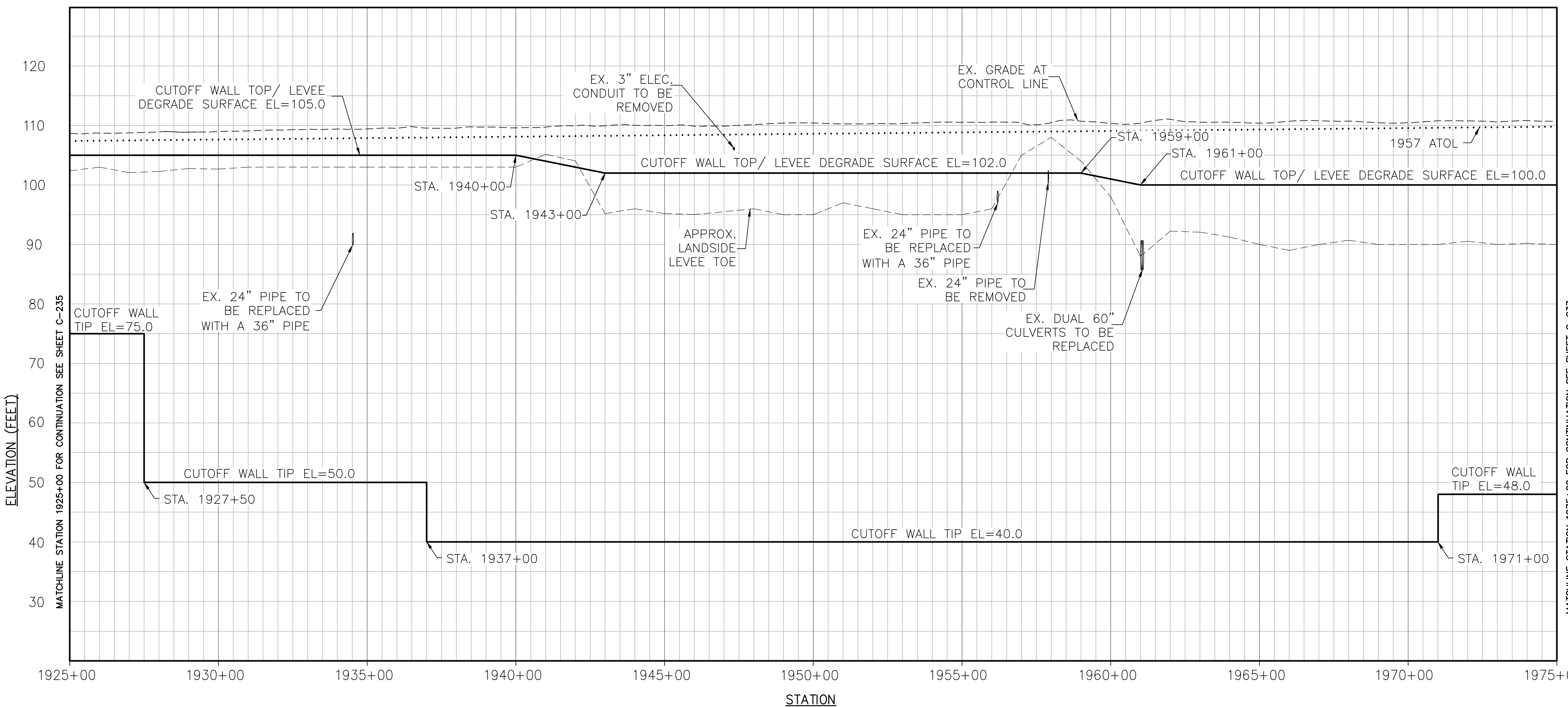
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1875+00 TO 1925+00

Sheet reference number:
C-235

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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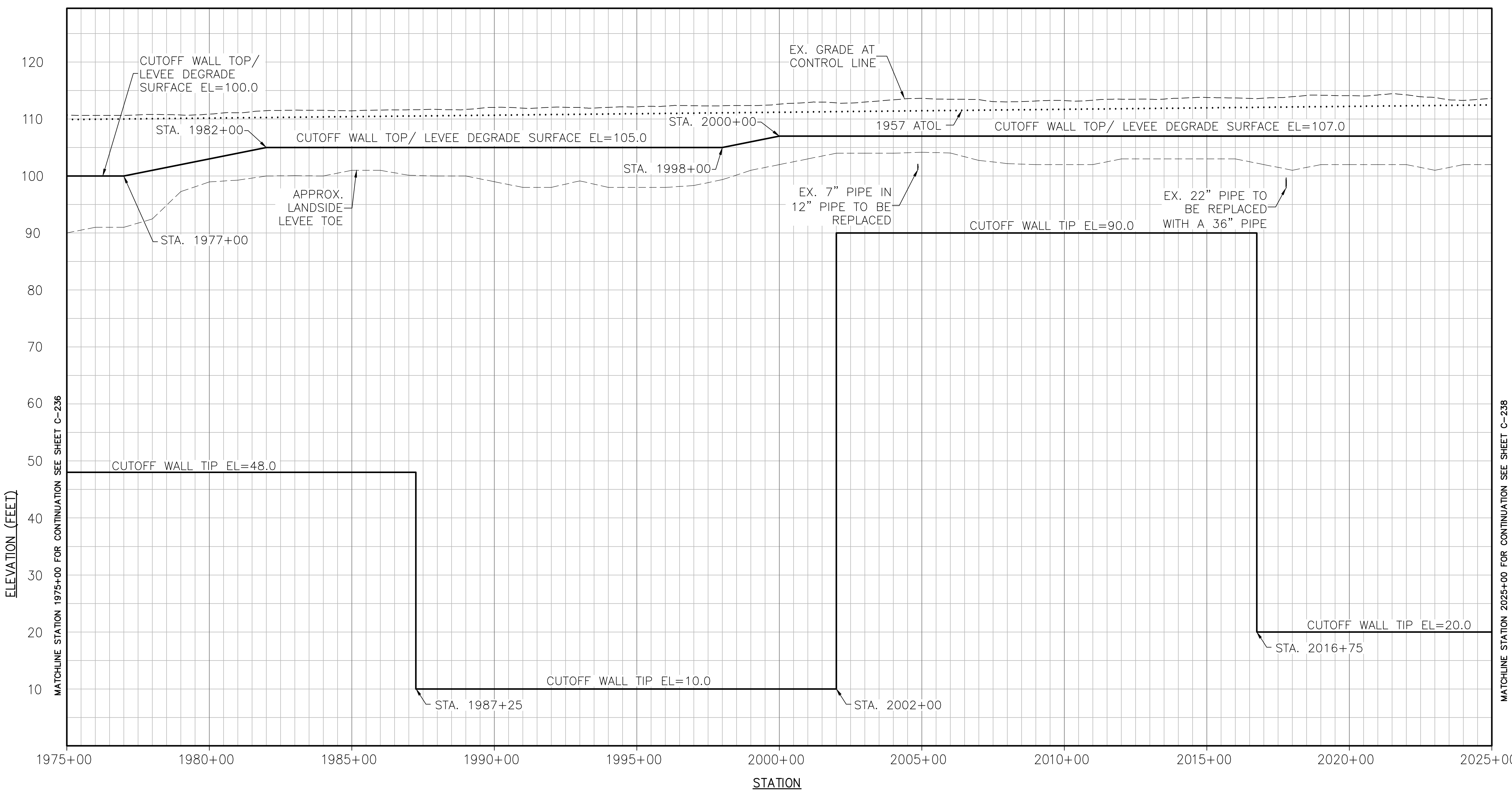
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1925+00 TO 1975+00

Sheet reference number:
C-236

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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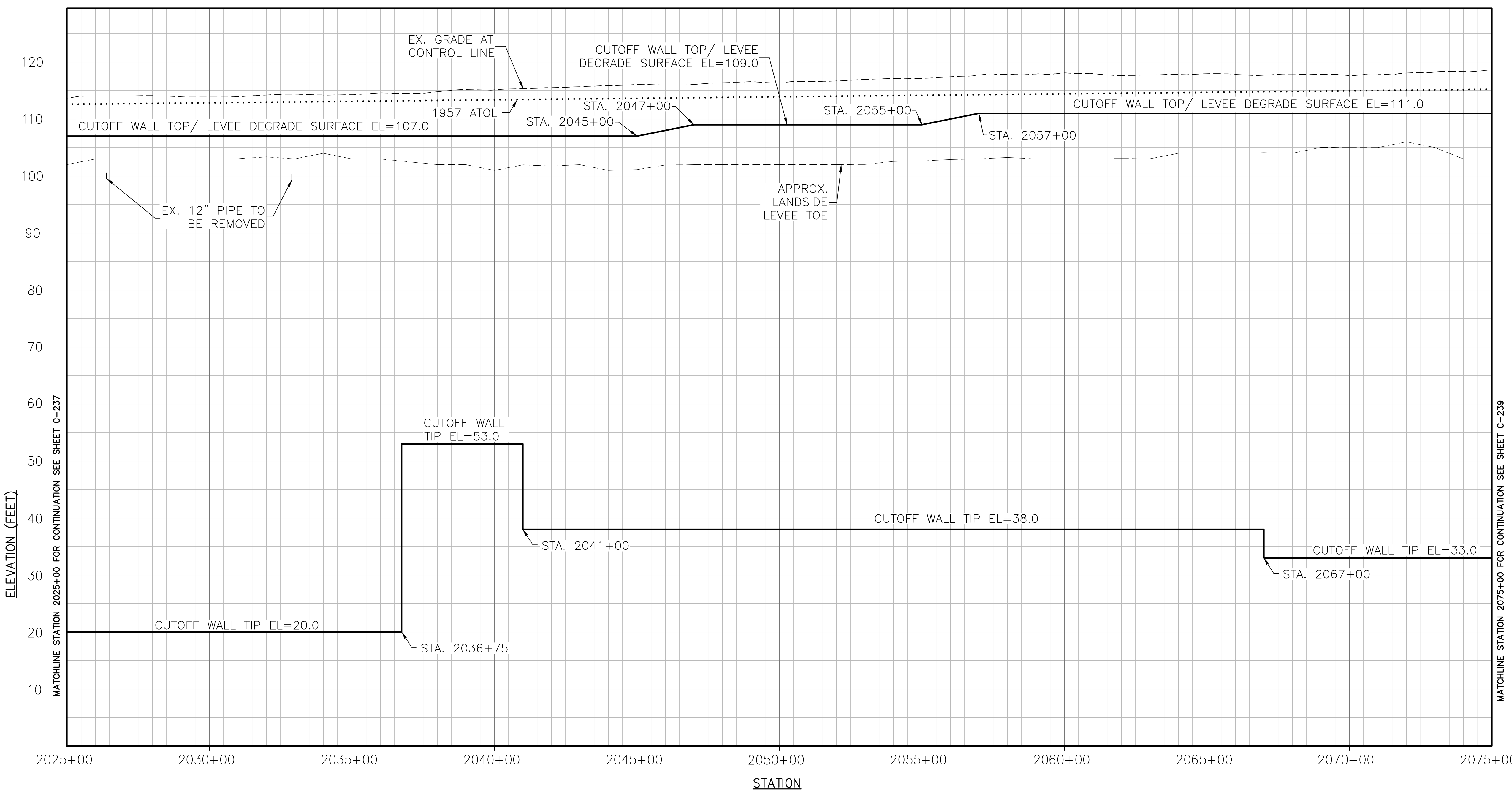
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1975+00 TO 2025+00

Sheet reference number:
C-237

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 2025+00 TO 2075+00

Sheet reference number:
C-238

VERTICAL DATUM

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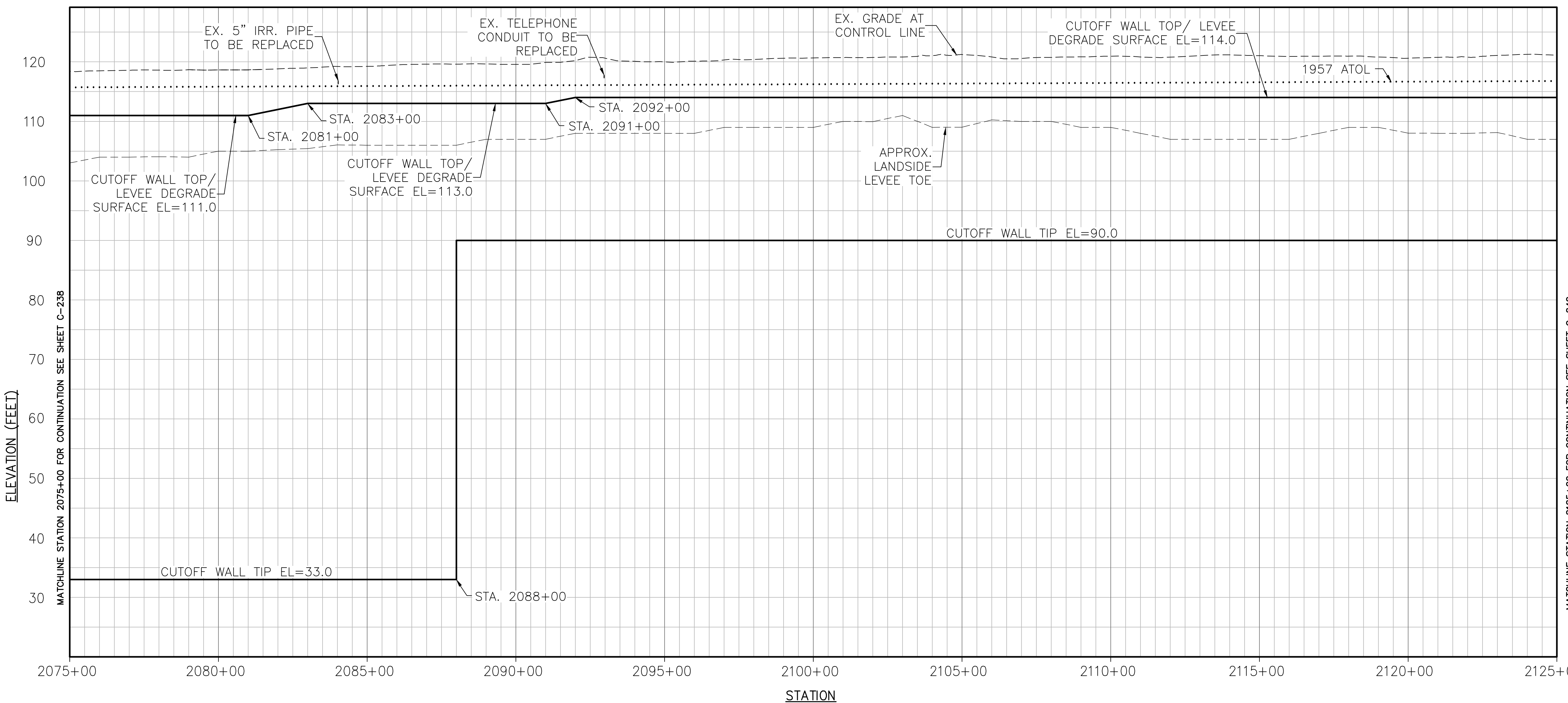

PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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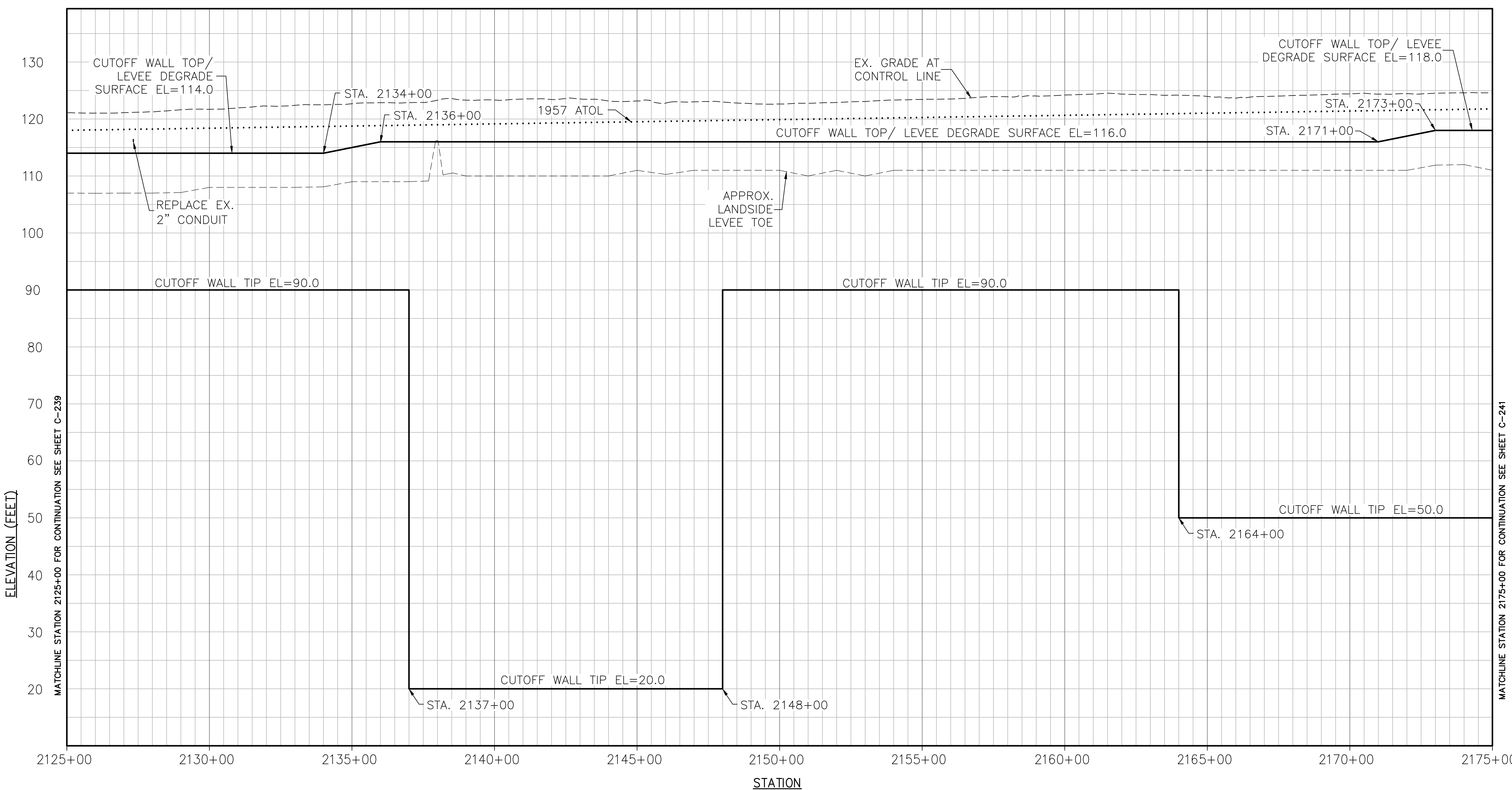
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 2075+00 TO 2125+00

Sheet reference number:
C-239

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 2125+00 TO 2175+00

Sheet reference number:
C-240

VERTICAL DATUM

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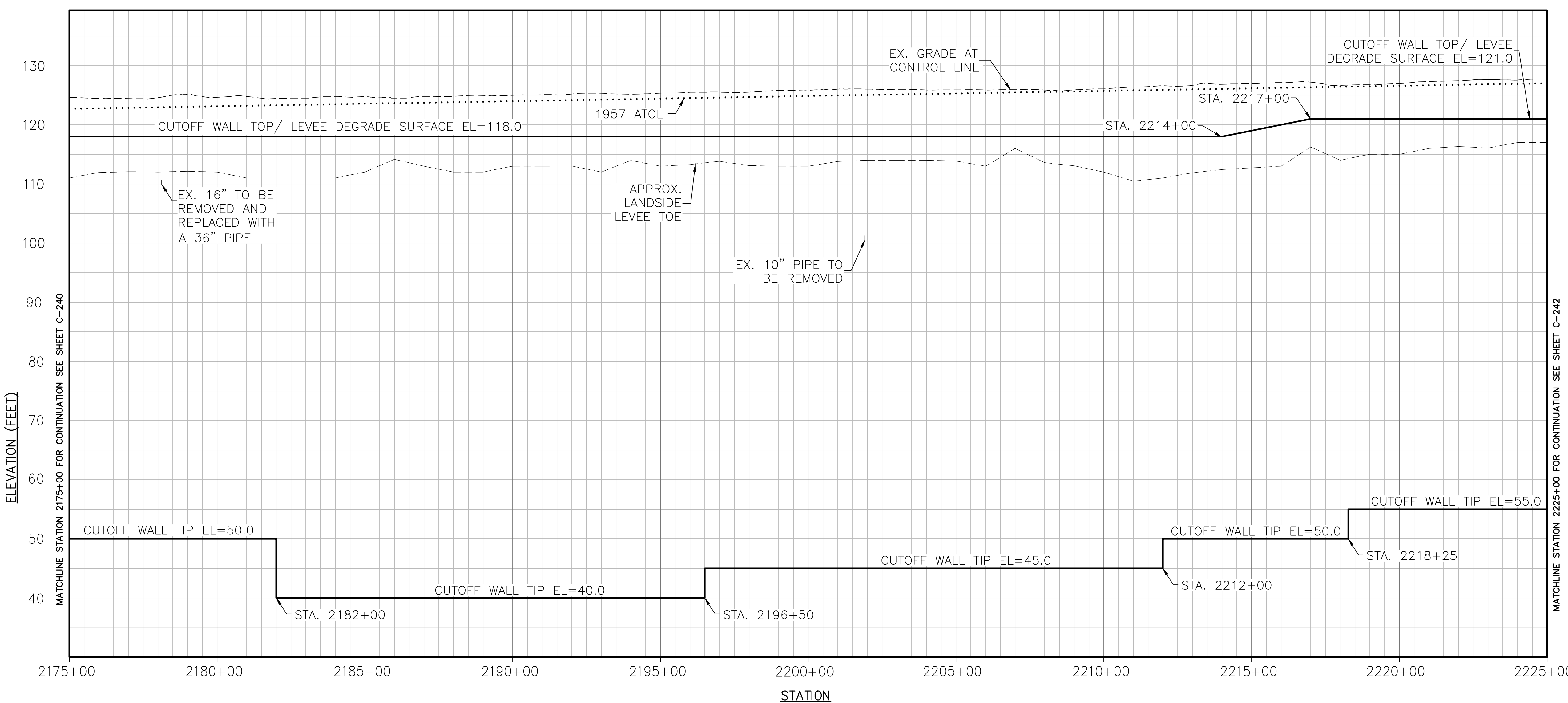

PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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ALTERNATIVE SB-8
PROFILE VIEW
STA 2175+00 TO 2225+00

Sheet reference number:
C-241

VERTICAL DATUM

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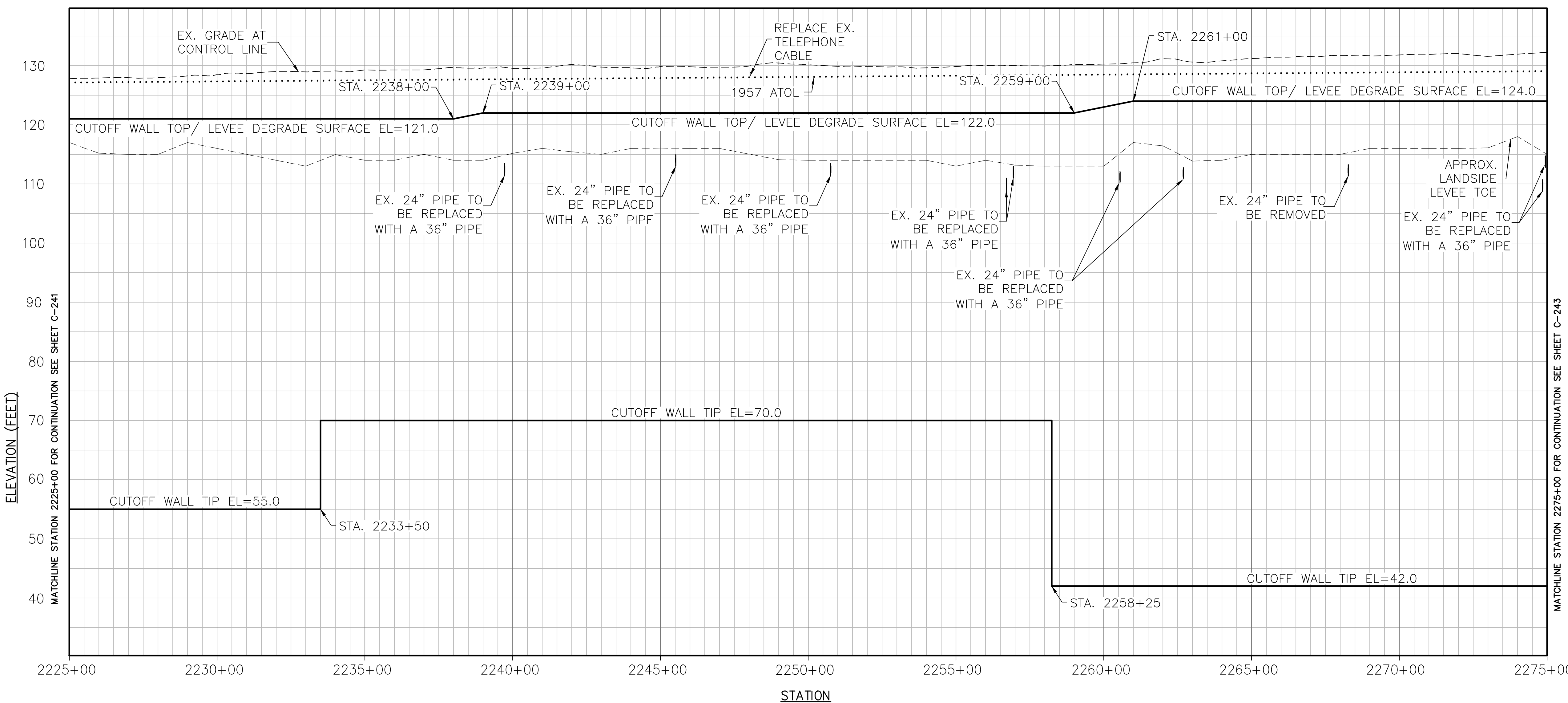

PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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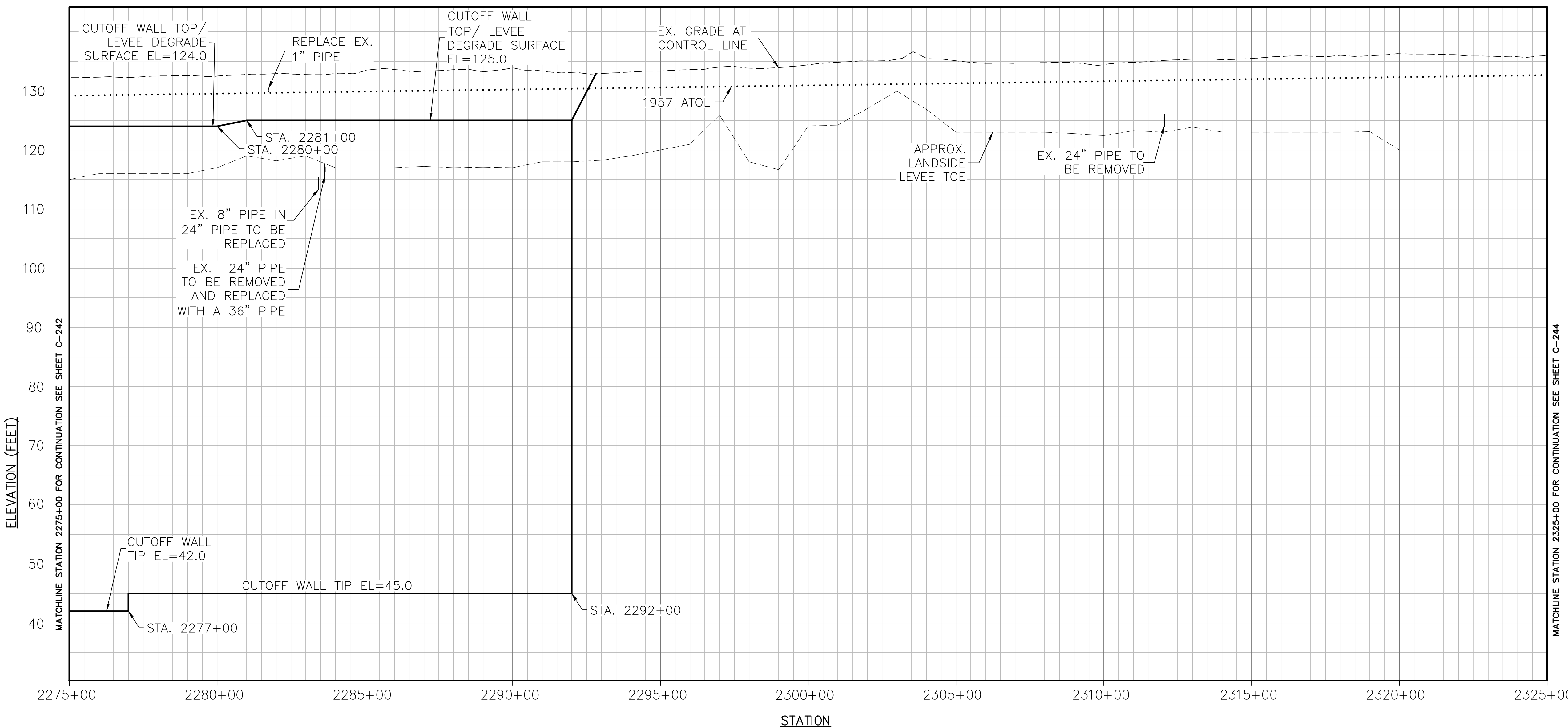
ALTERNATIVE SB-8
PROFILE VIEW
STA 2225+00 TO 2275+00

Sheet reference number:
C-242

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 2275+00 TO 2325+00

Sheet reference number:
C-243

VERTICAL DATUM

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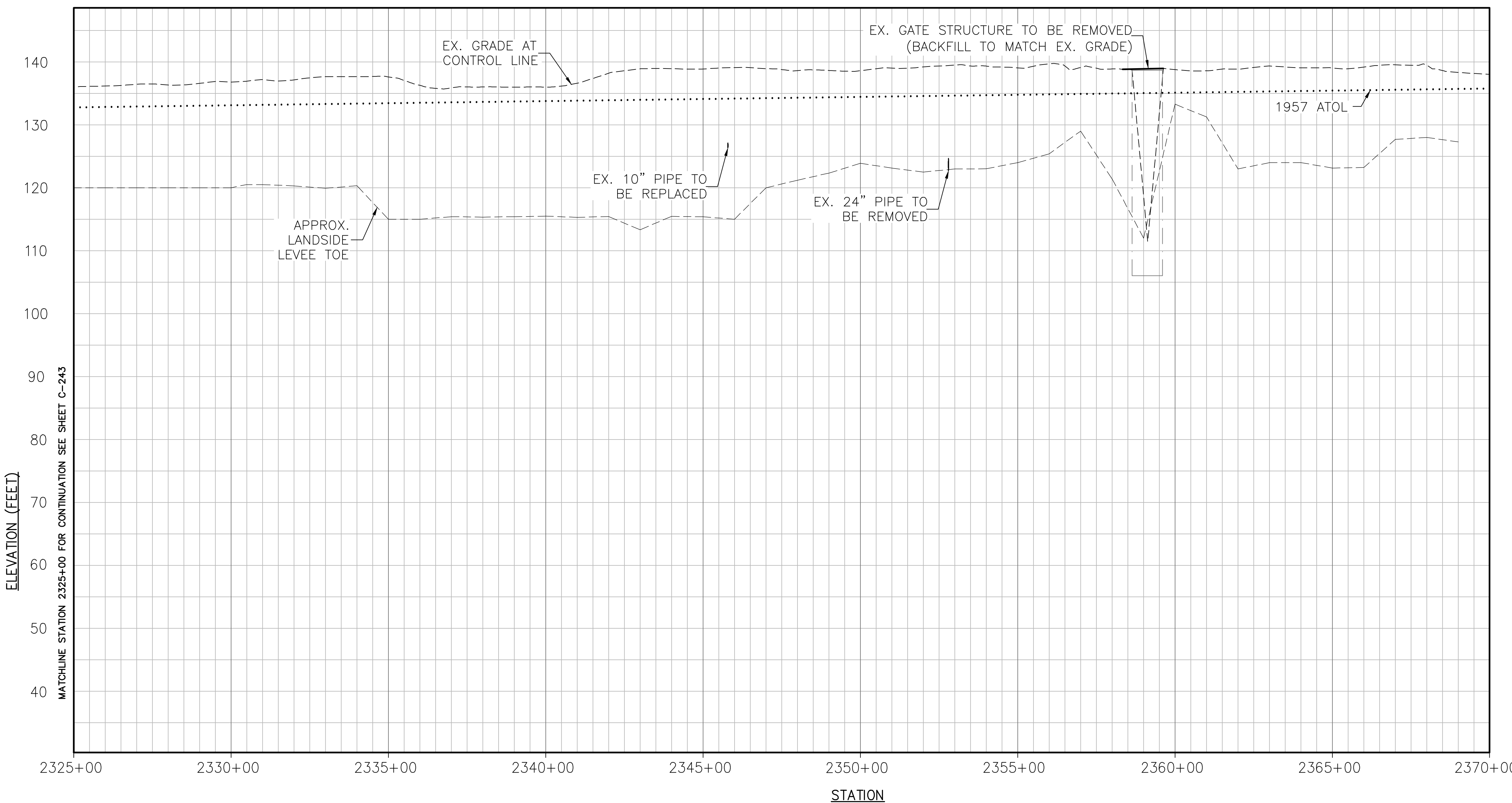

PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 2325+00 TO 2368+00

Sheet reference number:
C-244

VERTICAL DATUM

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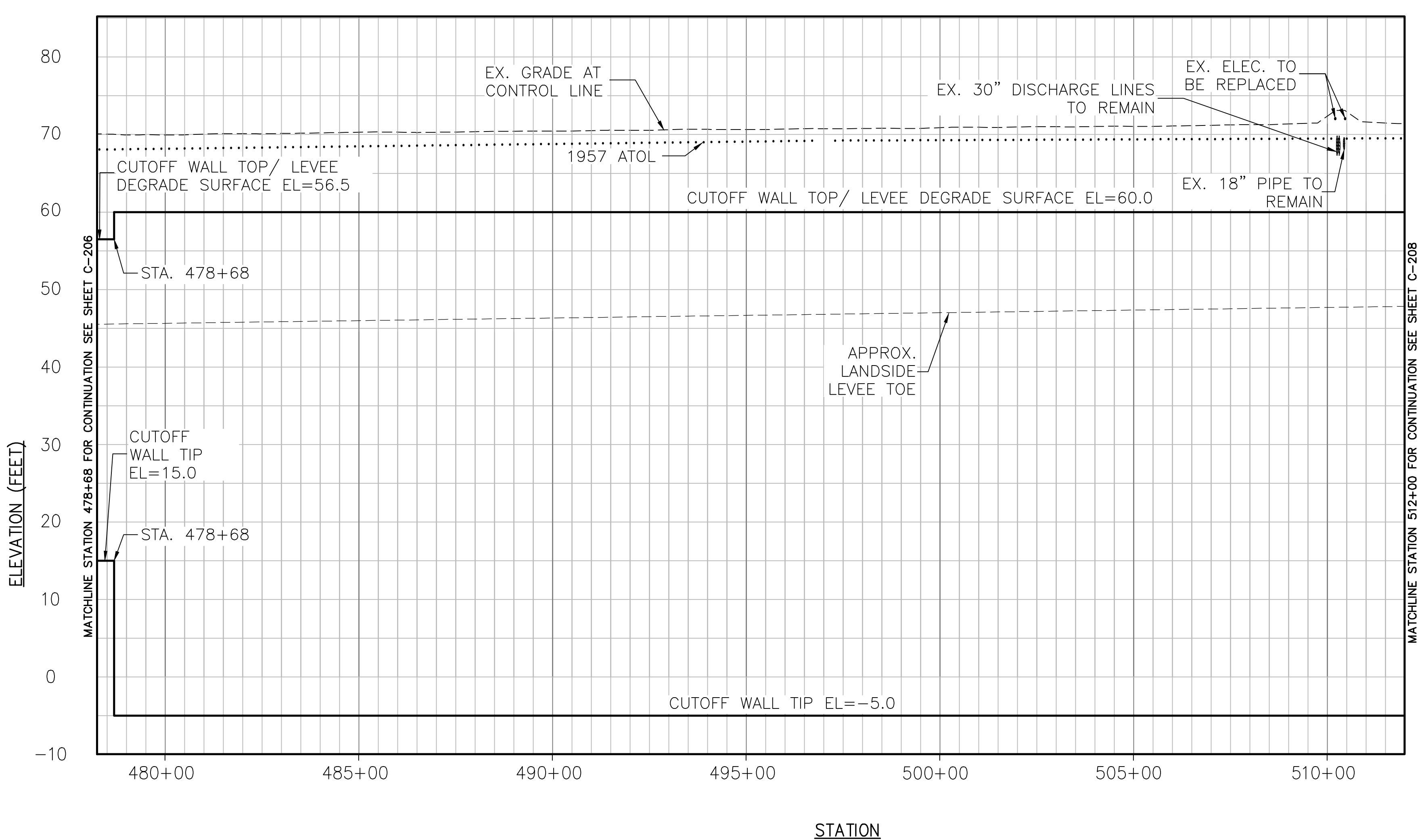

PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

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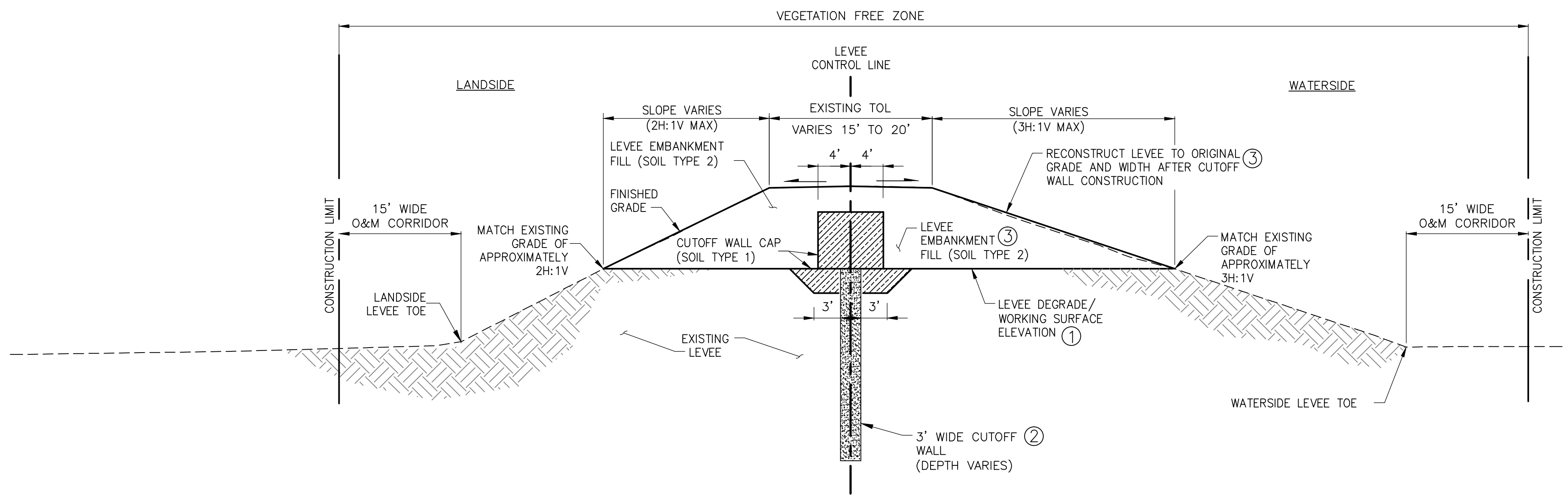
ALTERNATIVE SB-7 AND SB-8
STAR BEND SETBACK OPTION
PROFILE VIEW
STA. 478+68 to STA. 512+00

Sheet reference number:
C-245



TYPICAL CUTOFF WALL

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.

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DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT-CUTOFF WALL

Sheet reference number:
C-301

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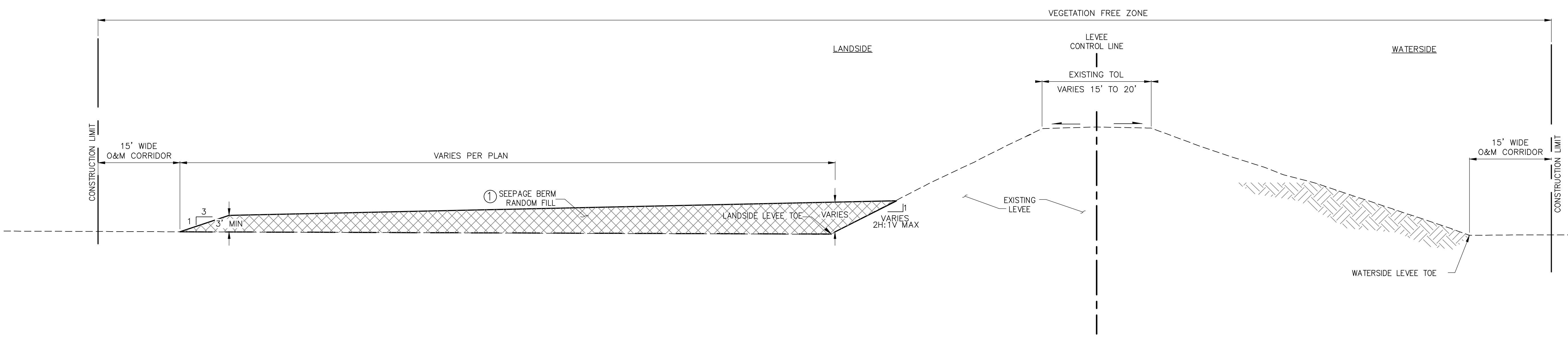

TYPICAL SEEPAGE BERM

SCALE: NONE

CONSTRUCTION SEQUENCE:

(1) INSTALL RANDOM FILL FOR SEEPAGE BERM

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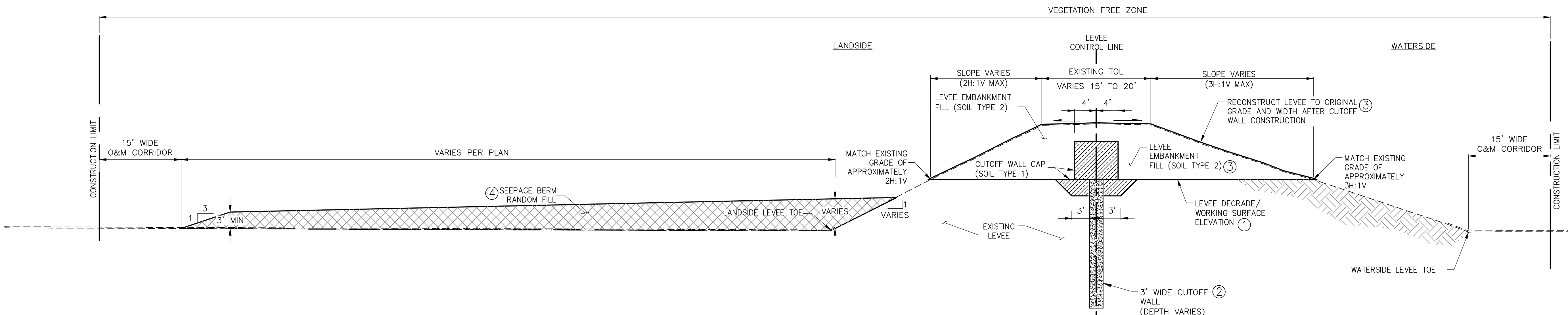
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT - SEEPAGE BERM

Sheet reference number:
C-302

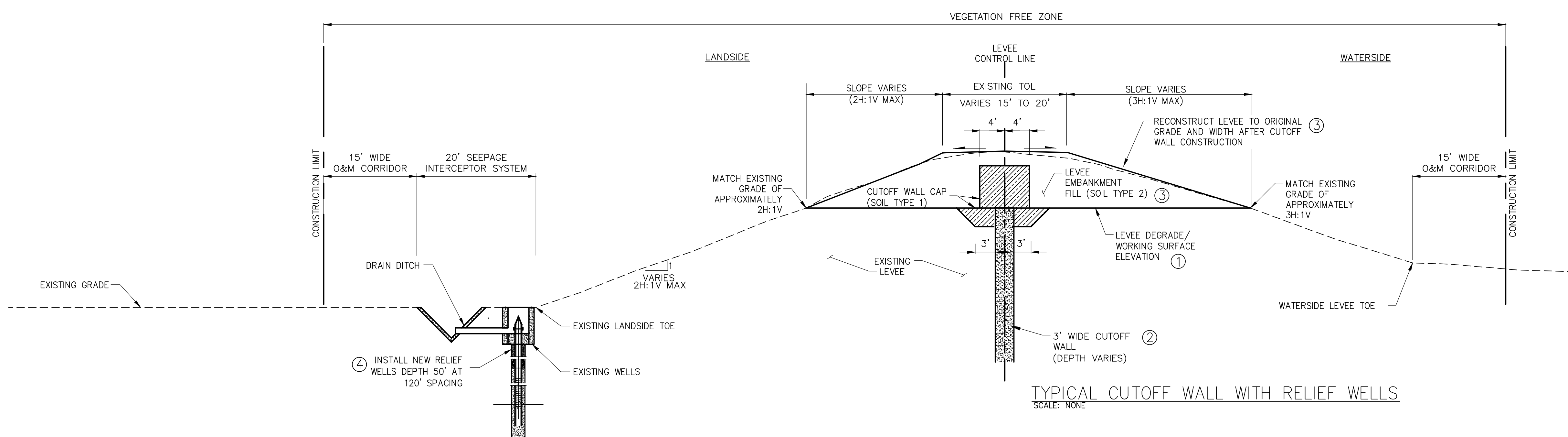


TYPICAL CUTOFF WALL WITH SEEPAGE BERM

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.
4. INSTALL RANDOM FILL FOR SEEPAGE BERM



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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Symbol	Description	Date	Approved
D8	DESCRIPTION8	DATE8	APPROVAL8
D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

Designed by: - | Dwn by: - | Spec No.: - | Reviewed by: - | Submitted by: - CHIEF, CIV ENGR DES SEC A | Date: - | Design file no: - | Drawing Code: - | Rev. - | File name: | Plot date: $$$$date$$$$ | Plot scale: -

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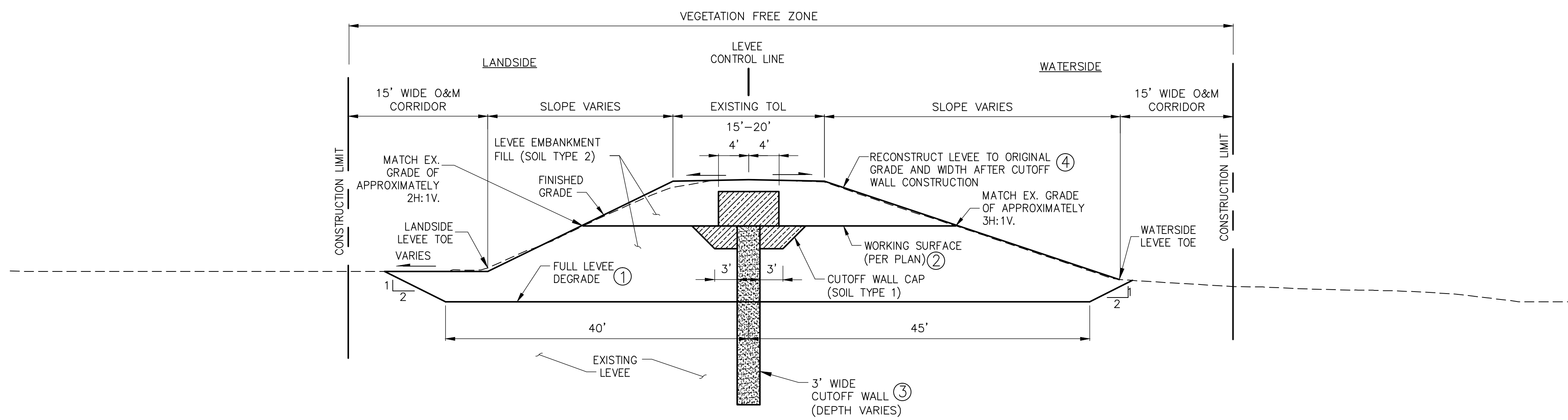
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT - CUTOFF WALL WITH SEEPAGE BERM OR RELIEF WELLS

Sheet reference number:
C-303

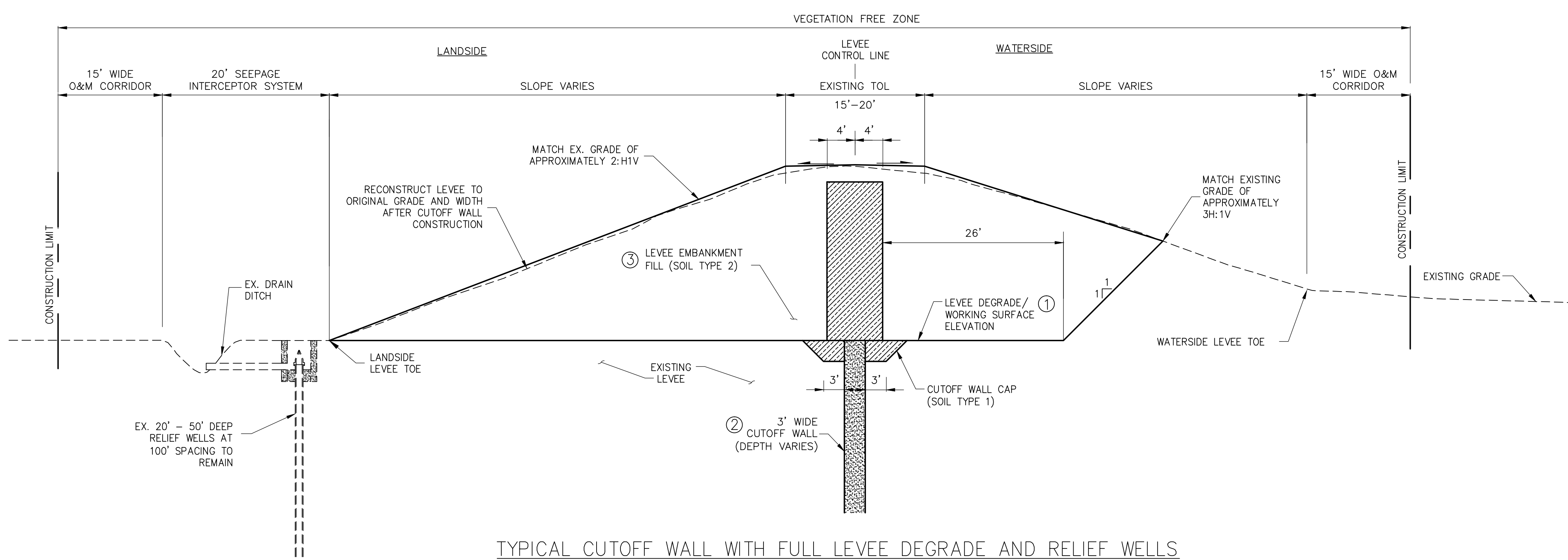


TYPICAL CUTOFF WALL WITH FULL LEVEE DEGRADE

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. FILL UP TO WORKING SURFACE ELEVATION
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.



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.

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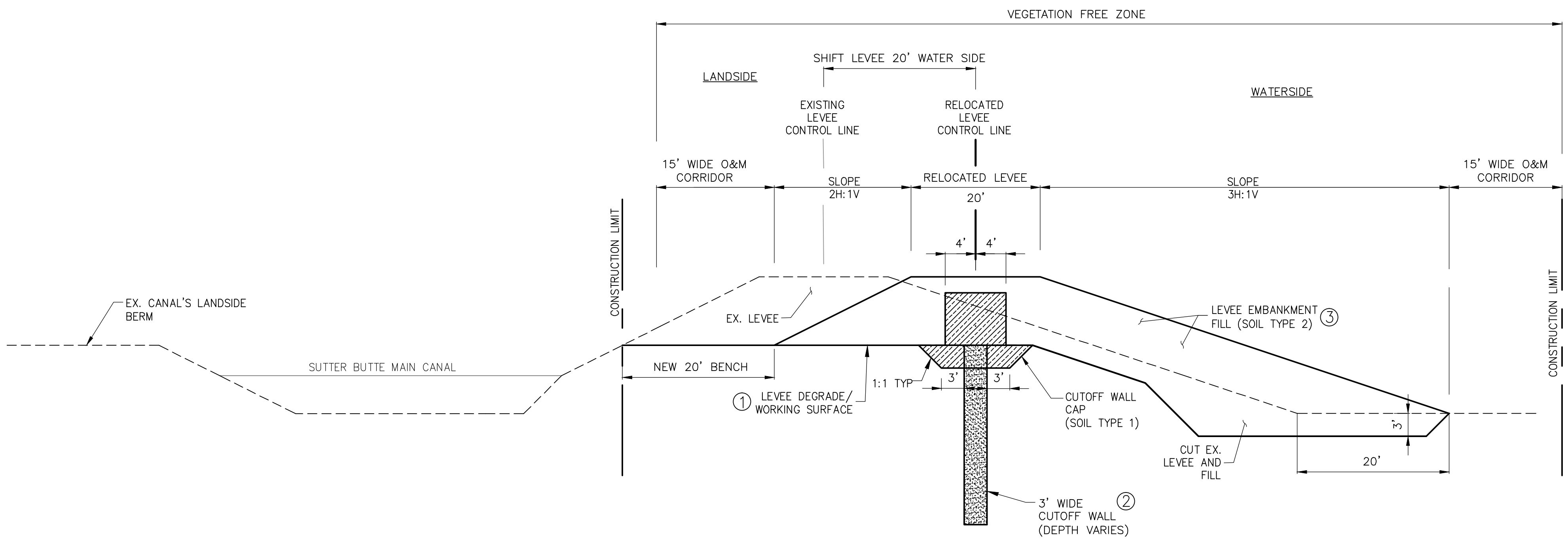
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH FULL LEVEE DEGRADE AND RELIEF WELLS

Sheet reference number:
C-304



TYPICAL CUTOFF WALL WITH LEVEE RELOCATION

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. CONSTRUCT RELOCATED LEVEE EMBANKMENT.

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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH LEVEE RELOCATION

Sheet reference number:
C-305

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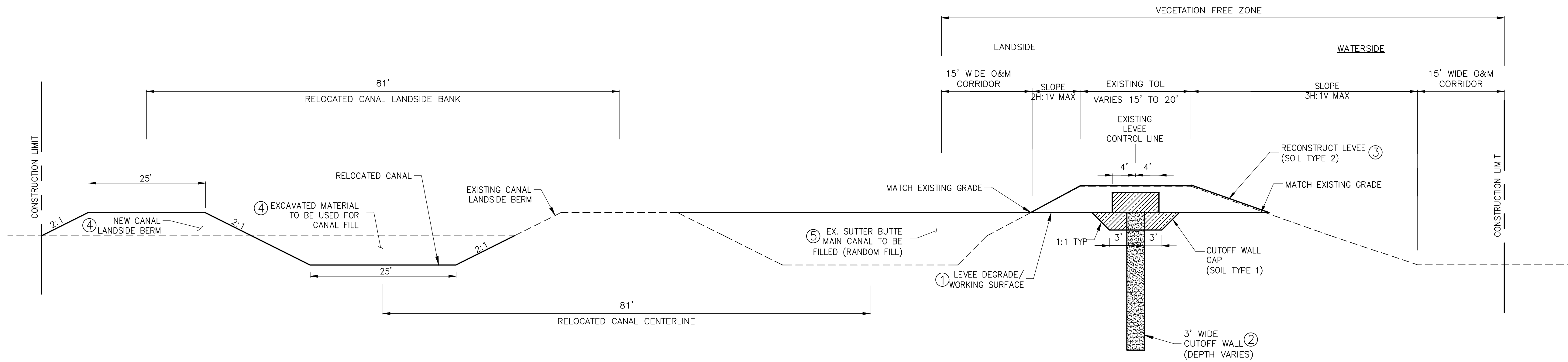

TYPICAL CUTOFF WALL WITH CANAL RELOCATION

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

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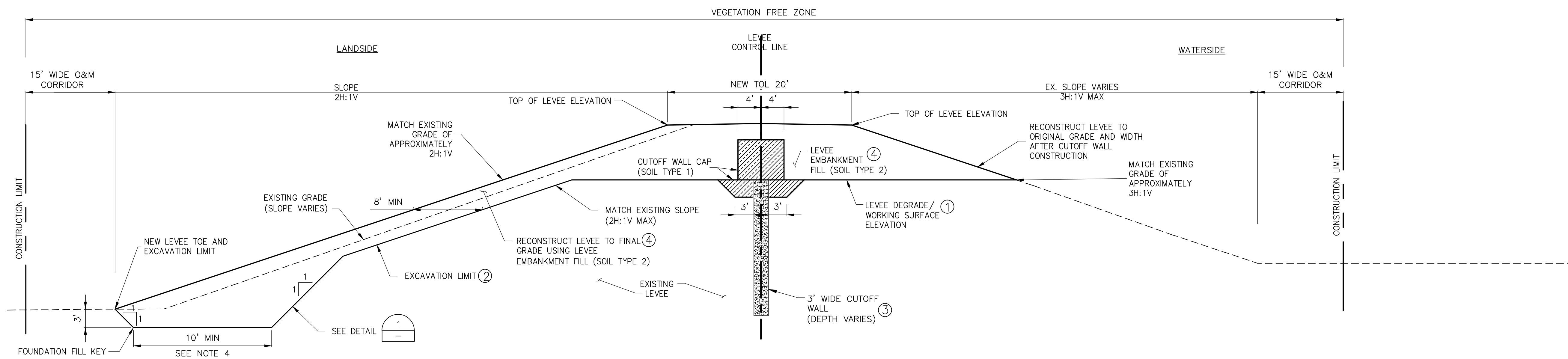
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT - CUTOFF WALL WITH CANAL RELOCATION

Sheet reference number:
C-306

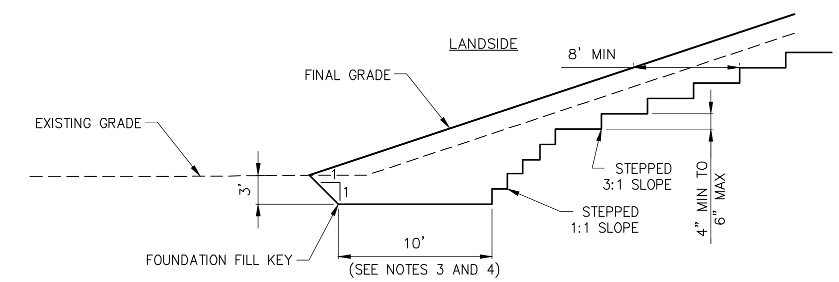


TYPICAL CUTOFF WALL WITH LANDSIDE TOE FILL

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE LANDSIDE OF EXISTING LEVEE.
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.



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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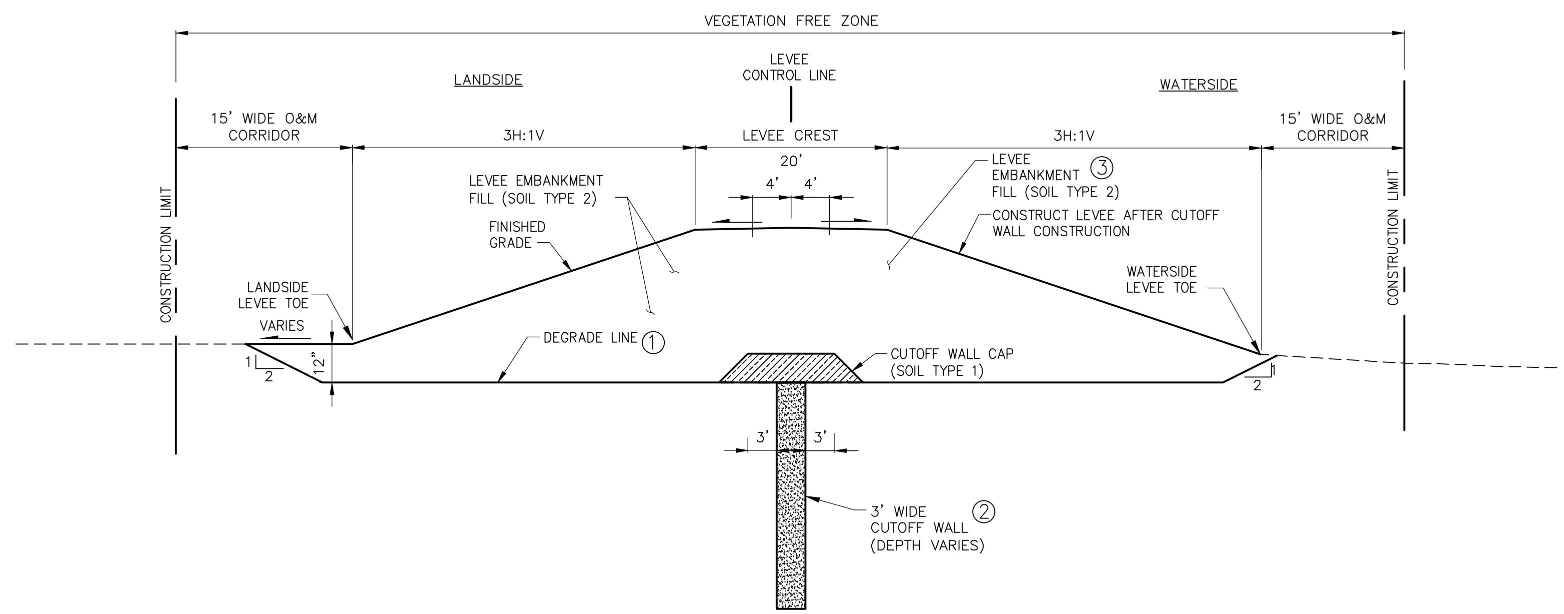
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT – TYPICAL CUTOFF WALL WITH LANDSIDE TOE FILL

Sheet reference number:

C-307



TYPICAL NEW LEVEE WITH CUTOFF WALL

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. EXCAVATE TO DEGRADE LINE
2. CONSTRUCT CUTOFF WALL.
3. CONSTRUCT LEVEE EMBANKMENT.

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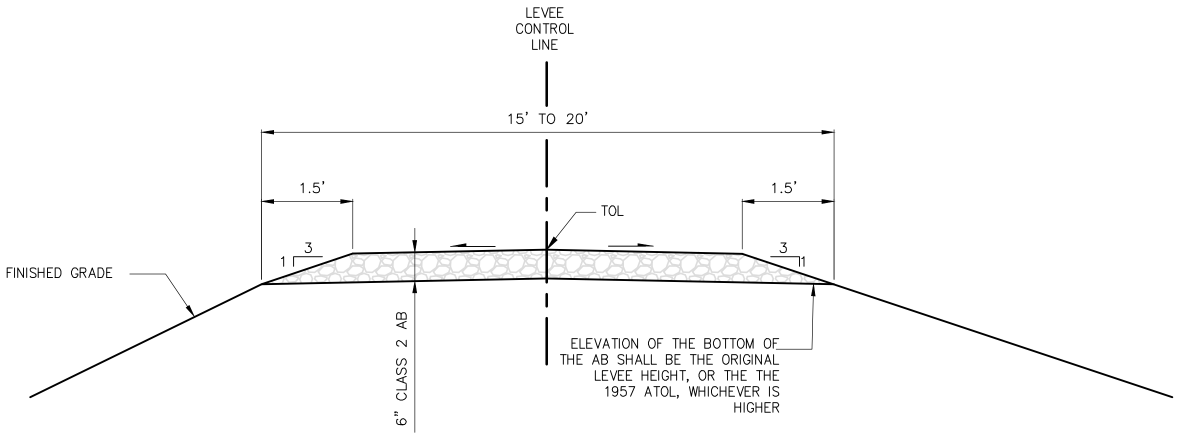
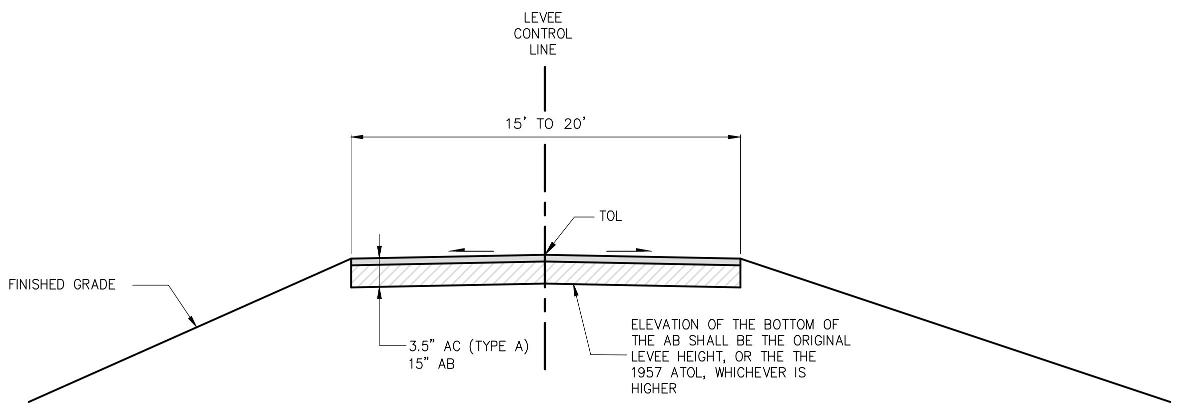
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT – NEW LEVEE WITH CUTOFF WALL

Sheet reference number:
C-308



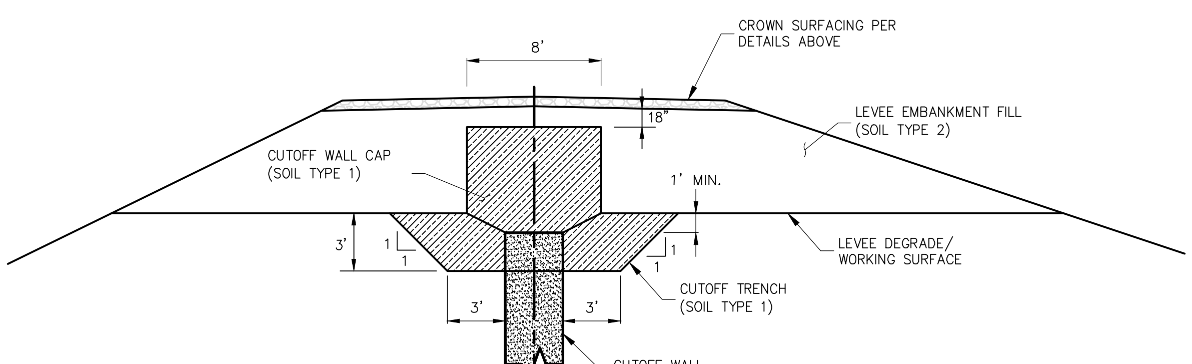
CROWN SURFACING DETAIL (TYP)

NTS



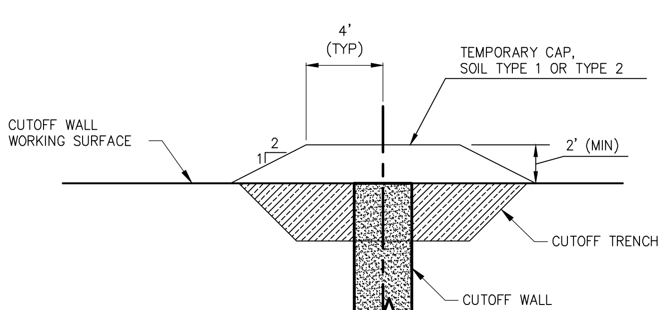
PAVED LEVEE ROAD SECTION

NTS



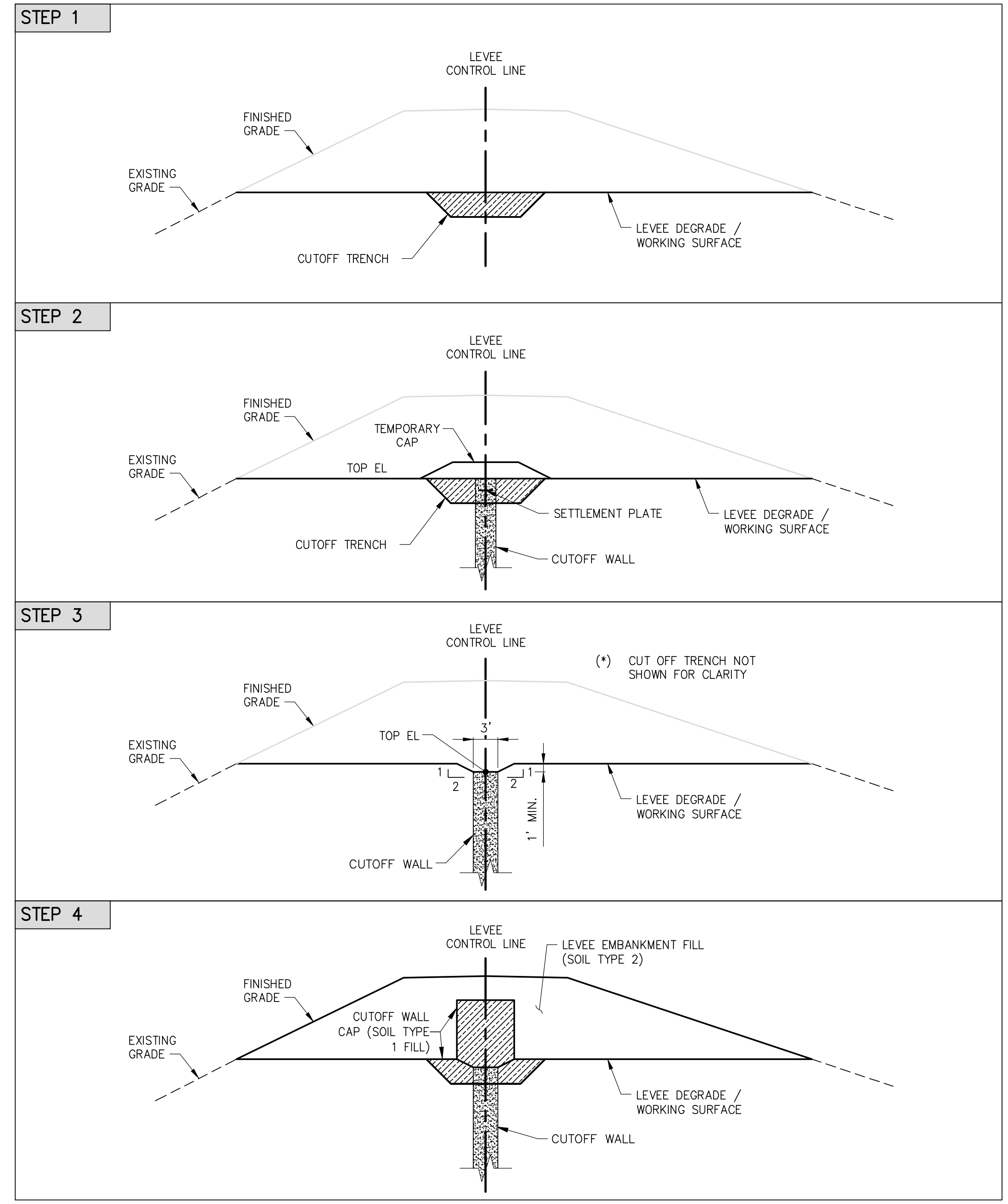
CUTOFF WALL CAP DETAIL

NTS



TEMPORARY CAP DETAIL

NTS



TYPICAL CUTOFF WALL CONSTRUCTION SEQUENCE

NTS

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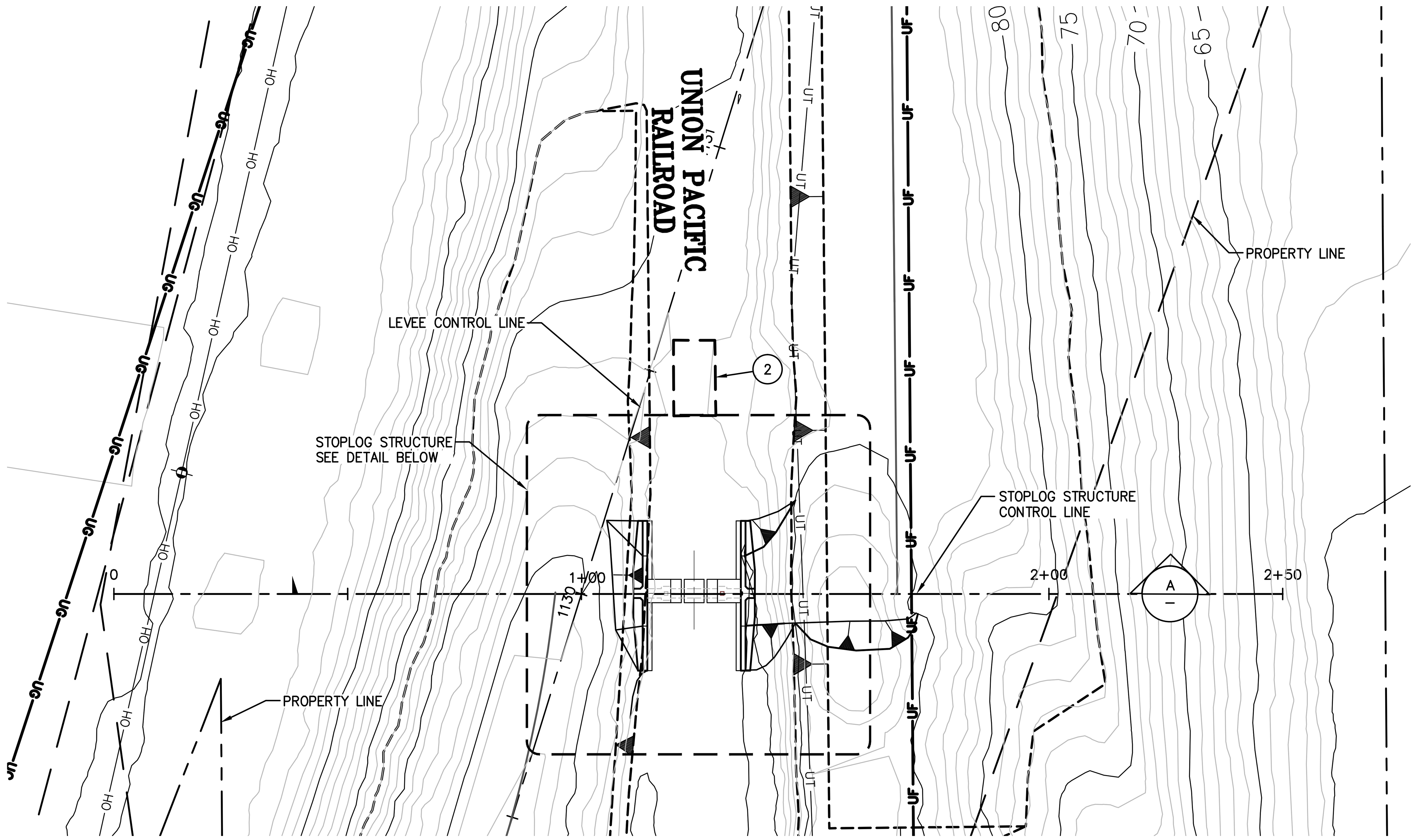
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT – MISC. DETAILS

Sheet reference number:
C-309

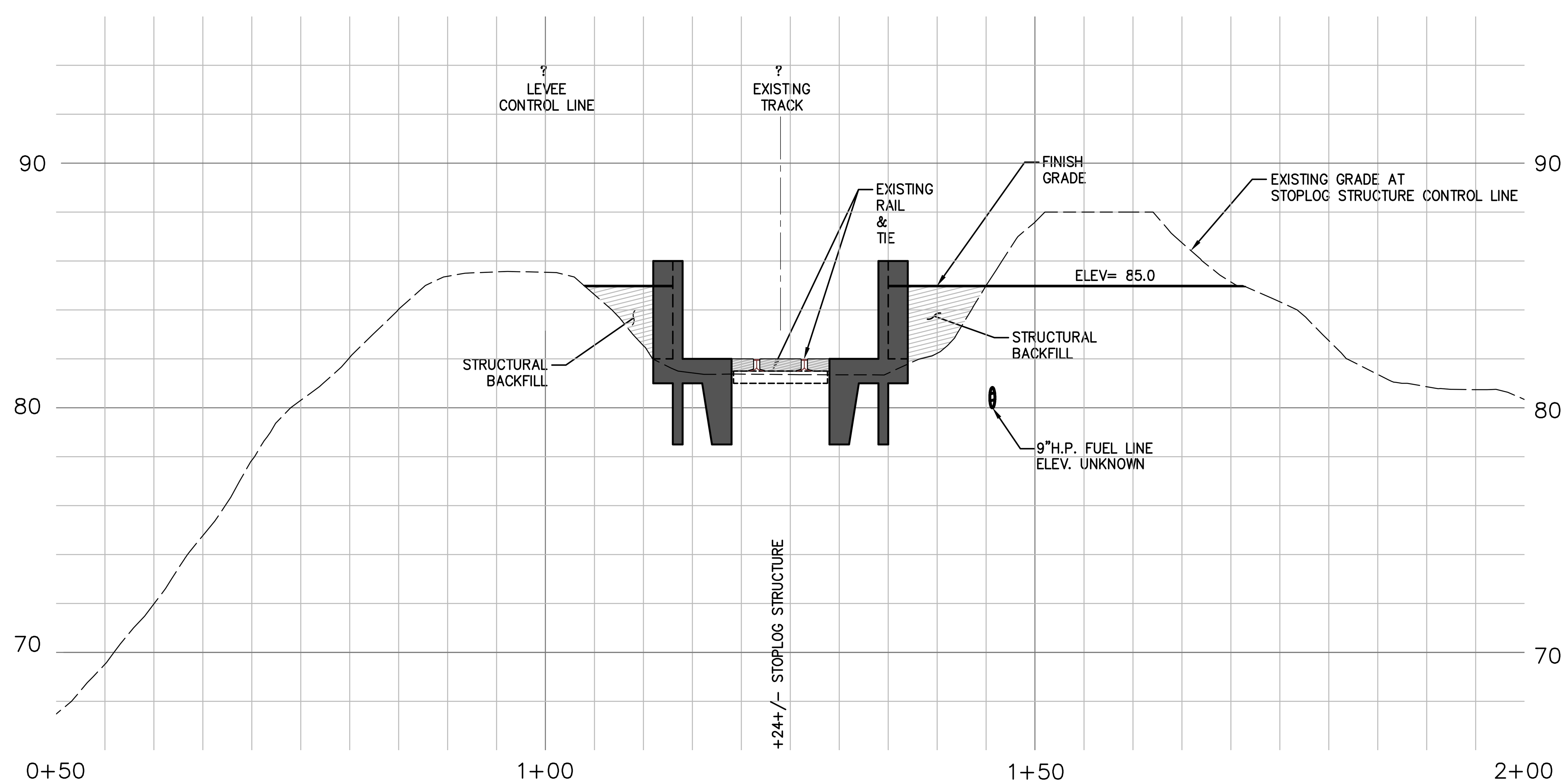
CONSTRUCTION NOTES:

1. CUTOFF WALL AND LEVEE DEGRADE NOT SHOWN, SEE DWG C-314 FOR WALL LOCATION AND LEVEE EXCAVATIONS.
2. EXISTING CONCRETE PANELS TO REMAIN.



STOPLOG STRUCTURE – PLAN

SCALE: 1"= 20'



STOPLOG STRUCTURE – ELEVATION

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ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT – STOP LOG STRUCTURE

Sheet reference number:
C-310

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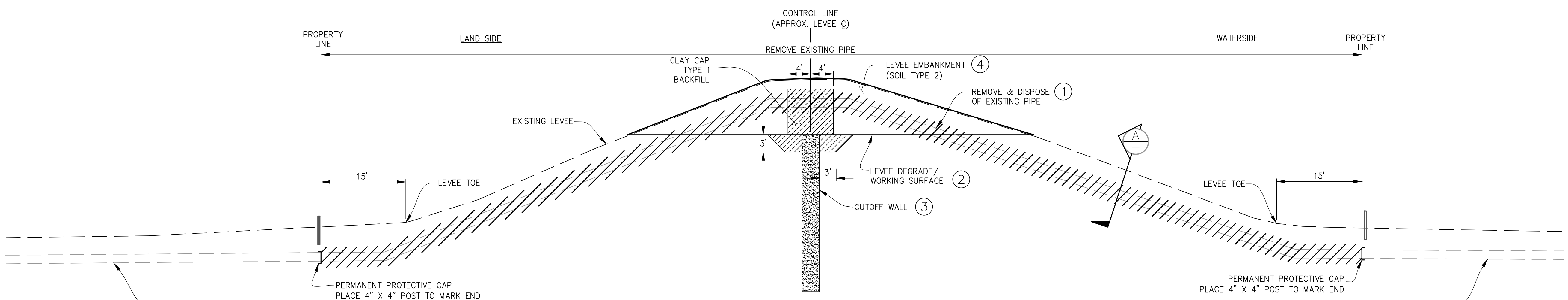
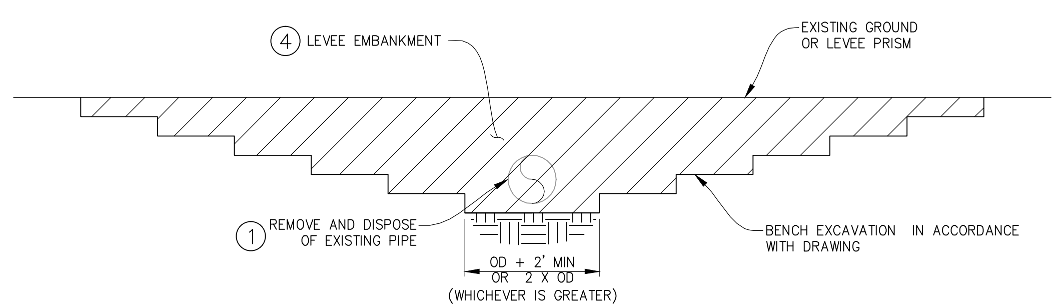


TYPICAL REMOVAL & DISPOSAL OF ABANDONED RAISED PIPE (TYPE 1A)

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

SCHEDULE OF RAISED PIPE REMOVALS		
EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH
219+00	12 IN	UNKNOWN
365+00	8 IN	4.8 FT
386+63	8 IN	4.6 FT
396+32	8 IN	4.1 FT
442+80	8 IN	4.1 FT
460+11	8 IN	4.1 FT
529+47	6 IN	4.0 FT
536+64	5 IN	2.0 FT
545+41	8 IN	3.1 FT
856+23	24 IN	5.2 FT
881+39	6 IN	5.1 FT
881+43	14 IN	5.1 FT
988+05	3 IN	UNKNOWN
1020+85	4 IN	UNKNOWN
1037+50	8 IN	UNKNOWN
1180+50	12 IN	UNKNOWN
1180+98	3 IN	UNKNOWN
1181+50	8 IN	UNKNOWN
1524+35	6 IN	UNKNOWN
1532+40	6 IN	UNKNOWN
1888+50	6 IN	5.2 FT
1893+60	1 IN	UNKNOWN

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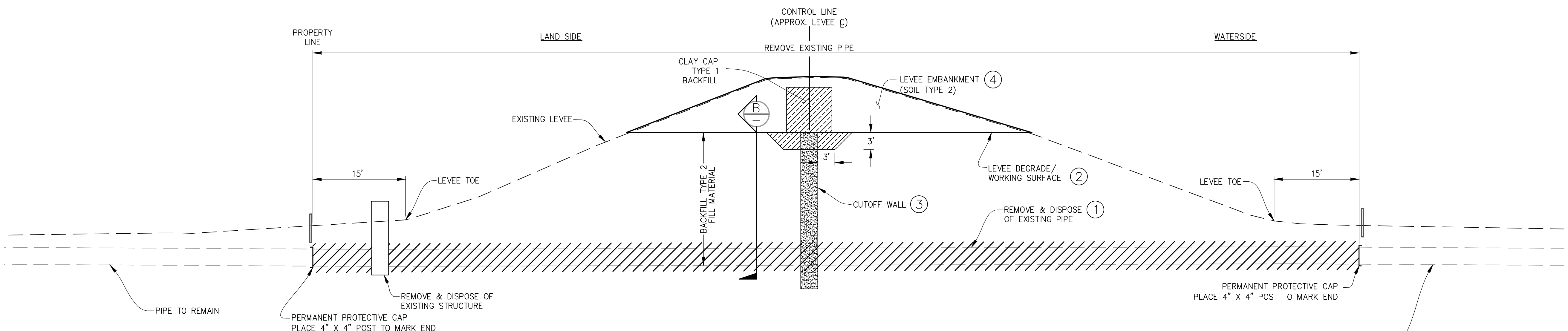
ALTERNATIVE SB-7 AND SB-8
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND DISPOSAL OF ABANDONED RAISED PIPE

Sheet reference number:
C-401

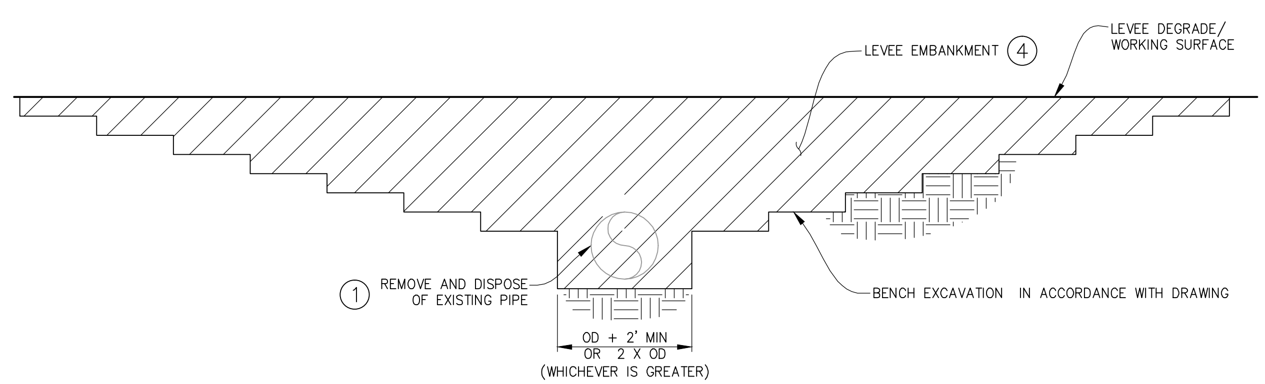


TYPICAL REMOVAL & DISPOSAL OF ABANDONED THROUGH PIPE (TYPE 1B)

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

SCHEDULE OF THROUGH PIPE REMOVALS		
EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH
298+89	36 IN	UNKNOWN
407+72	8 IN	21.8 FT
1043+52	27 IN	38.6 FT
1556+22	8 IN	UNKNOWN
1585+05	12 IN	UNKNOWN
1785+55	24 IN	UNKNOWN
1813+70	24 IN	UNKNOWN
1868+17	18 IN	UNKNOWN
2026+40	12 IN	13.5 FT
2032+90	12 IN	14.0 FT
2201+87	10 IN	13.1 FT
2268+27	24 IN	18.4 FT
2312+05	24 IN	UNKNOWN
2352+80	24 IN	UNKNOWN

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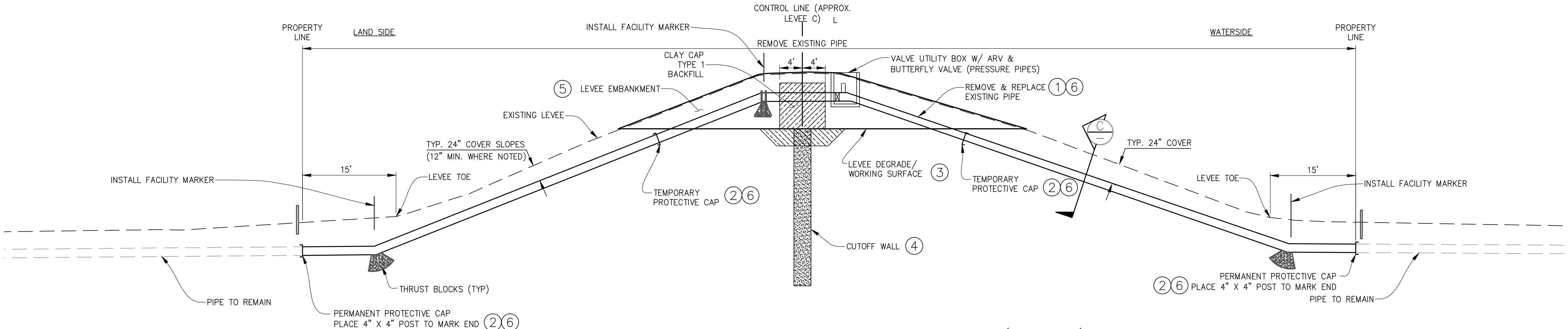
ALTERNATIVE SB-7 AND SB-8
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND DISPOSAL OF ABANDONED THROUGH PIPE

Sheet reference number:
C-402



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

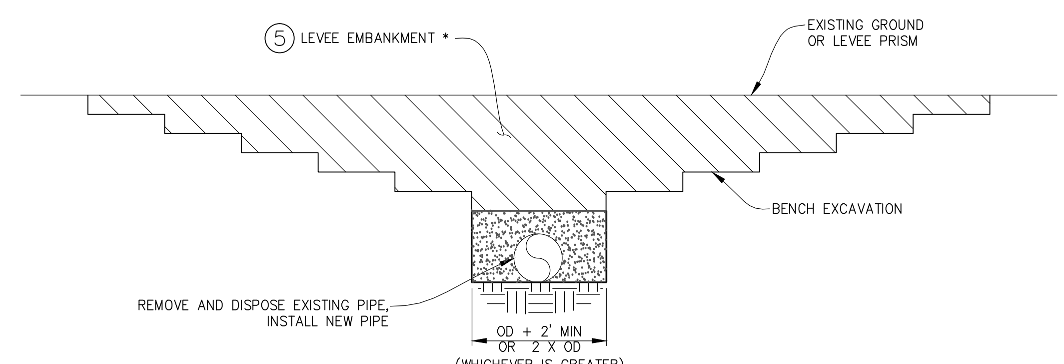
NOTE: THE BOTTOM OF THE NEW PIPE SHALL BE ABOVE THE FREEBOARD ELEVATION AT THE LEVEE CROWN

SCHEDULE OF RAISED PIPE REPLACEMENTS

EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH	NEW PIPE DIA.
209+23	14 IN	3.0 FT	14 IN
409+50	18 IN	1.7 FT	18 IN
409+55	14 IN	1.4 FT	14 IN
409+58	18 IN	0.8 FT	18 IN
409+62	18 IN	0.8 FT	18 IN
409+66	18 IN	0.8 FT	18 IN
409+84	2 IN	2.0 FT	2 IN
512+06	2–15 IN	3.8 FT	2–15 IN
647+61	26 IN	1.4 FT	26 IN
647+66	26 IN	1.4 FT	26 IN
647+70	26 IN	1.4 FT	26 IN
647+74	26 IN	1.6 FT	26 IN
664+07	8 IN	3.6 FT	8 IN
689+09	18 IN	27.6 FT	16 IN
828+55	24 IN	2.3 FT	
831+10			2–24 IN
856+08	24 IN	5.2 FT	24 IN
893+78	12 IN	3.3 FT	12 IN
893+84	16 IN	2.7 FT	16 IN
894+23	CABLE	UNKNOWN	CABLE
913+19	2–12 IN	3.0 FT	2–12 IN
972+00	2 IN	UNKNOWN	2 IN
1028+10	CABLE	UNKNOWN	CABLE
1029+10	CABLE	UNKNOWN	CABLE
1043+03	16 IN	1.3 FT	16 IN

SCHEDULE OF RAISED PIPE REPLACEMENTS

EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH	NEW PIPE DIA.
1043+22	24 IN	4.0 FT	24 IN
1043+27	24 IN	2.0 FT	24 IN
1043+45	36 IN	5.0 FT	36 IN
1073+41	12 IN	UNKNOWN	12 IN
1079+91	8 IN	UNKNOWN	8 IN
1096+50	48 IN	N/A	48 IN
1096+62	42 IN	2.5 FT	42 IN
1096+71	24 IN	4.7 FT	24 IN
1096+81	28 IN	5.0 FT	30 IN
1111+46	16 IN	1.1 FT	16 IN
1127+48	10 IN	2.0 FT	10 IN
1131+82	CABLE	UNKNOWN	CABLE
1132+09	9 IN	UNKNOWN	9 IN
1135+31	16 IN	UNKNOWN	16 IN
1229+41	16 IN	3.0 FT	16 IN
1265+29	18 IN	UNKNOWN	18 IN
1314+80	20 IN	1.4 FT	20 IN
1347+00	CABLE	UNKNOWN	CABLE
1430+40	36 IN	15.6 FT	36 IN
1430+48	60 IN	15.6 FT	60 IN
1430+56	60 IN	15.6 FT	60 IN
1823+01	12 /24 IN	21.8 FT	12 IN
1834+42	12 /24 IN	15.4 FT	12 IN
1849+80	18 IN	2.8 FT	18 IN
2004+86	7 IN	14.0 FT	7 IN
2084+03	5 IN	14.0 FT	5 IN
2092+90	CABLE	UNKNOWN	CABLE
2127+33	2 IN	2.0 FT	2 IN
2248+30	CABLE	UNKNOWN	CABLE
2283+44	1 IN	UNKNOWN	1 IN
2283+44	8 /24IN	17.3 FT	8 IN
2345+79	10 IN	12.7 FT	10 IN



SECTION C

SCALE: NONE

*NEW CUTOFF WALL CAP SHALL BE INSTALLED, WHERE EXCAVATED, FOUR (4) FEET BOTH SIDES FOR WALL.

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TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF RAISED PIPE

Sheet reference number:
C-403

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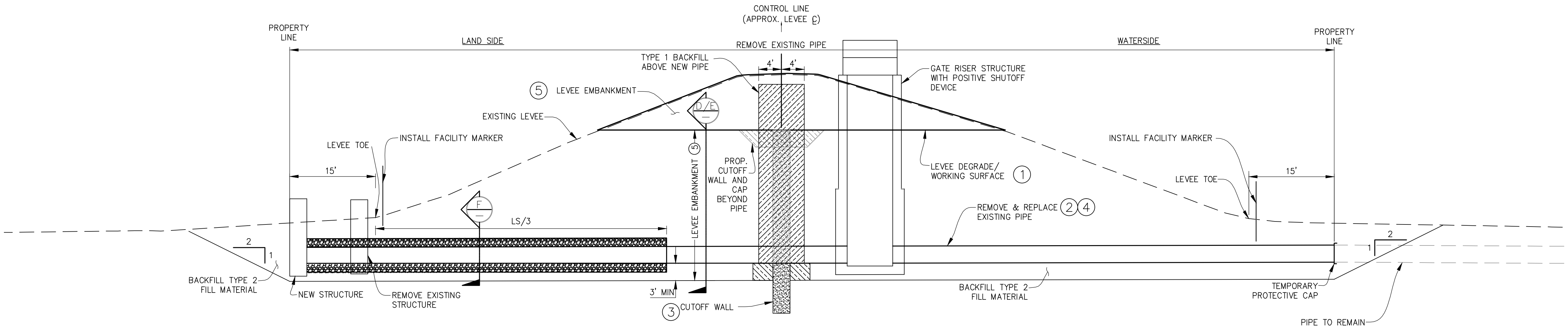
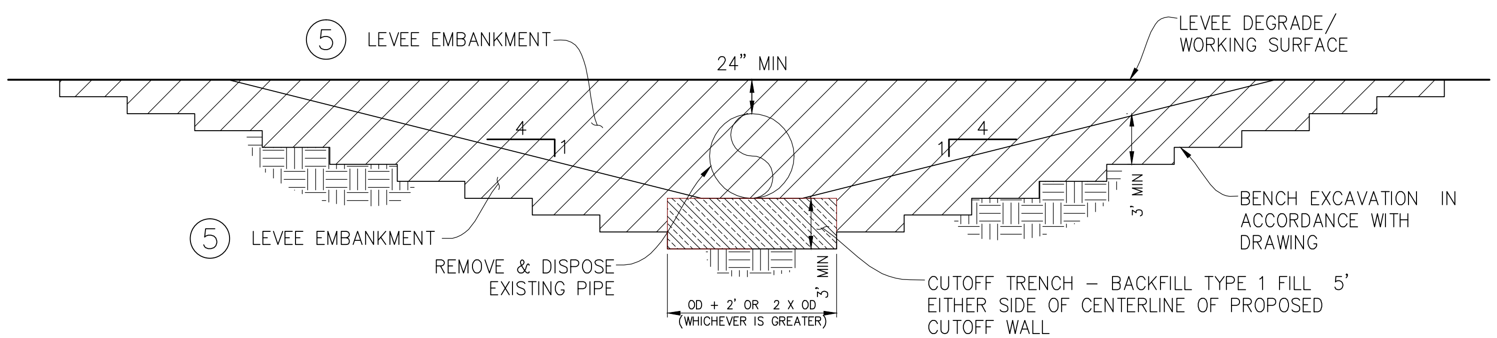


TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE (TYPE 2B)

SCALE: NONE

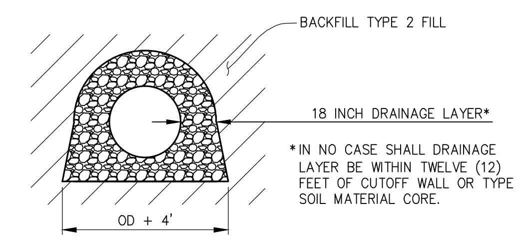
CONSTRUCTION SEQUENCE:

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.



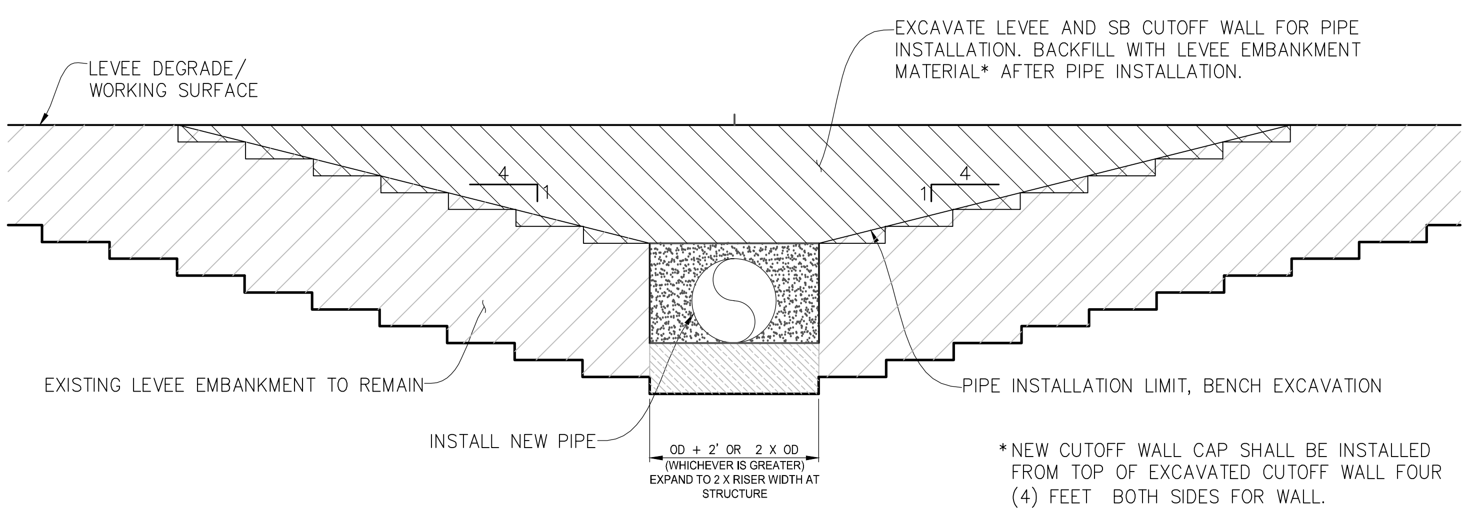
SECTION D

SCALE: NONE



SECTION F

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

SCHEDULE OF THROUGH PIPE REPLACEMENTS

EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH RISER	NEW PIPE DIA.
298+38	54 IN	25.1 FT	54 IN
1536+12	36 IN	20.0 FT	36 IN
1549+63	12 IN	13.7 FT	36 IN
1639+00	2–24 IN	19.0 FT	36 IN
1767+57	60 IN	15.0 FT	60 IN
1765+77	60 IN	15.0 FT	60 IN
1777+00	24 IN	7.9 FT	36 IN
1785+24	24 IN	8.4 FT	36 IN
1792+96	24 IN	8.0 FT	36 IN
1809+65	24 IN	9.4 FT	24 IN
1818+72	24 IN	21.6 FT	36 IN

SCHEDULE OF THROUGH PIPE REPLACEMENTS

EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH RISER	NEW PIPE DIA.
1961+03	2–60 IN	24.6 FT	2–60 IN
2017+78	22 IN	18.3 FT	36 IN
2178+39	16 IN	16.8 FT	36 IN
2239+66	24 IN	18.6 FT	36 IN
2245+52	24 IN	18.2 FT	36 IN
2250+76	24 IN	21.7 FT	36 IN
2256+71	24 IN	24.0 FT	36 IN
2256+94	24 IN	18.4 FT	36 IN
2260+55	24 IN	20.0 FT	36 IN
2262+69	24 IN	24.6 FT	36 IN
2274+86	24 IN	24.8 FT	36 IN
2274+95	24 IN	24.5 FT	36 IN
2283+65	24 IN	17.3 FT	36 IN

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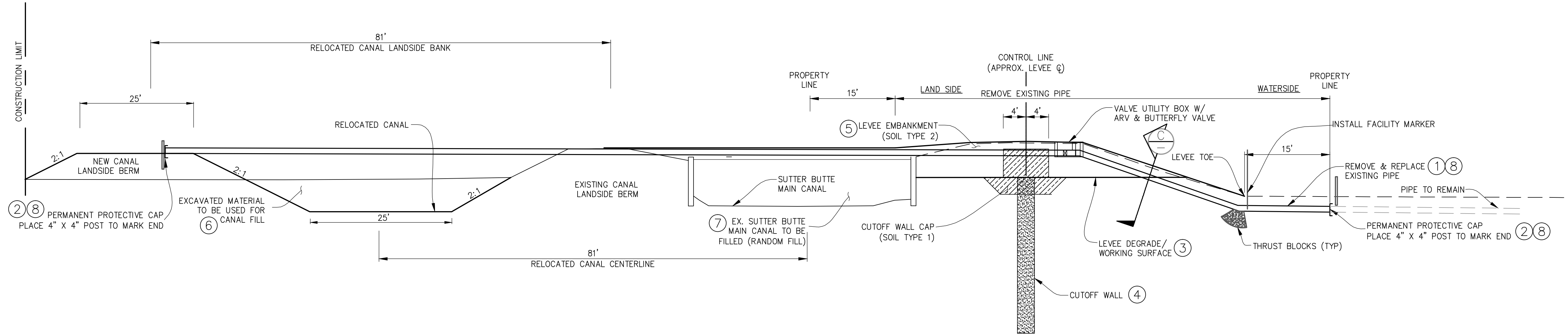
ALTERNATIVE SB-7 AND SB-8
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE

Sheet reference number:
C-404

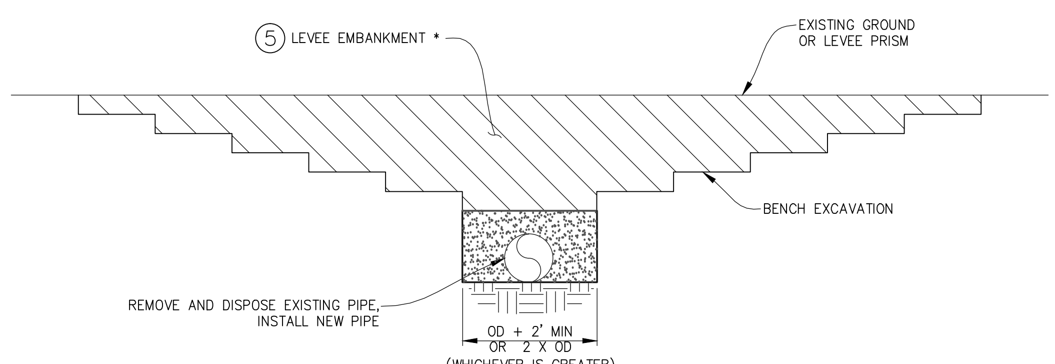


TYPICAL REMOVAL & REPLACEMENT OF RAISED PIPE WITH CANAL RELOCATION (TYPE 3A1)

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.

SCHEDULE OF RAISED PIPE REPLACEMENTS W/ CANAL RELOCATION			
EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH	NEW PIPE DIA.
1765+15	12 IN	1.0 FT	12 IN

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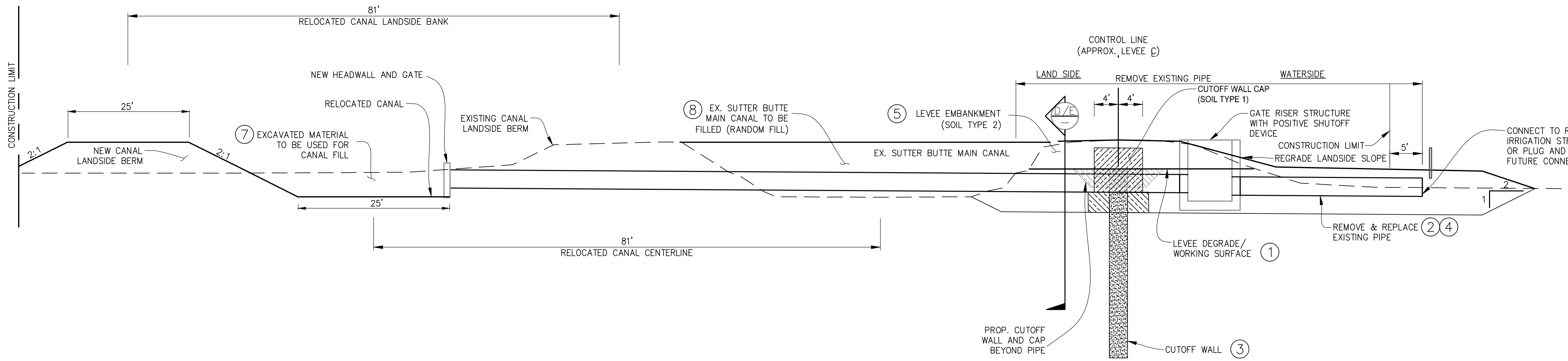
ALTERNATIVE SB-7 AND SB-8

TYPICAL UTILITY IMPROVEMENT - REMOVAL AND REPLACEMENT OF RAISED PIPE W/ CANAL RELOCATION

Sheet reference number: C-405

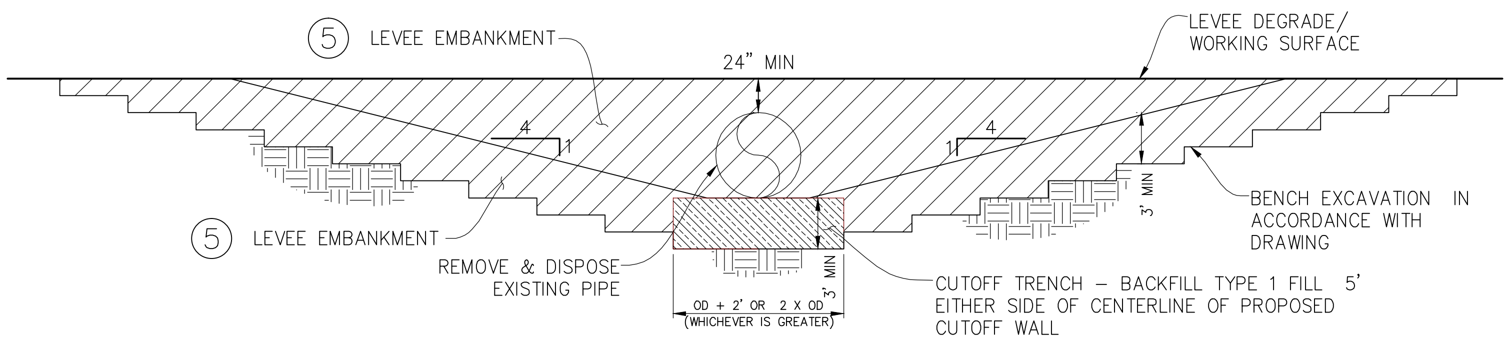


TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE WITH CANAL RELOCATION (TYPE 3A2)

SCALE: NONE

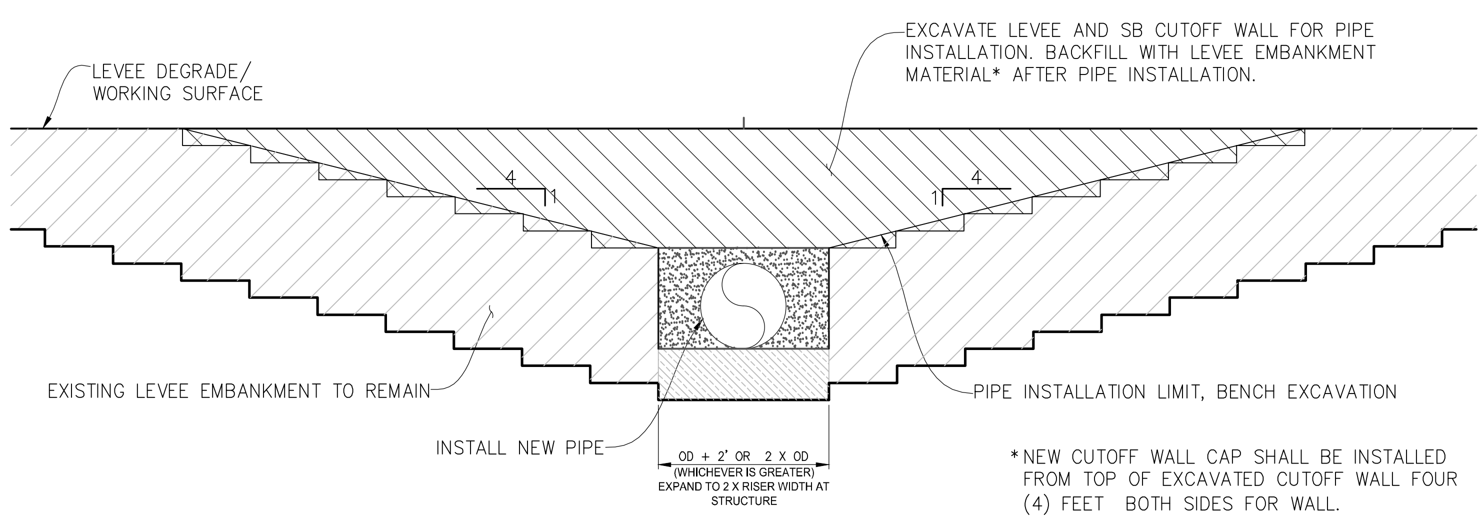
CONSTRUCTION SEQUENCE:

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



*NEW CUTOFF WALL CAP SHALL BE INSTALLED FROM TOP OF EXCAVATED CUTOFF WALL FOUR (4) FEET BOTH SIDES FOR WALL.

SECTION E

SCALE: NONE

SCHEDULE OF THROUGH PIPE REPLACEMENTS WITH CANAL RELOCATION

EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH RISER	NEW PIPE DIA.
1756+27	12 IN	10.1 FT	18 IN
1765+33	12 IN	7.6 FT	12 IN

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Symbol	Description	Date	Approval
D8	DESCRIPTION8	DATE8	APPROVAL8
D7	DESCRIPTION7	DATE7	APPROVAL7
D6	DESCRIPTION6	DATE6	APPROVAL6
D5	DESCRIPTION5	DATE5	APPROVAL5
D4	DESCRIPTION4	DATE4	APPROVAL4
D3	DESCRIPTION3	DATE3	APPROVAL3
D2	DESCRIPTION2	DATE2	APPROVAL2
D1	DESCRIPTION1	DATE1	APPROVAL1

Designed by: – | Date: – | Rev. –
Dwn by: – | Spec No.: – | Design file no: –
Reviewed by: – | Drawing Code: –
Submitted by: CHIEF, CIV ENGR DES SEC A | File name: $$$$$cvia$$$$ | Plot date: – | Plot scale: –

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TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE W/ CANAL RELOCATION

Sheet reference number:
C-406

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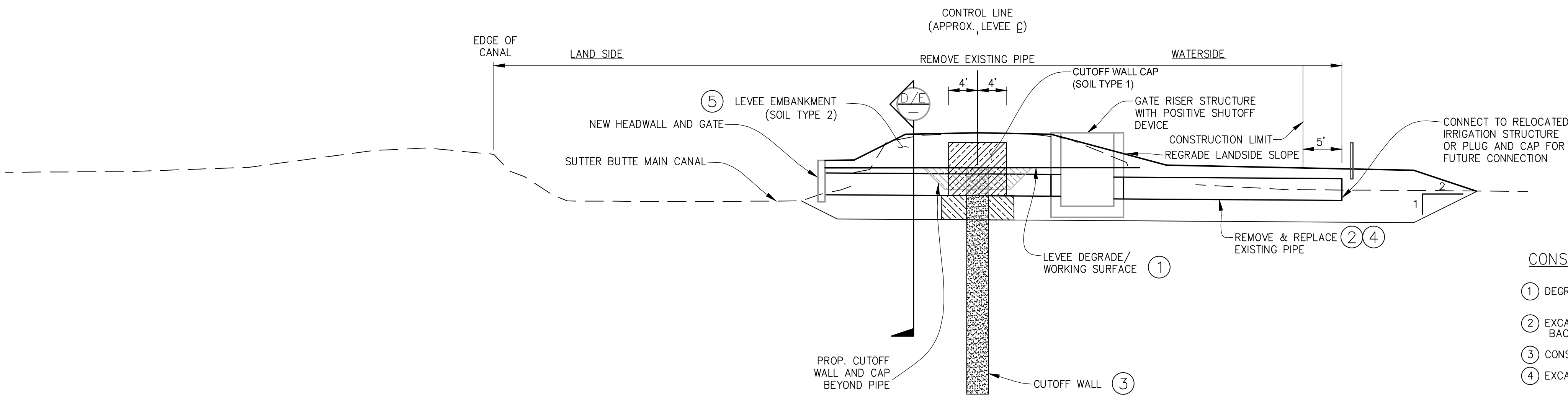
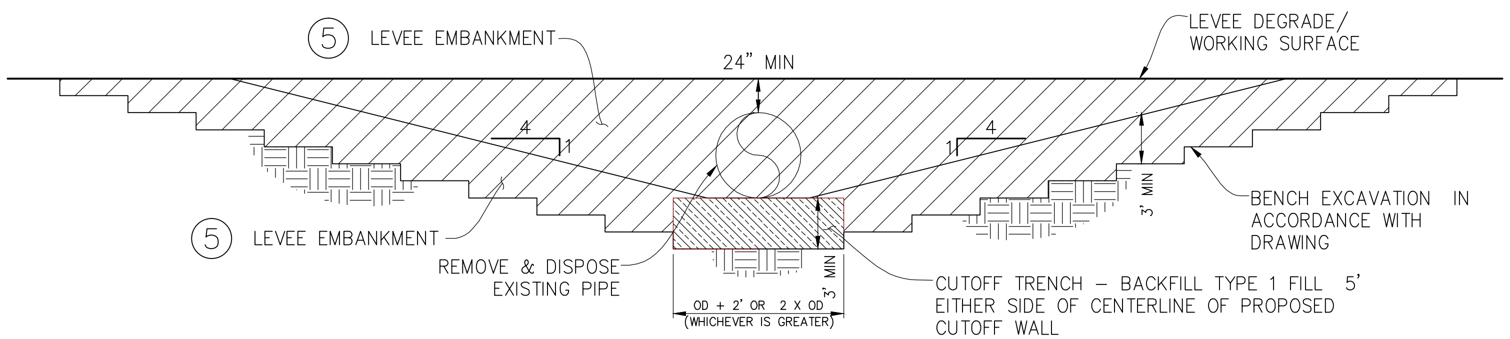


TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE ADJACENT TO CANAL (TYPE 3B)

SCALE: NONE

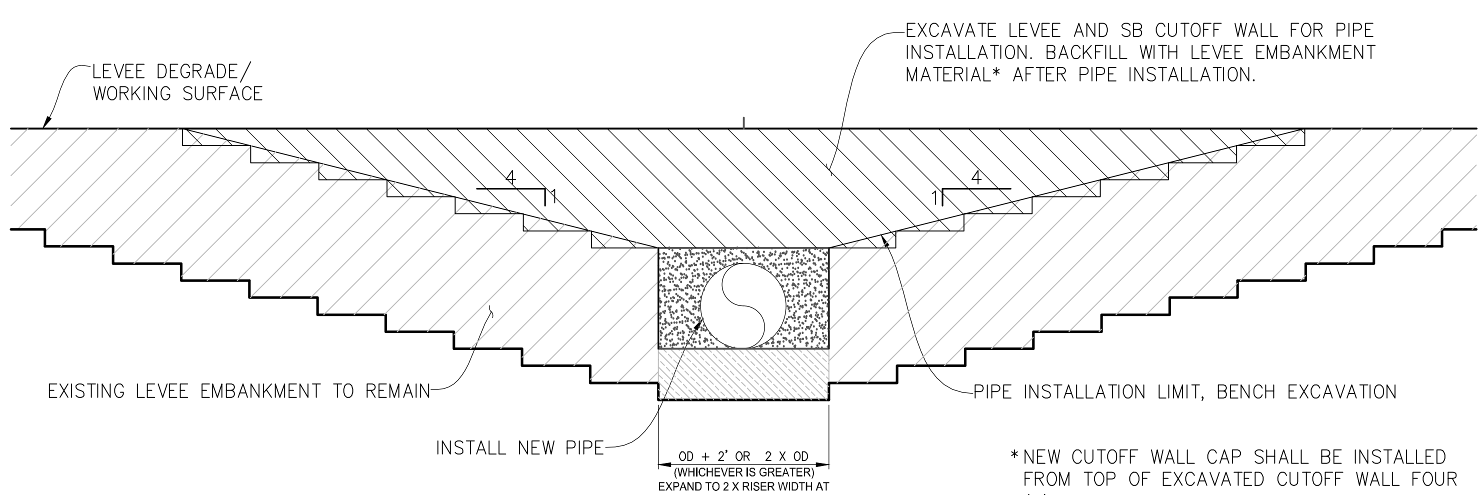
CONSTRUCTION SEQUENCE:

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



*NEW CUTOFF WALL CAP SHALL BE INSTALLED FROM TOP OF EXCAVATED CUTOFF WALL FOUR (4) FEET BOTH SIDES FOR WALL.

SECTION E

SCALE: NONE

SCHEDULE OF THROUGH PIPE REPLACEMENTS ADJACENT TO CANAL

EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH RISER	NEW PIPE DIA.
1956+20	24 IN	16.9 FT	36 IN

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TYPICAL UTILITY IMPROVEMENT - REMOVAL AND REPLACEMENT OF THROUGH PIPE ADJACENT TO CANAL

Sheet reference number:
C-407

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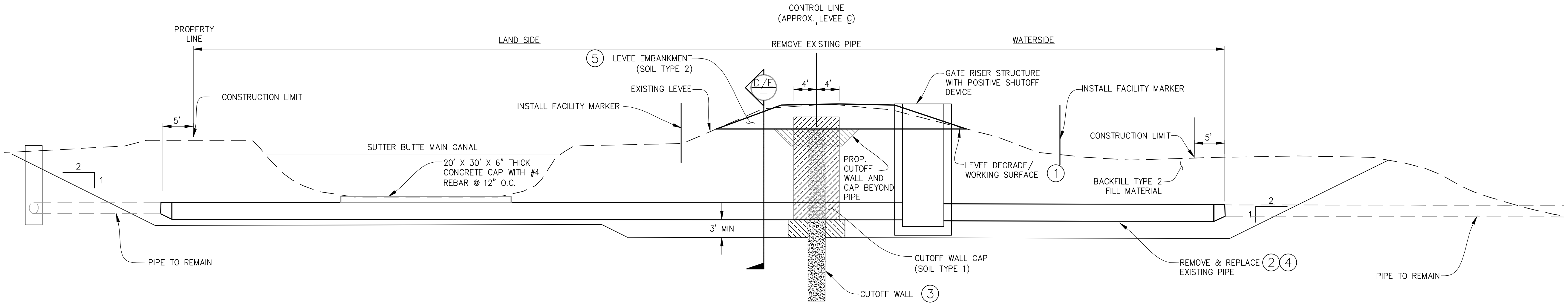
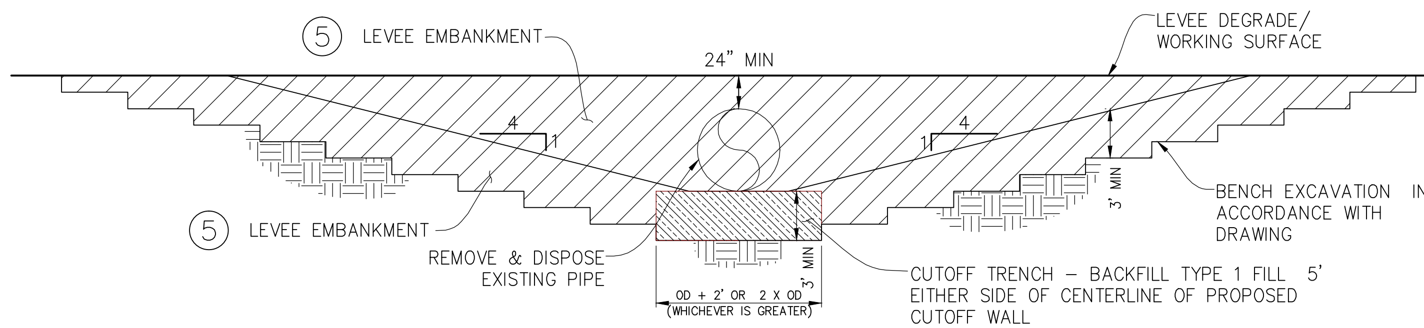


TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL (TYPE 3C1)

SCALE: NONE

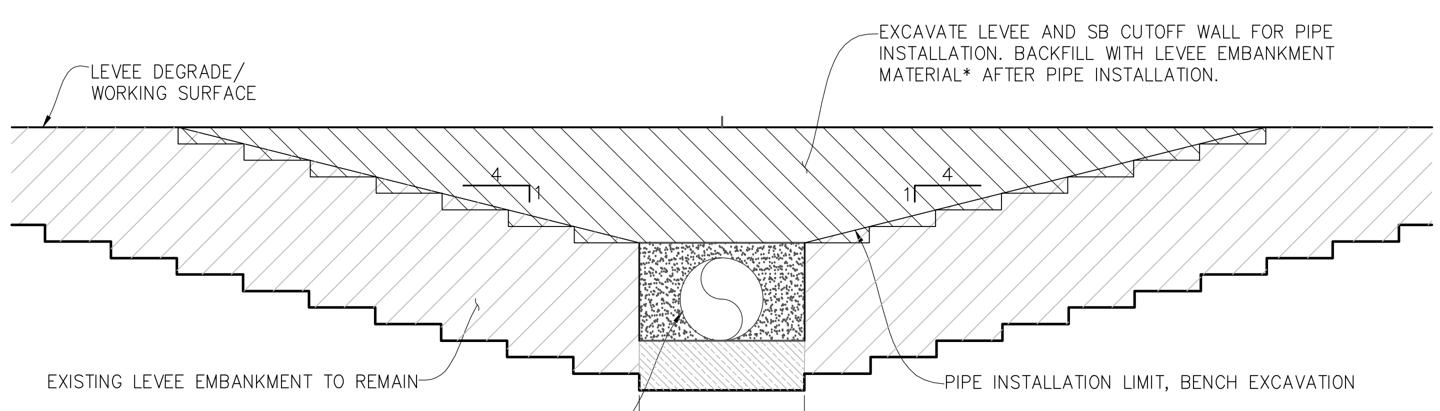
CONSTRUCTION SEQUENCE:

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

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

SCHEDULE OF THROUGH PIPE REPLACEMENTS UNDER CANAL			
EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH RISER	NEW PIPE DIA.
1934+54	24 IN	21.6 FT	36 IN

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TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE UDNER CANAL

Sheet reference number: C-408

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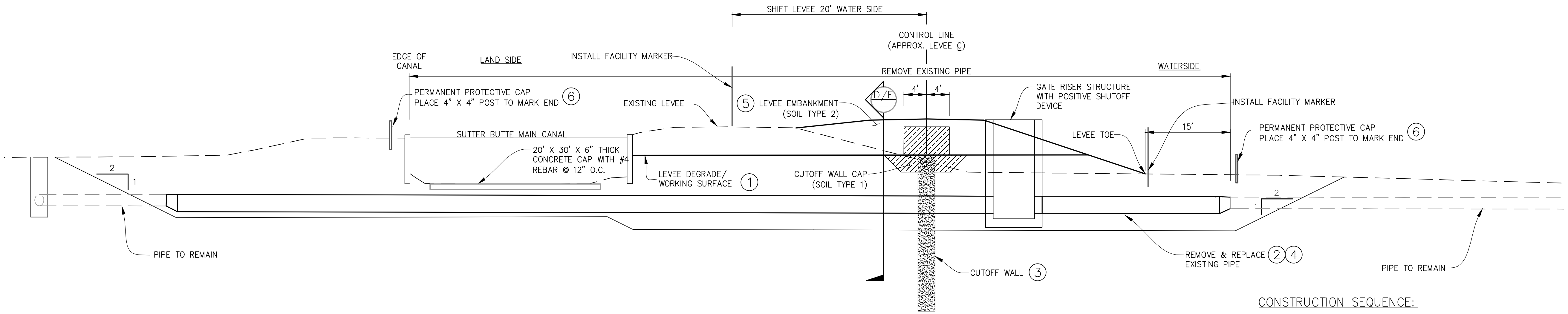
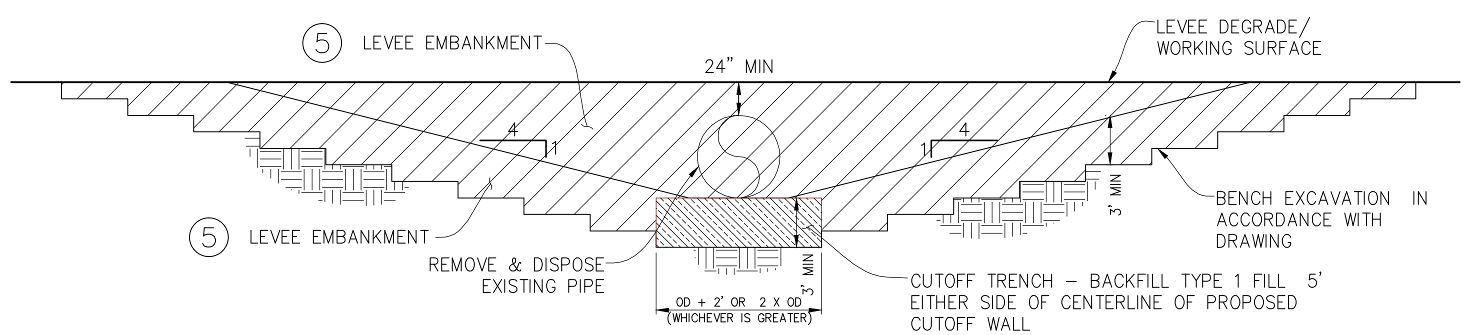


TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL WITH LEVEE RELOCATION (TYPE 3C2)

SCALE: NONE

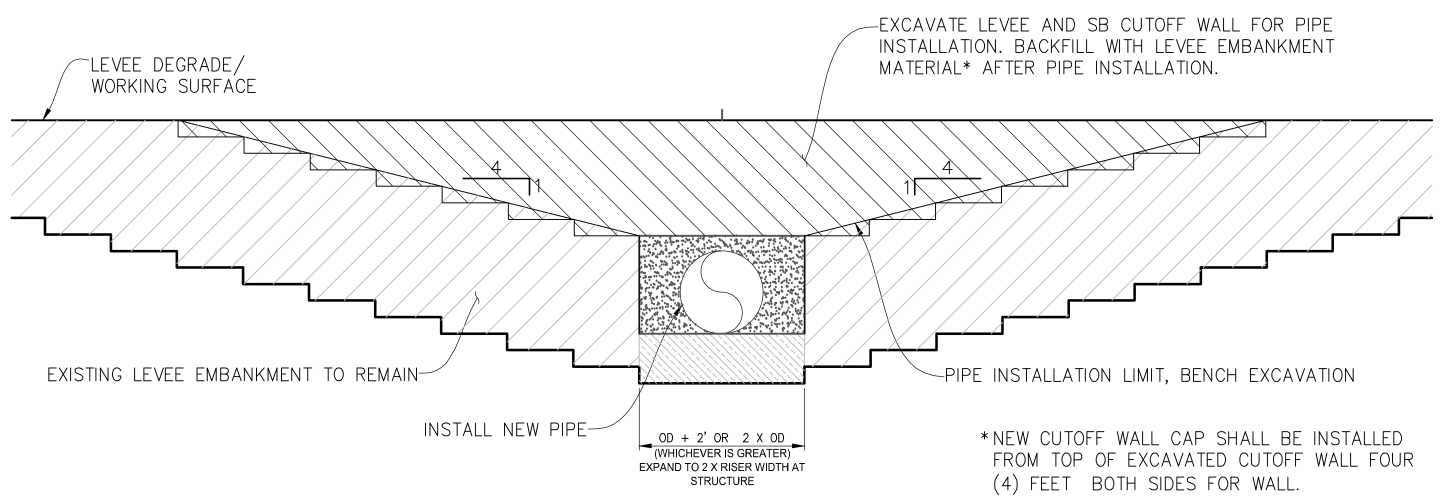
CONSTRUCTION SEQUENCE:

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

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

SCHEDULE OF THROUGH PIPE REPLACEMENTS UNDER CANAL W/ LEVEE RELOCATION

EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH RISER	NEW PIPE DIA.
1610+92	18 IN	18.9 FT	36 IN
1675+27	60x72 IN	17.0 FT	60x72 IN
1741+32	16 IN	14.8 FT	18 IN

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DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL UTILITY IMPROVEMENT – REMOVAL AND REPLACEMENT OF THROUGH PIPE UNDER CANAL W/LEVEE RELOCATION

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US Army Corps of Engineers

Sacramento District

Sutter Basin Feasibility Study

Butte and Sutter Counties, California

HYDROLOGY APPENDIX

October 2013

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
HYDROLOGY APPENDIX

October 2013

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SUTTER BASIN FEASIBILITY STUDY
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HYDROLOGY APPENDIX

JUNE 2012

1. Purpose, Scope, and Authority

1.1 PURPOSE AND NEED FOR THE PROJECT AND REPORT

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 and are at risk of breach failure at stages less than overtopping. 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.

The purpose of this hydrology report is to describe the hydrologic features of the basin and to document the design rainfall, the wind-wave analysis, the Sutter Bypass and Feather River discharge frequency, the Cherokee Canal discharge frequency, and the tributary/interior hydrology of the Sutter basin to include the Wadsworth canal discharge-frequency.

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).

2. Descriptive Information

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 shown on Plate 3 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 spoils 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 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 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 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 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, 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.

3. Flood Problems

3.1 GENERAL CHARACTERISTICS

Historically, large areas outside the low-water channel were inundated by Feather River flows in the valley, generally extending from the City of Oroville to the Sacramento River near Verona and encompassing some 292,000 acres, much of which is now agricultural land consisting primarily of orchards, dairy farms, and truck crops. The communities of Marysville and Yuba City are particularly vulnerable to inundation. The average elevation of these two leveed cities varies from 5 to 20 feet below the high water level in the river.

3.2 TOPOGRAPHY

The watershed above Oroville Dam includes mountain crests over 8,000 feet high, mountain valleys at elevations as high as 5,000 feet, deep canyons, and rolling foothills. Elevations range from 10,466 feet at Mt. Lassen Peak to 900 feet at the dam site. A topographic map and stream profiles of the Feather River Basin are presented in Plates 4 and 5.1 and 5.2, respectively. About 58 percent of the basin area is above an elevation of 5,000 feet, and only 7 percent is below 2,500 feet. Table 1 shows the distribution of the basin area above Oroville Dam and the corresponding area-elevation curve is shown on Plate 6. The percentage of the drainage area controlled by the major dams in the Feather River basin and Sacramento River basin downstream to the streamgage at Verona are sown in table 2 below.

TABLE 1

AREA ELEVATION (Percent of Area in Each Elevation)		
ELEVATION RANGE (ft)	AREA (SQMILES)	PERCENT OF AREA
<1000	33	0.9
1000-2000	115	3.2
2000-3000	178	4.9
3000-4000	337	9.4
4000-5000	854	23.7
5000-6000	1,257	34.9
6000-7000	710	19.7
7000-8000	113	3.1
8000-9000	4	0.1
>9000	0.01	0.0
Source: USGS 30 meter DEM		

TABLE 2

Drainage Area and Area Controlled in the Sacramento Basin to Verona						
huc_cd	Station_name	USGS_Stn#	Total Darea(sq-mi)	Local Darea(sq-mi)	Percent of Area Controlled	Elev (ft)
18020005	SACRAMENTO R A KENNETT CA	11369500	6355	6355	100.0%	618
---	Shasta Lake and Dam		6421	6421	100.0%	585
18020101	SACRAMENTO R A KESWICK CA	11370500	6468	47	99.3%	480
18020103	SACRAMENTO R NR RED BLUFF CA	11378000	9020	2599	71.2%	254
18020103	SACRAMENTO R NR HAMILTON CITY CA	11383800	10833	4412	59.3%	
18020103	STONY C NR HAMILTON CITY CA	11388500	773	773	100.0%	150
18020104	SACRAMENTO R A BUTTE CITY CA	11389000	12075	4881	59.6%	
18020104	SACRAMENTO R A COLUSA CA	11389500	12090	4896	59.5%	
18020104	SACRAMENTO R BL WILKINS SLOUGH NR GRIMES CA	11390500	12915	5721	55.7%	
18020104	SACRAMENTO R A KNIGHTS LANDING CA	11391000	14535	7341	49.5%	
18020123	COMPUTED INFLOW TO LK OROVILLE CA	11406799	3607	3607	100.0%	
---	Oroville Lake and Dam		3611	3611	100.0%	180
18020106	FEATHER R A OROVILLE CA	11407000	3624	13	99.6%	
18020106	FEATHER R NR GRIDLEY CA	11407150	3676	65	98.2%	
---	New Bullards Bar Lake and Dam		489	489	100.0%	1392
18020125	N YUBA R BL BULLARDS BAR DAM CA	11413500	487	487	100.0%	1390
18020125	N YUBA R LOW FLOW REL BL NEW BULLARDS BAR DAM CA	11413517	489	2	99.6%	1280
18020125	YUBA R BL NEW COLGATE POWERPLANT NR FRENCH CORRAL	11413700	717	230	67.9%	550
18020125	YUBA R BL ENGLEBRIGHT DAM NR SMARTSVILLE CA	11418000	1108	621	44.0%	
18020125	YUBA R A SMARTSVILLE CA	11419000	1200	713	40.6%	264
18020106	YUBA R A DAQUERRA PT NR BROWNS VALLEY CA	11420800	1330	843	36.6%	
18020107	YUBA R NR MARYSVILLE CA	11421000	1339	852	36.4%	
18020106	FEATHER R BL SHANGHAI BEND NR OLIVEHURST CA	11421700	5334	1236	76.8%	
18020108	BEAR R NR WHEATLAND CA (6.5 mi d/s of Camp Far West Dam)	11424000	292	292	100.0%	72
18020106	FEATHER R NR NICOLAUS	11425000	5921	1531	74.1%	
18020109	SACRAMENTO R A VERONA CA	11425500	21251	10440	50.9%	43

Data Source: USGS gage station inventory at http://nwis.waterdata.usgs.gov/nwis/inventory
Data Source for Dams: Pertinent data sheets for Water Management, Sacramento District, USACE.

3.3 GEOLOGY AND SOILS

Geologically, the Feather River Basin includes portions of the Cascade and Sierra Nevada Ranges. The basin is bounded on the northwest and north by volcanic ridges and mountains radiating from Mt. Lassen, the predominant feature of the northern extremity of the Feather River Basin and the southern limit of the Cascades. On the northeast and east, the basin boundaries correspond roughly to the northern and eastern limits of the Sierra Nevada. The Feather River Basin terminates on the south with the northern boundary of the American River Basin. The majority of the basin is located within the Sierra Nevada, a huge monoclinal fault block tilted very slightly westward and extending beneath the alluvium filled Sacramento Valley on the west. The geologic formations in the basin consist of a wide variety of metamorphic rocks into which granitic rocks of various types have intruded. Recent (in geologic time) stream channel deposits comprise an' important portion of the basin including mountain meadows and stream floodplains, which consist of boulders, gravel, sand and silt. Several faults and fault systems located in areas adjacent to the basin are considered active.

Soils of the Feather River Basin consist of those residual soils formed in place by deterioration and weathering of underlying parent rock; valley fill soils, with the older soils having been modified during the period since deposition and the recent fills showing little change in physical or chemical composition since deposition; and lacustrine soils derived from decomposition of organic materials under marshy conditions. The residual soils are found on mountainous areas and vary in depth from very shallow with considerable surface rock to soils having good depth and little or no surface rock. The older alluvial soils usually have been modified by leaching processes to form dense clay pans or cemented hardpans. These soils are found in lower valley-floor areas, particularly on the west, where they join the alluvial areas of the Sacramento Valley floor. The rich soil of the valley floor below the dam grows a great variety of farm crops.

3.4 SEDIMENT

Sedimentation rates in the Feather River Basin and adjacent basins are relatively low due to limited development, the general shallowness of soils and a low rate of upstream erosion. The annual sediment yield for the drainage area above Lake Oroville is estimated to be about 0.2 acre-feet per square mile, which corresponds to 720 acre-feet/year. Much of the recent deposition that has occurred in the lower Feather River Basin was due to the extensive use of hydraulic mining in the late nineteenth century. DWR conducted a siltation study of Lake Oroville during 1993-1994. The study concluded that 18,000 acre-feet of sediment deposition has occurred since completion of the project. This corresponds to an annual rate of 667 acre-feet/year.

4. Climate

4.1 GENERAL

The climate of the Feather River Basin is significantly influenced by the topography of the area and there are marked variations in temperature and precipitation within short distances. Climate is characterized by cool, wet winters and hot, dry summers. The majority of the annual rainfall occurs in 2 or 3 of the winter months. The seasons are so distinctly different that the period from May to October may be termed the dry season and November to April the wet season.

4.2 TEMPERATURE

Temperatures in the valley are high in the summer and moderate in the winter. Temperatures in the mountains decrease generally with elevation; the summers are moderate at higher elevations while the winters are severe. Observed temperature extremes are113 and 17 degrees at Marysville, 115 and 12 degrees at Oroville, 110 and -24 degrees at Quincy, and 104 and -29 degrees at Sierraville. The monthly and annual distribution of mean, maximum, and minimum temperatures at representative stations are presented in Table 3.Except for extremely high elevations, these temperatures are representative of the whole watershed area.

TABLE 3

MONTHLY AND ANNUAL
MEAN, MAXIMUM, AND MINIMUM TEMPERATURES
(Degrees Fahrenheit)

Month	Marysville (57 ft)			De Sabla (2720 ft)			Canyon Dam (4560 ft)			Portola (4850 ft)		
	Mean	Max	Min	[Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
January	46.0	54.1	38.0	41.7	51.4	31.9	30.5	39.1	21.9	29.9	41.9	17.9
February	51.4	61.1	41.7	43.9	54.4	33.3	33.5	43.4	23.5	33.3	46.1	20.6
March	55.3	66.3	44.3	46.4	57.8	34.9	37.8	49.0	26.6	37.9	51.3	24.4
April	60.8	73.7	47.9	51.4	64.3	38.5	43.8	57.3	30.2	43.2	58.5	27.8
May	67.7	81.8	53.6	58.4	72.6	44.2	51.8	67.3	36.4	50.3	67.5	33.1
June	74.5	90.1	58.9	66.4	82.0	50.9	59.4	76.1	42.7	57.4	76.8	38.1
July	79.1	96.3	61.9	72.3	89.3	55.3	66.0	84.7	47.3	63.6	85.8	41.5
August	77.5	94.5	60.5	71.2	88.5	54.0	64.6	83.5	45.7	62.2	84.4	39.8
September	73.5	89.7	57.3	66.9	83.5	50.4	59.0	76.9	41.2	56.8	78.3	35.3
October	65.3	79.7	50.8	58.4	72.9	44.0	49.5	64.5	34.4	48.4	67.6	29.3
November	53.9	64.7	43.1	47.2	58.1	36.3	38.4	48.5	28.4	38.3	52.5	23.9
December	46.7	55.0	38.4	42.0	51.7	32.3	31.8	39.9	23.6	31.5	43.6	19.5
Annual	62.6	75.6	49.7	55.5	68.9	42.2	47.2	60.9	33.5	46.1	62.9	29.3
Period of Record	1948-2004			1948-2004			1948-2004			1948-2002		

Source: Western Regional Climate Center, 2004

4.3 PRECIPITATION

Annual precipitation varies throughout the drainage area, ranging from 20 to 25 inches on the valley floor to about 100 inches in the higher mountains, and averages about 45 inches over the watershed above Oroville Dam. Winter precipitation usually falls as rain up to the 5,000 foot elevation and as snow at higher elevations, but some storms produce rain up to the highest elevations of the basin and snowfall occurs as low as the valley floor at rare intervals. About 90 percent of the runoff producing precipitation occurs during the winter months of November through April. The areal distribution of normal annual precipitation is shown on Plate 7. The mean monthly distribution at selected stations is given in Table 3.

TABLE 4

MEAN MONTHLY PRECIPITATION								
Month	Marysville (57 ft)		De Sabla (2720 ft)		CanyonDam (4560 ft)		Portola (4850 ft)	
	Inches	%	Inches	%	Inches	%	Inches	%
January	4.37	20.4%	12.75	19.2%	7.4	19.1%	4.13	18.8%
February	3.53	16.4%	10.81	16.3%	6.34	16.4%	3.34	15.2%
March	2.93	13.7%	8.98	13.5%	5.21	13.5%	3.03	13.8%
April	1.61	7.5%	4.93	7.4%	2.6	6.7%	1.34	6.1%
May	0.64	3.0%	2.28	3.4%	1.54	4.0%	1.09	5.0%
June	0.23	1.1%	0.89	1.3%	0.74	1.9%	0.58	2.6%
July	0.04	0.2%	0.1	0.2%	0.18	0.5%	0.36	1.6%
August	0.08	0.4%	0.28	0.4%	0.32	0.8%	0.35	1.6%
September	0.33	1.5%	1.09	1.6%	0.71	1.8%	0.53	2.4%
October	1.27	5.9%	3.65	5.5%	2.2	5.7%	1.18	5.4%
November	2.82	13.1%	8.74	13.2%	4.87	12.6%	2.36	10.7%
December	3.61	16.8%	11.88	17.9%	6.52	16.9%	3.73	16.9%
Average Annual	21.46	100%	66.37	100%	38.65	100%	22.02	100%
Maximum Annual	1983		1983		1983		1996	
Minimum Annual	1976		1976		1976		1976	
Period of Record	1948-2004		1948-2004		1948-200		1919-2004	
Source: Western Regional Climate Center, 2004								

4.4 SNOWFALL

Winter snowfall above 5,000 feet elevation normally accumulates until the first of April when increasing temperatures mark the beginning of the snowmelt season. Snow falling at lower elevations usually melts within a relatively short time. Snow course data are collected at 25 locations within the Feather River Basin by Pacific Gas and Electric Company, California Department of Water Resources, the East Lake Ranger District, and the Eagle Lake Ranger District as part of the California Cooperative Snow Survey program. Basin snowpack data for six representative snow courses are presented in Table 4. The locations of the snow courses are shown on Plate 8.

TABLE 5

SNOW SURVEY DATA (Water Equivalent - Inches)							
Snow Course	AVERAGE					MAXIMUM	MINIMUM
	1-Jan	1-Feb	1-Mar	1-Apr	1-May	(Date)	(Date)
Lower Lassen Peak (Elev 8250 ft.) (POR 1930-2000)	33.4	48.2	62.8	78.7	80.8	162.1 3/27/1995	6.4 1/1/1987
Mount Dyer #1 (Elev 7100 ft) (POR 1930-2000)	9.6	14.5	19.4	25	23	71.7 5/1/1983	0 Multiple
Rowland Creek (Elev 6700 ft) (POR 1950-2000)	6.9	11.8	15.4	17.7	13.3	43.8 4/1/1952	0 Multiple
Eureka Lake (Elev 6200 ft) (POR 1939-2000)	n/a	19.5	28	31.6	21.7	72.9 4/1/1952	0 Multiple
Letterbox (Elev 5600 ft) (POR 1940-2000)	17.8	25.8	37.3	48.4	40.6	106.5 4/1/1952	0 Multiple
Chester Flat (Elev 4600 ft) POR 1930-2000)	3.7	7.5	9	6.4	1.6	29.1 4/1/1952	0 Multiple
Source: California Department of Water Resources, California Data Exchange Center, 2003							

4.5 EVAPORATION AND WIND

The average historical evaporation at Lake Oroville is listed in Table 5. Pan evaporation was measured with a class "A" pan. Peak wind velocities in California are generally associated with winter-type storm fronts, whereas the strongest sustained winds occur in the summer with maximum sunshine. The prevailing wind direction in the lower Feather River Basin is from the south and southeast during the months of April through September, and from the north during the months of October through December. A continuous recording ground level anemometer was recently installed at Oroville Dam. Table 7 is a compilation of the mean and peak monthly wind velocities for Beale Air Force Base and the Red Bluff Airport.

TABLE 6

HISTORICAL MONTHLY PAN EVAPORATION LAKE OROVILLE	
MONTH	MEAN EVAPORATION (in)
January	1.2
February	2.02
March	3.59
April	5.36
May	7.96
June	10.1
July	11.99
August	10.86
September	8.36
October	5.36
November	2.12
December	1.17
Annual Total	70.09

Source: DWR Bulletin 73-79, Nov 1979 (Period of Record WY1959-WY1979). DWR and University of California Statewide Integrated Pest Management Program (Period of Record WY198l-WY2002)

TABLE 7

MEAN AND PEAK MONTHLY WIND VELOCITIES

Month	Beale Air Force Base		Red Bluff Airport	
	Mean	Peak Gust	Mean	Peak Gust
(mph)	(mph)	(mph)	(mph)	
January	5	59	9	47
February	5	62	9	55
March	6	51	10	60
April	6	53	10	47
May	6	43	9	45
June	6	44	9	41
July	5	38	8	39
August	5	35	8	35
September	5	48	8	43
October	3	53	8	48
November	5	64	8	54
December	5	67	8	49
Annual	5	67	9	60

Source: Climatic Wind Data for the United States, 1998, NCDC, Period of Record not specified.

4.6 STORMS AND FLOODS

The Feather River Basin lies on the seaward face of the Sierra Nevada which rises directly across the path of storms moving inland from the Mid-Pacific Ocean. The low barrier of the Coast Range which intervenes between the ocean and the Sierra Nevada is pierced by the large San Francisco Bay Gap westward from the Feather River Basin so that considerable volumes of moist maritime air reach the basin at low elevations.

The most important storms affecting this area are cyclonic wave disturbances along the polar front that usually originate in the vicinity of the Aleutian Islands. The normal trajectory of the waves along this front is to the south and east from the Pacific Ocean to the west coast. In the summertime, this frontal zone is located far to the north and the accompanying precipitation seldom reaches as far south as California. During the summer the air which reaches the region is generally stable and thunderstorms are rare. During the wintertime, from October to April, the frontal zone moves southward and the cyclonic wave disturbances move over California.

The annual precipitation is concentrated almost entirely during the winter storm season from November through March. Precipitation normally falls as snow above the 5,000 foot level. However, during extremely warm winter storms rain has fallen over the entire basin melting some of the snow and at times stripping most of the snowpack from the basin. By the end of the winter most of the area above 5,000 feet is covered by a compact snowpack that often averages more than 10 feet in depth over large areas. Occasionally, depths reach 30 feet. Because of this deep snowpack in the higher areas, storm rainfall therein is largely absorbed in the mass of the snow and appreciable storm runoff from such areas is prevented.

Studies of storms and floods of record indicate that critical flood producing conditions on the Feather River Basin will occur only during the winter season when there may be a prolonged series of general storms covering the entire basin. Storm precipitation amounts are typically distributed aerially in the same general pattern as normal annual precipitation amounts, although there are large departures from this rule. On occasion a general storm series may last 2 to 5 days. During such stormy periods, soil saturation occurs, infiltration capacities decline, and the natural and artificial storage within the basin is progressively filled.

Outside the winter season, storms are less severe, cover only a small portion of the basin at a time, and are so widely separated in time that basin storages have an opportunity to replenish, resulting in lower basin runoff. Thunderstorms lasting up to three hours can occur over small areas at higher elevations from late spring through early fall. The resulting runoff is characterized by high peaks of short duration with low volumes. For small tributaries, peak flows from thunderstorms can approach those that occur during major winter rain floods, but flows on the main stem are barely affected.

Floods in the Feather River Basin are typical of those occurring on the other Sierra Nevada streams. Floods are rather frequent and of two general types, winter rain floods and spring snowmelt floods. However, only rain floods, resulting from intense rainfall over the foothills and mountains during the winter season, cause serious flooding because the highest rate of snowmelt runoff is well below that corresponding to the damaging stage of the river.

Rain floods have a high peak discharge, are flashy, and are generally only a few days in duration. When antecedent rainfall has resulted in saturated ground conditions or when the ground is frozen, the volume of runoff can be much greater and flooding more severe. These floods may occur in rapid succession with secondary peaks occurring before flows from the preceding floods have completely receded.

Snowmelt floods can be expected any time from April through July. They are characterized by lower peak flows, long durations, and comparably large volumes of runoff. The snowmelt flood potential varies according to the depth and areal extent of the snowpack and temperature. The highest rates of snowmelt runoff usually occur during years with an unusually deep snowpack. High flows are sustained during May and June when rising temperatures cause the snowpack to melt. The top five historic snowmelt inflow flood events are shown in table 9.

4.7 RUNNOFF CHARACTERISTICS

Runoff occurs primarily during the months of November through June. Maximum flows between the months November and April are the result of direct runoff from intense precipitation augmented occasionally by melting snow (USACE, 1958). Runoff during the months of April through June is primarily from snowmelt. Such runoff generally does not result in flood-producing flows, but is ordinarily adequate to fill reservoir space maintained empty during the winter months for flood control. During late summer and early fall, runoff diminishes and streamflow is sustained by springs and drainage of lakes, reservoirs, and areas of effluent seepage (USACE, 1958). Greatest water demands occur during the months June through September. Thus, in years of normal or above normal snowmelt, flood control operation does not interfere with the filling of the reservoir for subsequent water deliveries.

Runoff accumulates rapidly in the upstream tributary areas where the flows are confined within the natural narrow canyon stream channels and the floods produced are of high intensity but relatively short duration. Flood peaks on the streams in the basin above Oroville Dam are often impaired and delayed by numerous upstream check dams, diversions and reservoirs.

Significant runoff occurs after the ground approaches saturation. Thereafter, successive storms would produce runoff with lower loss rates unless enough time expires between storms for the basin to dry out. Loss rates in the basin vary with the wetness of the ground and the intensity of the rainfall plus snowmelt. Constant loss rates, estimated for eight floods between 1940 and 1955, are presented in the March 1958 office report, Flood Control Hydrology, Feather River Basin, California. Constant loss rates were found to range from 0.06 in/hr to 0.13 in/hr.

Annual runoff volume since project completion has been highly variable, and has ranged from a minimum of 752,000 acre-feet in water year 1977 to a maximum of 8,857,000 acre-feet in water year 1983. The extremes represent 18 and 210 percent, respectively, of the 36-year average runoff of 4,227,000 acre-feet. Mean monthly unregulated runoff at Oroville Dam is presented in Table 8.

TABLE 8

MEAN MONTHLY UNREGULATED RUNOFF FEATHER RIVER AT OROVILLE DAM		
MONTH	**TOTAL MONTHLY RUNOFF (1000 AF)**	**PERCENT OF ANNUAL RUNOFF**
JANUARY	509	11.2
FEBRUARY	571	12.6
MARCH	705	15.5
APRIL	739	16.3
MAY	670	14.7
JUNE	349	7.7
JULY	159	3.5
AUGUST	104	2.3
SEPTEMBER	89	2
OCTOBER	106	2.3
NOVEMBER	196	4.3
DECEMBER	350	7.7
ANNUAL	4,547	100.0

The official operation record of Oroville Dam is maintained by the State of California. Operation of Oroville Dam began in October 1967. Daily historical operation data including inflow, outflow, storage and top of conservation are available at the California Data Exchange Center (CDEC) on the web at http://cdec.water.ca.gov/reservoir.html.

4.8 CLIMATE CHANGE

4.8.1. PURPOSE

This section presents a discussion of the potential impact of climate change for the Sutter basin feasibility study (SBFS) hydrology.

4.8. 2. GENERAL

Two possible trends associated with climate change that may affect the SBFS study area are a change in sea level and the shift in Sierra Nevada runoff patterns..

Recent research indicates continued or accelerated rise in global mean sea level height (sea level change) based on decades (and in some cases centuries) of measurements. Climate change has been identified as a likely cause of the increase in global sea level height by many researchers but is still subject to spirited debate. However, the reality of the observed rise in global sea level height at project specific locations and local vertical land movement needs to be adequately addressed by projects in and near coastal areas regardless of the causes (USACE, 2011A).

Also, studies have shown that increasing temperatures associated with climate change are causing a shift in the runoff patterns of Pacific slope watersheds with a large snowmelt component. The runoff shifts for those watersheds include increased runoff in winter, less snowmelt in summer, and earlier runoff in the spring (USACE, 2011B).

4.8.3. SEA LEVEL CHANGE

The discussions of sea-level analysis has been removed to the hydraulic analysis appendix.

4.8.4. IMPACT OF CLIMATE CHANGE ON RUNOFF

A sensitivity study of the potential impact of climate change on runoff was completed. A separate technical memorandum documents that effort in “Sensitivity of Alternative Selection to Climate Change”, dated 03January2013 (USACE, 2013).

The procedure used hydrologically was to adopt the percent change in 3-day flood flow at discrete locations in the Sacramento river basin from a paper by Tapas Das (Das, 2011). Those percent changes in 3-day flows were applied to the unregulated flow frequency curves to shift the frequency of future flows to a more frequent occurrence. The future unregulated flows were then input to the economics model were transform curves from the existing without project condition transformed the unregulated flow to regulated flow. The economics model then assessed the ranking of project alternatives based on three future climate scenarios as defined in the Das paper representing wetter and dryer future conditions.

The conclusion of that sensitivity study was that the impact of climate change will not change the selection of draft alternatives for the Sutter Basin Feasibility Study. Table 9 shows the final ranking of alternatives, showing that alternative SB-7 remains in first position. The results indicate that the ranking of the alternatives on the basis of net annual benefits is not sensitive to the climate change scenarios.

TABLE 9.

Rankings of Alternatives Based Upon Equivalent Net Annual Benefits by Climate Scenario

Alternative	NCAR (Driest Condition)	Existing Condition	GFDL (Wettest Condition)
SB-1	8	8	6
SB-2	2	2/3	5
SB-3	4	4	4
SB-4	7	7	8
SB-5	5	5/6	7
SB-6	6	5/6	3
SB-7	1	1	1
SB-8	3	2/3	2

5. Historic Flooding

Historic unregulated flows and volumes for the Feather River at Oroville for the five largest rain floods of record, based on 3-day volumes, are listed in Table 10. Unregulated flows and volumes for the Feather River at Oroville for the five largest snowmelt season (April through July) floods of record based on 3-day volumes are shown in Table 11. A discussion of the 1955, 1964, 1986, and 1997 floods follows.

TABLE 10

HISTORIC RAIN FLOOD INFLOWS
FEATHER RIVER AT OROVILLE DAM

DATE	PEAK a/ (cfs)	UNREGULATED 1-DAY VOLUME (acre-feet)	UNREGULATED 3-DAY VOLUME (acre-feet)
Jan- 1997	302,000	620,600	1,454,800
Feb- 1986	275,000	430,500	1,112,800
Dec- 1964	250,000	354,100	984,100
Mar- 1907	230,000	370,900	894,500
Dec- 1955	203,000	360,100	874,200

Source: USCAE 1999, and CDEC, Period of Record WY 1902- WY 2003 Excerpted fom Oroville DRAFT 2005 WCM a/ Peak flows impaired due to upstream regulation

TABLE 11

HISTORIC UNREGULATED SNOWMELT SEASON INFLOW FLOODS OF RECORD FOR THE FEATHER RIVER AT OROVILLE DAM		
WATER YEAR	1-DAY VOLUME (acre-feet)	3-DAY VOLUME (acre-feet)
1995	491,000	4,263,000
1982	425,000	3,156,000
1915	362,000	2,940,000
1911	308,000	4,368,000
1963	290,000	1,685,000
Source: USACE, CDEC, Period of Record WT 1902 - WY 2003 Excerpted from Oroville DRAFT 2005 WCM Snowmelt season begins April 1st		

During the week preceding Christmas 1955, northern and central California was subjected to one of the greatest floods in the area's history. The intense flood-producing precipitation covered an area of about 100,000 square miles, which represents over sixty percent of the gross area of the state. By December 15, the Feather River Basin was moderately wet from preceding storms, the snowline was at about 4,000 feet, and there was about 36 inches of snow above 7,000 feet. During the first cold phase of the storm, from the 15th to the 20th, about 10 inches of precipitation fell on the basin, as rain below about 5,500 feet and as snow above that elevation. The snowline retreated about 500 feet in elevation, but snow depths at 7,000 feet elevation increased to about 75 inches. After the 21st, temperatures and wind velocities increased greatly and the rainfall extended to the highest point in the basin. The snowline retreated about 700 feet in elevation and snow depths decreased about 18 inches at all elevations, contributing to heavy runoff from most of the basin below above 7,000 feet. Extensive flooding occurred throughout the basin. At Shanghai Bend, south of Yuba City, the west levee of the Feather River failed at about midnight on the 23rd. Water from this break entered Yuba City and flooded about ninety-five percent of the city. In the residential areas, the depth of flooding varied from a few inches to over 12 feet. Because the flooding occurred so quickly, and in the middle of the night, practically none of the contents of homes and businesses could be saved. About 12,000 people were evacuated from the Yuba City area for a period varying from a few days to several months. It was reported that 38 people lost their lives in this area as a result of the flood.

On December 23, 1955, a peak flow of 203,000 cfs and a gage reading of 76.5 feet above streambed occurred at the gaging station in the Feather River Canyon a few miles east of Oroville. An estimated peak discharge of 230,000 cfs occurred during the great flood of March 1907. However, in December 1955, upstream reservoirs, which did not exist in 1907, stored 137,000 acre-feet of floodwater between December 21 and December 28. It is estimated had Oroville Dam existed, the inventoried damages, losses, and costs below the dam site of about $50,000,000 and the loss of human lives could have been prevented. Such a reduction in flood flows in the Feather River would also have relieved the threat to the remaining portion of the levee system.

The flood of December 1964 - January 1965 resulted from a winter rainstorm that followed a meteorological pattern typical of other flood-producing storms over the basin. Heavy precipitation occurred in the preceding 60 days over the general area, with up to 5 inches of rain recorded at some valley stations. The storm came in four distinct waves. The first wave, which occurred during 18-20 December, was cold, and deposited 2-3 inches of snow in the mountains down to the 3,000 foot level. The following wave brought rising temperatures and heavy rains up to 6,000 feet elevation. Within the 4-day period, 20-23 December, about 13 inches of rain fell. The warm winds and rain melted most of the new snow accumulated during the initial storm. Another cold wave occurred during 26 December - 4 January, and brought rain to lower elevations and snow in the mountain. The final wave of this storm series occurred on 4-6 January when 3 to 10 inches of precipitation fell on the Feather and Yuba River Basins. Inflow to Oroville Reservoir peaked at 250,000 cfs. Flow at Oroville was attenuated by the partially constructed dam to a maximum outflow of 158,000 cfs.

The storms of February 1986 severely affected northern California and northwestern Nevada. Heavy precipitation reached record levels in many locations. The heaviest precipitation occurred 200 miles north to 100 miles south of a line from San Francisco to Sacramento to Lake Tahoe. Over much of this area the precipitation ranged between 100 to 350 percent of normal February Precipitation. In the Feather River Basin, the heavy rains began on February 12 and continued through February 21. With the continued rain and storm runoff, storage increases at Oroville from February 13 through February 23 were 640,300 acre-feet or approximately seventy percent of the space available at the beginning of the flood.

Several reservoirs above Oroville contributed to incidental flood flow retention. Collectively, these reservoirs stored 408,000 acre-feet during the flood. The maximum release from Oroville Dam was 147,400 cfs on February 18 and 19. The Feather River at Gridley gage recorded a peak flow of approximately 150,000 cfs on February 19 compared to the past Oroville Dam peak flow of 90,100 cfs on January 15, 1980. Flows on the Feather River below the dam equaled but did not exceed the design flows of the downstream levees. However, on February 20, a levee break occurred on the south bank of the Yuba River at the towns of Linda and Olivehurst causing extensive residential and commercial damage.

Flooding in early January 1997 resulted when a series of three subtropical storms followed a cold storm and one of wettest Decembers on record. Prior to the late December storms, rainfall was already well above normal throughout the Sacramento and San Joaquin River basins. Then, several days before Christmas 1996, a cold storm from the Gulf of Alaska brought snow to low elevations in the Sierra Nevada foothills. The first of three subtropical storms hit Northern California on December 29, 1996, with less than expected precipitation totals. On December 30, the second storm arrived. The third and most severe storm hit late December 31 and lasted through January 2. The snowpack at lower elevations, melted when the trio of warmer storms hit. However, not much snowpack loss was observed at snow sensors over 6,000 feet in elevation in the northern Sierra. Precipitation totals at lower elevations in the Central Valley were not unusually high in contrast to extreme rainfall in the upper watersheds. Extreme precipitation in the Sierra Nevada resulted in record flows in both the Sacramento and San Joaquin River basins. Several gaging stations used to measure the water level in streams and rivers recorded the largest peaks in the history of their operation during this series of storms. Based on 3-day volume, inflows to Lake Oroville were the largest on record. The estimated peak bi-hourly inflow was 302,000 cfs and occurred on 1 January 1997. The maximum release from Lake Oroville was 160,000 cfs. Oroville came close to reaching design capacity as only 27 percent of the flood management reservation pool remained.

The eastern levee of the Feather River failed on the evening of January 3, 1997, near the town of Arboga, California. Within 24 hours of the initial failure, the levee breach had reached over 800 feet in length. Floodwaters inundated 12,000 acres, damaging over 700 structures. Although the area was primarily agricultural, many of the damaged structures were concentrated along Country Club Road and in the town of Arboga. In total, approximately 600 residential structures were within the flooded area. This area had a wide range of flooding depths, with maximum depths about 20 feet (structures totally covered) in the south near the levee break to minimal depths in the north near the Yuba County Airport.

6. Hydrologic Analysis

In support of the Comprehensive Study (USACE, 2002), the Water Management Section of the Sacramento District, USACE, has developed synthetic 50-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent chance exceedence flood events. These seven synthetic exceedence frequency events will provide a basis for defining existing conditions and eventual alternatives analysis and plan formulation. In this sense, this hydrology study will serve as a cornerstone for future Comprehensive Study investigations.

The methodology used by the Water Management Section of the USACE, in performing the Comprehensive Study, including: 1) updated natural flow frequency curves for locations within the basins; 2) a retrospective of historic floods that have impacted Central Valley rivers and the synthetic flood runoff centerings developed to represent flood events of a specific exceedence frequency; and 3) construction of seven synthetic exceedence frequency flood hydrographs.

The synthetic hydrology, as presented in the Comprehensive Study, was created to be "Comprehensive" in nature. Some watersheds were studied in more detail or had more detailed information available than others; the hydrology presented herein for the Sutter Basin is deemed acceptable for use in a feasibility study. The models developed for the Comprehensive Study analysis were created with the following assumptions and limitations:

- The data are stationary.
- The natural flow frequency curves are strictly rainflood frequency curves. Snowmelt runoff is not directly incorporated into the analysis.
- Centering hydrographs are predicated on flood runoff, not precipitation. The approach was driven entirely by historic flow data; precipitation never entered into any portion of the methodology.
- Storm runoff centerings were formulated based on the Composite Floodplain concept.

- The unregulated frequency curves computed for the Comprehensive Study were created by following procedures outlined in Bulletin 17B.
- Travel times and attenuation factors (Muskingum Coefficients) are fixed for all simulated exceedence frequencies.
- Mainstem unregulated flow frequency curves were designed to quantify the total flows that the basins produced in rainfloods, not the average natural flows expected at mainstem locations during any of the synthetic exceedence frequency storm events.
- Patterns for synthetic floods are formulated based on historic storms.

6.1 STORM CENTERING AND MODELING PROCEDURE

The hydrology for the feasibility study will be based upon the storm centering method described in the Comp Study. A storm centering is the simulation of the effect of storms that are positioned (centered) over particular locations in a watershed to produce flow rates of specific frequencies at those locations. In the Comp Study, a suite of storm centerings were used in developing synthetic hydrology for the Sacramento and San Joaquin watersheds to emulate the diverse spectrum of floods that can occur from different combinations of concurrent storms on tributaries, accounting for orographic influences and other factors that influence regional rainfall runoff events. The synthetic hydrology as presented in the Comp Study represents the best available data for the large flood sources (Sutter Bypass and Feather River) of the Sutter Basin Feasibility Study. The hydrology has also been used for several other feasibility studies in the region, such as the American River Common Features, Yuba River, and Marysville studies.

The synthetic hydrology of the Comp Study was based upon a transformation of unregulated hydrologic conditions to regulated conditions. This was accomplished by developing balanced unregulated hydrographs based upon historical patterned storm events, resulting in hydrographs representing the varying flood durations. 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 Comp Study, simulates reservoir operations and produces regulated flow (USACE, 1996). Resulting hydrographs were obtained from the HEC-5 model at 'handoff' points and modeled in more hydraulic detail using a UNET unsteady hydraulic model. The Sacramento and San Joaquin Comp Study UNET model, developed and calibrated for the Comp Study, is designed to simulate unsteady flow through a network of open channels, weirs, bypasses, and storage areas (USACE, 2002C).

The Comp Study UNET model downstream of the latitude at the City of Colusa has been replaced for the Sutter Basin Feasibility Study with an HEC-RAS unsteady model. Hydrographs were extracted from the Comp Study UNET model at two locations (a United States Geological Survey (USGS) gage, Sacramento River at Colusa, and a California Department of Water Resources (DWR) gage, Butte Slough at Meridian) and transferred to the HEC-RAS model. The two locations represent the entire flow passing the latitude at the City of Colusa. All model assumptions, flow, and routings upstream from these two locations are from the Comp Study (USACE, 2002). There were several simulations that were done for the Comp Study, however for the Sutter Basin Feasibility Study hydraulic model, the UNET model results from a levee overtopping only and no failure simulation were used.

6.2 DESIGN RAINFALL ANALYSIS

The interior drainage analysis required rainfall depth-duration-frequency tables derived from California Department of Water Resources (DWR) gage data. The data is available on the world-wide-web at: http://www.water.ca.gov/floodmgmt/hafoo/csc/climate_data/ (NOAA, 2011). The Nicolaus and Yuba City gages were selected based on their location , elevation, and period of record. Design storm depths for these gages are provided in Table 12.

TABLE 12

Design Storm Depths [inches].						
Rainfall Gage	Period of Record [year]	Gage Elevation [feet]	100-Year		200-Year	
			24-Hr	96-Hr	24-Hr	96-Hr
Nicolaus	91	47	3.38	6.77	3.67	7.4
Yuba City	46	60	3.88	7.33	4.2	8.01
Sutter Buttes [a]	n/a	n/a	4.23	8.46	4.59	9.25

[a] Rainfall depths over the Sutter Buttes were calcuated as 125% of the Nicolaus gage depths.

All subbasins south of Yuba City were assigned storm depths from the Nicolaus gage. The remainder of the subbasins were assigned storm depths according to the Yuba City gage with the exception of the subbasins within the Sutter Buttes. The Sutter Buttes typically receive higher rainfall amounts than the surrounding valley due to orographic effects and were treated as a unique rainfall zone. NOAA atlas 14 point rainfall depths (NOAA, 2011) were evaluated for both the Sutter Buttes and the surrounding valley. From this analysis, it was estimated that the Sutter Buttes typically receive about 25% more rainfall than the surrounding area. Therefore, in the absence of a rainfall gage in the Sutter Buttes, design rainfall depths for this region were estimated as 25% higher than those for the Nicolaus gage.

The 24-hour storm was patterned according to a SCS Type I temporal distribution as recommended in the Sutter County Design Standards (Sutter County, 2005). The 24-hour storm duration was chosen to stress the study area from a peak rainfall intensity and peak flow standpoint.

The 96-hour temporal distribution used was developed for the Sutter Basin region (California- Region 5) as part of the NOAA Atlas 14 Precipitation-Frequency Study for California (NOAA, 2011). The 96-hour storm, although a greater volume, is a less intense storm than the 24-hour storm and was analyzed to stress the study area from a volume standpoint.

The 24-hour and 96-hour temporal distribution patterns are provided in the Sutter Butte Flood Control Agency (SBFCA) Interior Drainage Analysis, dated February 2012, in graphical and table formats.

6.3 WIND WAVE ANALYSIS

The wind wave analysis has been moved to the hydraulic analysis appendix.

7. Analysis for Unregulated Flow Frequency Curves

7.1 GENERAL ANALYSIS

Unregulated frequency curves were developed at key mainstem and tributary locations in both the Sacramento and San Joaquin River basins. Unregulated frequency curves plot historic points and statistical distributions of unimpaired flows (no reservoir influence). Curves display volumes or average flow rates for different time durations over a range of annual exceedence probabilities. These curves can be used to translate: 1) hydrographs to frequencies (i.e., in 1997, the 3-day natural inflow to Oroville Dam, Sacramento River was roughly 209,000-cfs, which translates to a 1.6-percent chance exceedence event); and 2) frequencies to flood volumes (i.e., according to the curves, the 3-day natural inflow to Oroville Dam associated with an annual 10-percent chance exceedence event is approximately 105,000 cfs). After a curve is developed, the runoff volume for any of the seven synthetic exceedence frequency flood events can be obtained from the plot for that curve's specific location.

7.2 UNREGULATED FREQUENCY ANALYSIS

The unregulated frequency curves computed for the Comprehensive Study were created by following procedures outlined in Bulletin 17B, Guidelines for Determining Flood Flow Frequency, U.S. Department of the Interior, dated March of 1982. This report directs Federal agencies to use the procedures included therein for all "planning activities involving water and related land resources." Bulletin 17B requires the use of a Pearson Type III distribution with log transformation of the data (Log Pearson Type III distribution) as the method to analyze flood flow frequency.

In this report, charts containing frequency curves display two types of information. The frequency curve itself is one of these. The curve is derived from a statistical analysis of the recorded data after it has been transformed to log values. The mean, standard deviation and skew of the log-transformed data, are computed for the stream gage or reservoir. The data are screened for high and low outliers and if found, adjustments to the statistics are computed as outlined in Bulletin 17B. In addition, the resulting statistics are reviewed and sometimes adjusted or smoothed to account for sampling error differences among the various durations, or after comparison with similar gages in the watershed or region. The second type of information found on each frequency curve is the plot of the historical events given their estimated frequency. To determine its location on the frequency paper, the peak of each annually recorded event or peak flow value is given a hypothetical frequency based upon its assigned plotting position using a Log Pearson Type III distribution. In some instances, visual examination of the unregulated frequency curves contained in this report reveal a significant difference between the statistical frequency curve and the imaginary curve that would be formed if a pencil line were hand-drawn through the historical data points. For some curves in this report in which the characteristic described above was apparent, further examination was made. In addition, a few frequency curves were re-computed using alternative distributions such as Gumble type III or lognormal. The result was that the other distributions did not result in an improved fit. Bulletin 17B directs the use of a Log Pearson III Distribution unless compelling and substantive evidence can be found that other distributions are more appropriate.

Development of the unregulated frequency curves for the tributaries required daily natural flow data for all target locations. Data were obtained from USACE archives or computed by routing daily change in storage from upstream reservoirs and adding this routed value to the gage record at the location of interest. Most required storage time series were available through USGS publications. Other data were obtained directly from Central Valley and federal water agencies, including U.S. Bureau of Reclamation, U.S. Geological Survey, Oroville-Wyandotte Irrigation District, South Sutter Water District, Placer County Water Association, Nevada Irrigation District, Surface Water Data Inc., Southern California Edison, Sacramento Metropolitan Utility District, and Pacific Gas and Electric.

Data from tributaries were routed to downstream locations for use in constructing mainstem "index" frequency curves. The frequency curves that characterize the total flows through the mainstem index locations represent "at-latitude" flows (i.e., any and all diverted or channelized flows that pass through a particular gage's geographic latitude). Muskingum routings with travel times (in hours) and reach-specific attenuation factors were used to transport daily hydrographs through the basins, as shown in Table 13 for the Sacramento River Basin. Travel times and attenuation factors (Muskingum Coefficients) were obtained from past studies, through communication with local water agencies, or through comparisons of historic flood data. If no information was available from these sources, variables were estimated based on length of reach, average slope, and other channel characteristics. All river routings were assumed to be conservative (routings were simulated with indefinitely large channels); no flow was lost in overbank areas during transit.

TABLE 13

MUSKINGUM ROUTING PARAMETERS FOR SACRAMENTO RIVER BASIN INDEX POINTS				
Source	From	To	Travel Time (Hours)	Muskingum Coefficient
Sacramento River	Shasta Dam	Keswick	2	0.4
Sacramento River	Keswick	Clear Creek	3	0.4
Clear Creek	Whiskeytown Dam	Mouth	2	0.4
Sacramento River	Clear Creek	Cow Creek	2	0.1
Cow Creek	Gage near Millville	Mouth	1	0.2
Battle Creek	Gage below Coleman F.H.	Mouth	1	0.2
Sacramento River	Battle Creek	Bend-Bridge	3	0.1
Sacramento	Bend-Bridge	Ord Ferry	18	0.2
Mill Creek	Gage near Los Molinos	Ord Ferry	14	0.2
Elder Creek	Gage near Paskenta	Ord Ferry	20	0.2
Deer Creek	Gage near Vina	Ord Ferry	14	0.2
Thomes Creek	Gage at Paskenta	Ord Ferry	20	0.2
Big Chico Creek	Gage near Chico	Ord Ferry	6	0.2
Stony Creek	Black Butte	Ord Ferry	11	0.2
Sacramento	Ord Ferry	Moulton Weir	13	0.2
Sacramento	Moulton Weir	Colusa Weir	3	0.2
Sacramento	Colusa Weir	Tisdale Weir	9	0.2
Sacramento	Tisdale Weir	Knights Landing	7	0.2
Sacramento	Knights Landing	Fremont Weir	2	0.2
Ord Ferry Overflow	Ord Ferry	Highway 162	32	0.1
Butte Creek	Gage at Chico	Highway 162	7	0.2
Butte Creek and Ord Ferry Overflow	Highway 162	Moulton Weir	10	0.1
Moulton Weir Spill	Sacramento River	Butte Creek	4	0.1
Butte Basin Flow	Moulton Weir/Butte Creek	Colusa Weir	4	0.1
Butte Basin Flow	Colusa Weir	Butte Sink	16	0.1
Butte Basin Flow	Butte Sink	Tisdale Weir	8	0.1
Sutter Bypass/Tisdale I	Tisdale Weir	Fremont Weir	20	0.1
Feather River	Oroville	Gridley	3	0.2
Feather River	Gridley	Honcut	1	0.17
Feather River	Honcut	Yuba City	4	0.17
North Yuba River	Bullards Bar Dam	Englebright	3	0.15
Yuba River	Deer Creek	Dry Creek	2	0.15
Yuba River	Dry Creek	Marysville	1	0.15
Yuba River	Marysville	Mouth	1	0.15
Feather River	Yuba River	Bear River	8	0.35
Bear River	Wheatland	Mouth	5	0.35
Feather River	Bear River	Nicolaus	2	0.35
Feather River	Nicolaus	Fremont Weir	4	0.2
Sacramento River	Verona	Sacramento Weir	5	0.2

This procedure was not intended to reflect the natural dynamics of the Central Valley, where large flood flows often discharge to out-of-bank areas and are lost or greatly attenuated. The unregulated flow frequency curves were designed to quantify the total flows that the basins produced in rain floods throughout the period of record, rather than the average natural flows expected at mainstem locations during any of the seven synthetic exceedence frequency storm events.

Historical data were plotted using moving averages of the daily time series for 3-, 5-, 7-, 10-, 15-, and 30-day duration natural flow at all points of interest. Wintertime maxima were picked from the moving average for each water year. All snowmelt-driven events were screened out from these duration maxima; screened events were replaced with the highest rainflood, or rainfall driven, maxima experienced during that water year, which included any rain-on-snow events occurring during the obvious rainflood season of a particular annual record. Values were sorted, ranked, and graphed with median plotting positions. Statistics were computed for these samples of annual rainfloods with USACE statistical analysis tools (FFA and REGFREQ). Sample mean, standard deviation, and skew were computed and, in some cases, smoothed to better represent the values for each duration. The Pearson Type III Distribution with log transformation of the data and final statistics were used to construct best-fit curves for all durations and were plotted on the same graph as the historic values for each location.

Unregulated frequency curves were prepared for 43 tributary locations and 8 mainstem locations. In all cases, curves were developed or updated to reflect post-1997 flood hydrology. For any location, the amount of runoff volume produced during simulation of any one of the seven synthetic exceedence frequency flood events can be read off of the family of best-fit curves or computed directly from the final statistical distribution of each duration.

Flood volumes at mainstem index locations represent the sum of volumes contributed by all upstream tributaries, but do not offer any information regarding how each tributary provides to the whole. In this sense, these index curves can provide exceedence frequency targets, in terms of volumes, at mainstem locations for any of the seven synthetic exceedence frequency flood patterns that involve a number of upstream tributaries. During the development process, it was assumed the effects of increased urbanization occurring throughout the period of record were insignificant on the timing of runoff within the watersheds of the Sacramento and San Joaquin rivers. For a further investigation of this assumption, please reference the "Watershed Impact Analysis" done by HEC (USACE, 2002).

The approach formulated and described above was driven entirely by historic flow data. Each year of record included the influence of snowmelt, infiltration, interception, precipitation distribution, timing of runoff, storm development characteristics, and physical basin attributes for that annual rainflood event. Historic flow data records provided a sufficient sample of flood events to characterize hypothetical flood volumes and tributary-system relationships.

No synthetic precipitation events were required. In fact, precipitation never entered into any portion of the methodology.

Design flows and regulated flow-frequency tabular values are shown below in Table 14. The mainstem storm centering for the Sacramento River used for the Sacramento River below Colusa, and the Sutter Bypass is at the latitude of Sacramento. The tributary storm centering for the Feather River below Oroville Dam is centered at Shanghai bend. The frequency curves for the locations of the Sacramento River at Colusa and the Feather River at Shanghai Bend are shown as plates 9 and 10.

TABLE 14. Design Flows and Regulated Flows

Stream & 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
isdale Weir to Sutter Bypass	30,000	28,000	30,000	31,000	32,000	34,000	36,000	41,000
ther River								
)roville to Honcut Creek	210,000	60,000	100,000	150,000	150,000	150,000	174,000	320,400
loncut Creek to Yuba River	210,000	49,000	107,000	157,000	159,600	163,000	182,000	293,600
'uba River to Bear River	300,000	71,000	192,000	256,000	281,000	283,000	360,000	534,000
ear River to Sutter Bypass	320,000	78,000	211,000	288,000	321,000	336,000	409,000	574,000
ter Bypass								
leridian to Wadsworth Canal	150,000	57,000	102,000	126,000	155,000	184,000	228,000	327,000
Vadsworth Canal to Tisdale Weir	155,000	58,000	103,000	127,000	156,000	185,000	229,000	327,000
isdale Weir to Feather River	180,000	71,000	117,000	141,000	163,000	197,000	237,000	329,000
eather River to Sacramento River	380,000	141,000	283,000	393,000	436,000	490,000	581,000	799,000
dsworth Canal								
ributary Specific Storm Centering	1,500	820	2,550	3,200	3,980	4,830	5,750	7,070
rokee Canal								
lelson Shipee Road to Western Canal	8,500							
Vestern Canal to Afton Road	11,500	6,000	10,300	12,100	13,200	14,300	15,200	16,300
fton Road to Gridley – Colusa Road	12,500							

Notes: data pulled from PBI Addendum 1 models which are the final models for the Sutter Basin Feasibility Study.
Design flows obtained from USACE drawing file 50-10-3334. Levee Channel Profiles, dated 15 March 1957.
Peak flow is the higher of the Sacramento or Shanghai Bend storm centering peak flows.
Wadsworth Canal and Cherokee Canal peak flows are from unregulated streams.
Peak flows for the 0.5% and 0.2% ACE flood events include effects from levee overtopping and may be reduced from the possible maximums.

7.3 UNREGULATED FREQUENCY CURVES FOR SACRAMENTO RIVER AT THE LATITUDE OF SACRAMENTO AND ORD FERRY

The unregulated frequency curve for the latitude of Sacramento is a tool that can be used to develop a mainstem storm centering. Mainstem centerings were designed to stress widespread valley areas. Index frequency curves were prepared at Ord Ferry and Sacramento in the Sacramento River Basin. These curves provide the hypothetical volumes that the basin will produce during simulations of each of the seven synthetic exceedence frequency flood events. The role of the mainstem centerings is to distribute these volumes back into the basin, tributary by tributary, in accordance with patterns visible in historic flood events. Once the volume is distributed it will be translated into hydrographs and routed through reservoir simulation models (Appendix C of the Comp Study) to produce the synthetic exceedence frequency regulated hydrographs at the two locations needed to construct floodplains throughout the Sacramento river system.

Mainstem centerings reflect a generalized flood pattern based on a number of historic events. Through the incorporation of multiple floods into one characteristic pattern, relationships between tributaries become more stable and the influence of powerful, but isolated, storm cells are downplayed.

The frequency curve for the latitude of Sacramento is shown as plate 11. Flow frequency curves are generated at a specific location, usually a gage location. However, for a river basin a large as the Sacramento River basin, a synthetic storm centering approach is required to correctly portray the discharge probability at locations away from the storm center. Table 15 below shows the percent chance exceedence for selected locations throughout the Sacramento River basin with a storm center at Ord Ferry, while table 16 shows the percent exceedance for a centering at the latitude of Sacramento. A flow-frequency table computed from the statistics shown in the Ord Ferry frequency curve is shown in Table 17 below, while the flows from the centering at the latitude of Sacramento frequency curve is shown in Table 18 below.

TABLE 15 Sacramento River Mainstem at Latitude of Ord Ferry

Synthetic Flood Centerings for Sacramento River Total Flow at Latitude of Ord Ferry							
Index Point	Percent Chance Exceedence						
	50%	10%	4%	2%	1%	0.50%	0.20%
Sacramento River at Shasta	82.08	16.91	5.71	2.41	1.25	0.65	0.28
Clear Creek at Whiskeytown	61.56	15.04	9.03	5.61	2.92	1.52	0.65
Cow Creek nr Millville	61.56	13.53	8.02	3.89	2.02	1.05	0.45
Cottonwood Creek nr Cottonwood	61.56	15.04	9.03	5.61	2.92	1.52	0.65
Battle Creek below Coleman FH	61.56	13.53	8.02	3.89	2.02	1.05	0.45
Mill Creek near Los Molinos	87.94	15.03	7.22	5.94	3.1	1.61	0.69
Elder Creek near Paskenta	87.94	19.33	12.5	10.1	5.26	2.74	1.17
Thomes Creek at Paskenta	87.94	19.33	12.5	10.1	5.26	2.74	1.17
Deer Creek near Vina	87.94	15.03	7.22	5.94	3.01	1.61	0.69
Big Chico Creek near Chico	87.94	15.03	7.22	5.94	3.01	1.61	0.69
Stony Creek at Black Butte	87.94	19.33	12.5	10.1	5.26	2.74	1.17
Butte Creek near Chico	87.94	15.03	10.2	8.42	4.39	2.28	0.97
Feather River at Oroville	87.94	19.33	9.62	8.42	4.39	2.28	0.97
Yuba River at New Bullards Bar	87.94	19.33	11.76	9.18	4.78	2.49	1.06
Yuba River at Englebright	87.94	19.33	11.76	9.18	4.78	2.49	1.06
Deer Creek near Smartsville	87.94	19.33	11.76	9.18	4.78	2.49	1.06
Bear River near Wheatland	87.94	19.33	12.03	10.1	5.26	2.74	1.17
Cache Creek at Clear Lake	87.94	19.33	18.05	12.63	6.58	3.42	1.46
North Fork Cache Creek at Indian Valley	87.94	19.33	18.05	12.63	6.58	3.42	1.46
American River at Folsom	87.94	19.33	14.29	12.63	6.58	3.42	1.46
Putah Creek at Berryessa	87.94	19.33	18.05	12.63	6.58	3.42	1.46

TABLE 16 Sacramento River Mainstem at Latitude of Sacramento

Synthetic Flood Centerings for Sacramento River Total Flow at Latitude of Sacramento							
Index Point	Percent Chance Exceedence						
	50%	10%	4%	2%	1%	0.50%	0.20%
Sacramento River at Shasta	84.42	17.03	8.09	4.41	2.21	1.13	0.44
Clear Creek at Whiskeytown	80.91	17.03	10.79	6.47	3.24	1.66	0.65
Cow Creek nr Millville	80.91	16.18	9.71	5.39	2.70	1.38	0.60
Cottonwood Creek nr Cottonwood	80.91	17.03	10.79	6.47	3.24	1.66	0.65
Battle Creek below Coleman FH	80.91	16.18	9.71	5.39	2.70	1.38	0.60
Mill Creek near Los Molinos	88.26	16.18	9.71	4.22	2.35	1.23	0.51
Elder Creek near Paskenta	88.26	19.42	10.79	4.85	2.70	1.38	0.58
Thomes Creek at Paskenta	88.26	19.42	10.79	4.85	2.70	1.38	0.58
Deer Creek near Vina	88.26	16.18	9.71	4.22	2.35	1.23	0.51
Big Chico Creek near Chico	88.26	16.18	9.71	4.22	2.35	1.23	0.51
Stony Creek at Black Butte	88.26	19.42	10.79	4.85	2.70	1.38	0.58
Butte Creek near Chico	66.70	13.63	6.08	2.75	1.38	0.71	0.30
Feather River at Oroville	53.60	11.78	4.42	2.41	1.20	0.62	0.24
Yuba River at New Bullards Bar	55.09	12.52	4.86	2.10	1.05	0.54	0.21
Yuba River at Englebright	55.09	12.52	4.86	2.10	1.05	0.54	0.21
Deer Creek near Smartsville	55.12	12.52	4.86	2.10	1.05	0.54	0.21
Bear River near Wheatland	53.60	11.13	4.42	2.10	1.05	0.54	0.21
Cache Creek at Clear Lake	52.19	12.52	6.95	4.45	2.22	1.14	0.45
North Fork Cache Creek at Indian Valley	52.19	12.52	6.95	4.45	2.22	1.14	0.45
American River at Folsom	55.09	12.52	4.86	2.51	1.26	0.64	0.25
Putah Creek at Berryessa	52.19	12.52	6.95	4.45	2.22	1.14	0.45

TABLE 17

Unregulated Flow Frequency for the "Ord Ferry" storm centering							
Avg flow[2](cfs) for given duration and AEP[3]							
1/AEP[3]	2	10	25	50	100	200	500
Duration (days[1])	0.5	0.1	0.04	0.02	0.01	0.005	0.002
1	102,000	234,000	317,000	386,000	460,000	541,000	657,000
3	81,000	184,000	247,000	299,000	354,000	414,000	499,000
7	65,000	145,000	193,000	232,000	272,000	315,000	376,000
15	49,000	103,000	131,000	153,000	174,000	196,000	225,000
30	38,000	76,000	97,000	112,000	127,000	143,000	163,000

TABLE 18

Unregulated Flow Frequency for the "at latitude of Sacramento" storm centering							
Avg flow[2](cfs) for given duration and AEP[3]							
1/AEP[3]	**2**	**10**	**25**	**50**	**100**	**200**	**500**
Duration (days[1])	**0.5**	**0.1**	**0.04**	**0.02**	**0.01**	**0.005**	**0.002**
1	157,000	399,000	561,000	700,000	853,000	1,023,000	1,275,000
3	144,000	357,000	498,000	617,000	749,000	894,000	1,108,000
5	132,000	320,000	444,000	547,000	661,000	786,000	969,000
7	122,000	297,000	410,000	506,000	611,000	726,000	894,000
15	97,000	223,000	299,000	361,000	426,000	496,000	595,000
30	76,000	164,000	213,000	252,000	292,000	334,000	390,000

7.4 UNREGULATED FREQUENCY CURVES FOR FEATHER RIVER AT SHANGHAI BEND

7.4.1 Hypothetical Storm Pattern Generation

The intent of this hydrologic analysis is to prepare a hypothetical storm pattern and flood hydrographs that can be fed into reservoir system and hydraulic models for each frequency event (10-, 2-, 1-, and 0.2-percent chance exceedences). In order to define floodplains for this particular reach of the Feather River, synthetic storms centered over this area were developed. The Comprehensive Study includes a number of synthetic storms that produce large floods along the Feather and Yuba rivers, including storms centered at Oroville Dam on the Feather River, Marysville on the Yuba River, and at the Latitude of Sacramento (USACE, 2002). However, none of these storms were centered at locations along the Feather River within this study area. Therefore, hypothetical storms were developed where the most upstream and downstream locations of the study reach (Feather River at Shanghai Bend and the Sacramento River at Latitude of Verona) experience greater intensity than any other location within the Sacramento Valley.

Large floods at Shanghai Bend result from the combination of high flows from both the Yuba River and Upper Feather River. Historically, large events occurring at Shanghai Bend have resulted from rare events occurring on the Upper Feather River (above Oroville) and also on the Yuba River, with one of these rivers having a slightly rarer event than the other. For example, in 1997 a slightly less frequent event occurred at Oroville than on the Yuba River at Marysville, and in 1965 Marysville experienced a less frequent event than Oroville. However, in both of these years, large floods occurred at Shanghai Bend. Because of the possibility that either scenario could happen, two different hypothetical storm patterns were produced. These storm patterns are shown in Tables 19 and 20.

TABLE 19

Feather River Above Shanghai Bend Storm Centering With a Specific Centering on the Yuba River							
Index Point	**Percent Chance Exceedence**						
	50%	**10%**	**4%**	**2%**	**1%**	**0.50%**	**0.20%**
Sacramento R at Shasta	101.01	20.20	8.08	5.77	2.89	1.44	0.58
Clear Cr at Whiskeytown	344.83	68.97	27.59	19.70	9.85	4.93	1.97
Cow Cr nr Millville	196.08	39.22	15.69	11.20	5.60	2.80	1.12
Cottonwood Cr nr Cottonwood	344.83	68.97	27.59	19.70	9.85	4.93	1.97
Battle Cr blw Coleman FH	196.08	39.22	15.69	11.20	5.60	2.80	1.12
Mill Cr nr Los Molinos	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Elder Cr nr Paskenta	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Thomes Cr at Paskenta	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Deer Cr nr Vina	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Big Chico Cr nr Chico	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Stony Cr at Black Butte	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Butte Cr nr Chico	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Feather R. at Oroville	54.95	10.87	4.35	2.17	1.06	0.53	0.21
Yuba R. at New Bullards Bar	50.00	10.00	4.00	2.00	1.00	0.50	0.20
Yuba R nr Marysville	50.00	10.00	4.00	2.00	1.00	0.50	0.20
Deer Cr nr Smartsville	125.00	25.00	10.00	5.00	2.50	1.25	0.50
Bear R nr Wheatland	125.00	25.00	10.00	5.00	2.50	1.25	0.50
Cache Cr at Clear Lake	153.85	30.77	12.31	6.15	3.08	1.54	0.62
Cache Cr at Indian Valley	153.85	30.77	12.31	6.15	3.08	1.54	0.62
American R at Folsom	76.34	15.27	6.11	3.05	1.53	0.76	0.31
Putah Cr at Berryessa	153.85	30.77	12.31	6.15	3.08	1.54	0.62
Note – The seven frequency storms centered at Shanghai Bend and Verona are the bold values located in the column headers. The concurrent frequency values for each index location are given below each column header. For example, a 2.89% chance exceedence event occurs on the Sacramento River above Shasta Dam during the 1% chance exceedence event centered at Shanghai Bend and Verona.							

TABLE 20

Unregulated Flow Frequency for Feather River at Shanghai Bend storm centering							
	Avg flow[2](cfs) for given duration and AEP[3]						
1/AEP[3]	**2**	**10**	**25**	**50**	**100**	**200**	**500**
Duration (days[1])	**0.5**	**0.1**	**0.04**	**0.02**	**0.01**	**0.005**	**0.002**
0.0416	93,600	282,800	408,900	513,600	626,300	746,900	918,300
1	73,600	222,600	321,800	404,200	492,900	587,900	722,800
3	56,600	172,200	249,400	313,600	382,800	457,000	562,400
7	39,900	115,800	165,200	205,700	249,000	295,000	359,900
15	29,300	77,600	106,100	128,400	151,200	174,600	206,100
30	22,100	54,900	73,600	88,000	102,600	117,300	137,000

There are only subtle differences between these two storm patterns. These differences lie within the index locations on the Feather and Yuba rivers. For storm centering A, exceedence frequency values generated at Shanghai Bend and the Latitude of Verona are the same as the frequency assigned to the Yuba River. However, for storm centering B, the Yuba River experiences a more frequent event, and the Feather River at Oroville is assigned the same exceedence frequency value that is produced at Shanghai Bend and the Latitude of Verona. In other words, storm centering A has more emphasis on the Yuba River, and storm centering B has more emphasis on the Feather River.

In developing these storm centerings, the guidelines for preparation of mainstem centerings developed for the Comprehensive Study were followed (USACE, 2002). Shanghai Bend and the Latitude of Verona are the bull's eyes of the storm. That is, no other location within the Sacramento River Basin experiences a larger flood than at Shanghai Bend and the Latitude of Verona for the seven hypothetical storms (10-, 2-, 1-, and 0.2- percent chance exceedences). First, the distribution of storm intensity for the Upper Feather and Yuba River basins was developed. Initial exceedence frequency values were assigned to the Yuba River and Feather River index locations. Hydrographs were then constructed at these tributary locations and routed through the system to Shanghai Bend. Duration maxima (peak, 1-, 3-, 7-, 15-, and 30-day) were computed for the hydrographs at Shanghai Bend and compared with the average flows from the frequency curves. The initial pattern was then increased or decreased and the comparison process was repeated until results agreed reasonably with the unregulated rain flood frequency curves.

Once this portion of the pattern was set, the same process was followed for the Latitude of Verona index location. The storm pattern for the rest of the tributary index locations were based upon the average of the Feather and Yuba River storm centerings generated for the Comprehensive Study [#]. This pattern was iteratively adjusted by a fixed percentage until the duration maxima (1-, 3-, 7-, 15-, and 30-day) computed at the Latitude of Verona agreed reasonably with the unregulated rain flood frequency curve at this index location.

The frequency curves used in this process were obtained from the Comprehensive Study (USACE, 2002), except for the Shanghai Bend unregulated flow frequency curve. This curve was adopted from the 1999 FEMA report entitled, “Rain Flood Flow Frequency Analysis, Feather and Yuba Rivers” (USACE, 2002). No adjustments were made to any of the frequency curves except for the peak curve for Shanghai Bend. According to Robert Collins, District Hydrologist, the peak mean for the unregulated flow frequency curve at Shanghai Bend was proportioned based on the relationship of the peak and 1-day means at Oroville, since no peak unregulated data at Shanghai Bend was available. The frequency curve for the Feather River at Shanghai Bend with the modified statistics is presented in Plate 12.

It was determined through a comparison of stages from hydraulic models using as input the hydrology from the various storm centerings that the Feather-Yuba storm centering at Shanghai Bend and the mainstem storm centering at the latitude of Sacramento produced the highest stages. Therefore only those two storm centerings were kept for the analysis of Sutter basin flood risk management.

7.5 UNREGULATED FREQUENCY CURVES FOR CHEROKEE CANAL AT RICHVALE

7.5.1 Purpose:

The hydrology presented in this hydrology appendix for the Butte County portion of the Sutter Basin focuses on the Cherokee Canal, which is a potential source of flooding in the northern portion of the feasibility study area. The hydrology includes the development of flood frequency estimates and 30-day balanced hydrographs for the n-year (50-, 20-, 10-, 4.0-, 2.0-, 1.0-, 0.5-, and 0.2-) percent chance synthetic flood events on the Cherokee Canal from Cottonwood Creek to Afton Road.

7.5.2 Study Area:

The Cherokee Canal, located in Butte County, is tributary to Butte Creek. The Cherokee Canal watershed includes the total drainage above the Cherokee Canal, an artificial channel that flows southwesterly to lower Butte Creek. The watershed is bounded by the Feather River watershed to the east and southeast, by Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south. The three primary tributaries to Cherokee Canal are Dry Creek, which, with its tributary, Clear Creek, flows out of the Sierra Nevada foothills, and Cottonwood and Gold Run creeks, which flow west from Table Mountain.

The Cherokee Canal drainage area covers approximately 94 square miles. Its elevation varies from about 70 feet on the Cherokee Canal to about 2,200 feet in the headwaters of Dry Creek. The most heavily urbanized area in the watershed is the incorporated city of Paradise, where the headwaters of Dry and Clear creeks are located. Land use on the valley floor is mostly agricultural, with rice fields predominating. Native vegetation covers the foothills. Plate 14, the general map, shows the boundaries of the upper Cherokee Watershed and the Cherokee Canal watercourse from the headwaters down to the confluence with Butte Creek. Plate 15 shows the area’s topography and a more detailed map of the upper Cherokee Canal drainage.

7.5.3. Background:

Between 1959 and 1960 the Corps of Engineers constructed the Cherokee Canal flood control project from Butte Sink up to Dry Creek. The Federal Flood Control Act of 1944 authorized the construction of the Cherokee Canal as part of several flood control projects on Sacramento River tributaries. The objectives of the Cherokee Canal flood control project were to provide flood protection and to control inflow of sediment into the canal. According to the Cherokee Canal Design Memorandum, dated 15 November 1958, the Cherokee Canal Levee Project included levee construction and channel improvement on the Cherokee Canal and its principal tributaries. The project, as designed, would provide flood protection to 22,000 acres of improved agricultural land, highways, railroads, and irrigation canals. The project begins at the Lower Butte Basin and runs northeasterly to high ground about 13 miles north of Biggs, for a total distance of approximately 22 miles. The design capacity for Cherokee Canal was 8,500 cfs from the upstream end of the canal down to the confluence with Cottonwood Creek, 11,500 cfs from Cottonwood Creek down to Afton Road (the Biggs Princeton Highway), and 12,500 cfs from

Afton Road to the downstream end of the canal. The design capacity reaches are identified on Plate 15.

7.5.4. Stream Gage and Recent Flood History:

A streamflow gaging station was established on the Cherokee Canal at Butte City Road Bridge (State Highway 162). The General Map, Plate 14, shows the location of this streamflow gage, "Cherokee Canal near Richvale," California DWR station A02984. Records for this station have been collected from water year 1961 to present. Flow and stage records are available back to 1976 on the Department of Water Resources Water Data Library website(DWR, 2010). Table 21 lists the five highest flows of record for the Cherokee Canal gaging station. See Section 6.3 for information on the October 1962 high flow event and Section 7.1 for information on other high flow events on the Cherokee Canal.

Table 21

Tabulation of High Peak Flows For Cherokee Canal Gage (DWR Station A02984)

Peak Flow (cfs)	Date
15,200	13-Oct-62
11,000	13-Jan-69
10,000	11-Mar-89
9,750	21-Jan-64
9,460	24-Dec-83

During the first ten years of the project, several high flows reached or exceeded warning stage at the gage. The high flows deposited sediment from the upstream mining debris in the canal; brush and willows growing in the canal fixed the sediment deposits in place.

On 11 March 1989, a levee break occurred on the left bank of Cherokee Canal just upstream of Nelson-Shippee Road Bridge. The break was caused by overtopping, due to backwater from debris blocking the bridge opening. Design capacity of the canal at this location was 8,500 cfs. Apparently, the levee break resulted from an overnight flood on 11 March that carried enough debris to block the bridge opening and produce a peak flow of 10,000 cfs downstream at the Richvale gage. [#]

During the January 1995 flood, a waterside levee slip occurred on the left levee of Cherokee Canal about 300 feet north of State Highway 162, the location of the "near Richvale" gaging station (Plate 15). The slip was covered with sandbags and plastic to prevent levee failure, which would have flooded several farm houses and the USDA Rice Experimental Station 9USACE, 1995). The observed peak flow at the gage for this event was 8,220 cfs.

The Department of Water Resources removed sediment from various reaches of the Cherokee Canal in 1988, 1989, 1990, and 1996. Occasional high flows down Dry Creek continue to deposit sediment in the Cherokee Canal. Sediment accumulation and vegetation in the canal have reduced its channel capacity such that at some locations the Cherokee Canal channel capacity has been reduced between 37 percent and 44 percent of the original 11,500 cfs design capacity [#].

7.5.5 Hydraulic Analysis – General:
The hydrologic analysis in this appendix uses a hypothetical flood pattern to compute balanced flood hydrographs for an 8-flood synthetic series (50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2% event floods), which will be used in a hydraulic routing model along a critical reach of the Cherokee Canal for a levee break analysis. This critical reach of the canal extends from the Western Canal Levee, at the confluence of Cottonwood Creek, down to the Biggs Extension, about a mile upstream of the Richvale gaging station. The reach is being analyzed to test for a potential left bank levee break that could cause flooding in the town of Biggs to the south. The analysis also includes a test of response time needed to repair a breach in the levee. If the levee is not repaired in a timely manner, later flood waves could increase the flooding to the south. For that reason, the synthetic flood series is 30 days in duration. Hydrographs at the Richvale gaging station are equivalent to those for the critical levee reach as well as for the Cherokee Canal down to Afton Road, the lower end of the hydraulic model. Plate 15 shows the extent of the Cherokee Canal hydraulic model, from Afton Road up to the downstream end of Cottonwood Creek.

7.5.6 Flow Frequency Analysis:
The streamflow gage, Cherokee Canal near Richvale (DWR gage A02984) currently has 46 years of record available, from 1961 to 2006. More recent gaged data are still preliminary. The gage is located at Butte City Road Bridge, 2.1 miles south of Richvale. Flows at the gage are similar to those along the Cherokee Canal reach being analyzed upstream, from the Cottonwood Creek confluence to the Biggs Extension canal. No additional flow enters the canal downstream of the Cottonwood Creek confluence. Daily flows at the gage are available for the period of record; hourly flows are available for water years 1982 to 2006, as well as for the floods of October 1962, January 1964, December 1964, January 1965, and January 1969. DWR Northern District provided a table of annual peak flows for the period of record. Data for the Cherokee Canal near Richvale gage are from (USACE, 2002).

7.5.7 Results and Conclusions:
The unregulated flow frequency of the Cherokee Canal at Richvale is presented in Table 18 below, and on plate 16 at the end of the report. Table 22 lists the peak, and volume flows for the 8-flood series from the flow frequency curves. Plate 17 shows a graphical representation of the 5-day waves for the 8-flood series hydrographs. For this study, it was assumed that the peak flows listed in Table 18 are able to remain in-channel down the Cherokee Canal.

TABLE 22

Peak and Duration Flow Rates for the Synthetic 8-Flood Series Hydrographs							
Percent Exceedence Flood Event	Peak Flow (cfs)	1-Day Flow (cfs)	3-Day Flow (cfs)	5-Day Flow (cfs)	10-Day Flow (cfs)	15-Day Flow (cfs)	30-Day Flow (cfs)
50%	5,900	3,040	1,960	1,540	1,070	869	600
20%	8,700	4,460	2,860	2,260	1,570	1,270	879
10%	10,300	5,280	3,390	2,670	1,860	1,510	1,040
4%	12,100	6,190	3,980	3,130	2,180	1,770	1,220
2%	13,200	6,870	4,360	3,430	2,390	1,940	1,340
1%	14,300	7,310	4,700	3,700	2,580	2,090	1,440
0.50%	15,200	7,780	5,000	3,940	2,750	2,220	1,540
0.20%	16,300	8,340	5,360	4,220	2,950	2,380	1,650

7.5.8. Hydrologic Uncertainty:

EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies," (USACE, 1996), requires use of risk and uncertainty procedures in the evaluation of flood damage reduction studies. An unbroken record of 46 years of stream gage data (1961 to 2006) is available for the DWR station Cherokee Canal near Richvale (DWR gage A02984) that fits a known statistical distribution such as log Pearson III. Based on a review of the flow record and methodology, it is recommended that the systematic record length of 46 years be used as the equivalent record length in the analysis of project performance. The final statistics associated with this record length for the Cherokee Canal near Richvale are:

Mean (Log) = 3.7484
Adopted Standard Deviation = 0.224
Adopted Skew = -0.7

7.6 UNREGULATED FREQUENCY CURVES FOR WADSWORTH CANAL

Wadsworth Canal is an artificial channel that carries rainy season and agricultural runoff from the northeast part of Sutter County south to the Sutter Bypass. The drainage area covers the eastern slopes of the Sutter Buttes, northeastern Sutter County north of the East and West Interceptor canals, and a portion of southern Butte County west of Feather River. The tributaries contributing to Wadsworth Canal are: the West Interceptor Canal and its tributary, Sutter City Lateral; and the East Interceptor Canal with its tributaries (from east to west): Live Oak Slough, RD 777 Lateral 1, Snake River with its tributary, Morrison Slough, and Sand Creek. The drainage area, primarily agricultural, covers about 91 square miles.

The elevation varies from about 54 feet at the upper end of Wadsworth Canal to over 2100 feet on South Butte, the headwaters of the West Interceptor Canal drainage. Aside from Sutter Buttes, the topography of the Wadsworth drainage is relatively flat. The channel capacity of

Wadsworth Canal is 1,500 cfs. During a period of high runoff, the water fills Wadsworth Canal to capacity, then ponds behind the interceptor canals until there is room in Wadsworth Canal to accommodate the ponded water.

The California Department of Water Resources operates two stage gages on Wadsworth Canal:

A0-5927 Wadsworth Canal Near Sutter, Lower Station, and
A0-5929 Wadsworth Canal Near Sutter, Upper Station.

At times, backwater from the Sutter Bypass affects the stage-discharge relationship.

The Wadsworth unregulated frequency curve was developed based on DWR gage A05929, Wadsworth Canal Upper gage. The period of record is 01Oct1939 to 30Sep1996. Annual 1-day maximum flows are available for WY 1939 to WY 1974. Daily data is available from 01Oct1975 to 30Sep1996. The gage was discontinued after WY 1996. A table of peak unregulated flows and volumes for the Wadsworth Canal is shown below in table 23. The flow-frequency curve is shown on plate 18.

TABLE 23

Unregulated Flow at the Wadsworth Canal Upper Gage								
1/AEP	2	5	10	25	50	100	200	500
Duration (days)	0.5	0.2	0.1	0.04	0.02	0.01	0.005	0.002
Peak	817	1,607	2,254	3,197	3,983	4,833	5,750	7,067
1	743	1,390	1,874	2,523	3,024	3,533	4,049	4,740
3	592	1,122	1,522	2,062	2,480	2,906	3,340	3,923
7	455	853	1,151	1,551	1,860	2,173	2,492	2,919
10	400	741	994	1,332	1,591	1,853	2,119	2,474
30	249	434	566	738	867	995	1,124	1,293

7.7 VERIFICATION OF UNREGULATED FLOWS AT INFLOW AND HANDOFF POINTS FOR HYDRAULIC ROUTING

7.7.1. PURPOSE

The purpose of this section is to specify flow hydrographs for use as Sutter Basin Feasibility Study hydraulic model boundary conditions. The Sutter Basin Study Area and hydraulic model hydrologic boundary conditions are illustrated in Plate 19.

7.72. BACKGROUND

A system wide hydrology study of the Sacramento San Joaquin basin was completed in 2002. The study, titled Sacramento San Joaquin Comprehensive Study formed the basis of multiple flood risk management studies throughout the Sacramento and San Joaquin Basins. Several of these studies completed refinements to the hydrologic modeling. Hydrology for the Sutter Basin Feasibility Study is based on the latest hydrologic studies.

7.73. SUTTER BASIN FEASIBILITY STUDY HYDRAULIC MODEL

The Sutter Basin Study Area and HEC-RAS hydraulic model domain are illustrated in the attached Plate 19. The HEC-RAS model is a 1-dimensional unsteady model. The model includes 16 inflow type boundary locations which require hydrograph inputs for 1/2, 1/10, 1/25, 1/50, 1/100, 1/200, and 1/500 AEP flood event simulations.

Due to the size of the tributary area, the hydraulic model is run for two different hydrologic storm-centerings to determine the critical scenario (peak stage and/or flow) at internal model locations. The Sacramento (SAC) storm centering represents a storm centered over the upper Sacramento River watershed with lesser concurrent rainfall/runoff from the Feather/Yuba watershed. The Shanghai Storm Centering (SHY) represents a storm centered over the Feather/Yuba river watershed with lesser concurrent rainfall/runoff from the Sacramento River Basin. Analysis of each storm-centering requires a complete suite of hydrographs (16) for the model boundary conditions. A detailed description of the storm centering procedure is described in the 2002 Comprehensive Study technical documentation (USACE, 2002). The selection of the Sacramento and Shanghai storm centerings from the 25 storm centerings evaluated in the comprehensive study is described in a memorandum for file dated 10 December 2010.

7.74. HYDROGRAPHS

A single DSS file with hydrographs for each of the model boundary locations was provided as a digital attachment as HEC-DSS filename “Sutter_FS_Hydrographs.dss”. Tables are provided in the memorandum to describe the refinements made to the boundary conditions used during plan formulation of conceptual and preliminary alternatives.

A tabulation of the period of record and the peak unregulated flows within the study reaches is shown in table 24. The plates following the references of this report show the frequency curves and notes pertaining to the frequency curve creation.

TABLE 24

Period of Record and Peak Un-Regulated Flows								
Stream and Reach	Period of Record	Un-Regulated Peak Flows (cfs)						
		1/2	1/10	1/25	1/50	1/100	1/200	1/500
		0.5	0.1	0.04	0.02	0.01	0.005	0.002
Sacramento River								
Colusa to Tisdale Weir	76	111,000	257,000	328,000	406,000	484,000	566,000	681,000
Tisdale Weir to Sutter Bypass	76	169,000	423,000	625,000	756,000	928,000	1,143,000	1,360,000
Feather River								
Oroville to Honcut Creek	94	47,000	136,000	201,000	253,000	311,000	374,000	464,000
Honcut Creek to Yuba River	94	51,000	144,000	211,000	267,000	328,000	394,000	489,000
Yuba River to Bear River	94	84,000	250,000	365,000	459,000	561,000	670,000	827,000
Bear River to Sutter Bypass	94	90,000	265,000	391,000	491,000	599,000	714,000	878,000
Sutter Bypass								
Butte Slough to Wadworth Canal	76	56,700	101,300	126,300	254,800	182,400	225,400	327,400
Wadsworth Canal to Tisdale Weir	76	57,400	103,200	128,900	157,800	186,000	229,400	332,100
Tisdale Weir to Feather River	76	101,200	259,400	342,200	429,100	516,900	607,800	1,215,200
Feather River to Sacramento River	76	169,100	422,600	624,900	755,800	928,200	1,143,400	1,359,700
Wadsworth Canal								
East - West Interceptor to Sutter Bypass								
Concurrent with Sacramento Storm Centering	56	420	1,240	1,300	1,480	1,520	1,550	1,600
Tributary Specific Storm Centering	56	820	2,550	3,200	3,980	4,830	5,750	7,070
Cherokee Canal								
Nelson Shipee Road to Western Canal	-							
Western Canal to Afton Road	46	6,000	10,300	12,100	13,200	14,300	15,200	16,300
Afton Road to Gridley-Colusa Road	-							

Note: Peak un-regulated flows include the effects of headwater reservoir regulation
Note: Peak Un-Regulated flows are the higher of the Sacramento or Shang Shanghai Bend Storm Centerings
Note: The period of record is used in HEC-FDA to establish the confidence limits for the unregulated and regulated flows. The period of record shown above was taken from the unregulated flow-frequency curves that are shown as plates following the references in this report.

8. Reservoir Simulation Model (HEC-5) Routing

The Hydrologic Engineering Center's HEC-5 software (Simulation of Flood Control and Conservation Systems), Version 8.0 (USACE, 1998), was used to route the synthetic tributary flood hydrographs through the reservoir system on the Sacramento River - Basin for analysis of floodplain and channel hydraulics. The Reservoir Simulation Model User's Guide, (USACE, 2003), documents the reservoir model assumptions and methodology for routing the flood hydrographs through two reservoir system models, the headwater reservoirs model, and the lower basin reservoirs model. The reservoir system models routed tributary flows for the entire Sacramento basin; however, the only hydrographs needed for this study are those upstream of and at Hamilton City. The synthetic unregulated hydrographs constructed for Shasta Dam and Valley tributary locations from the Hamilton City flood centering series were input to the reservoir system models to simulate regulated hydrographs at mains tern points on the Sacramento River, including Hamilton City. The Shasta Dam hydrographs were routed through the HEC-5 headwater reservoirs model, to simulate results from regulation by reservoirs upstream of Shasta Dam for the synthetic flood series. The headwater reservoirs are listed on Table 20, and their relative locations shown in the schematic on Plate 20. The simulated regulated inflow hydrographs to Lake Shasta and the downstream tributary hydrographs were then input to the lower basins reservoir model. The schematic on Plate 21 shows the relationship of the reservoirs and the east- and westside tributaries downstream on the Sacramento River.

TABLE 25

LIST OF RESERVOIRS IN THE SACRAMENTO RIVER BASIN ABOVE ORD FERRY						
Reservoir	**Drainage**	**Owner**	**Gross Pool Storage (ac-ft)**	**Drainage Area (sq.mi.)**	**Began Operation**	**Purpose**
Britton (Pit No. 3)	Pit River	Pac Gas & Electric Co	34,600	4700	1925	Water Supply & Hydropower
Pit No.6	Pit River	Pac Gas & Electiic Co	15,700	5020	1905	Water Supply & Hydropower
Pit No. 7	Pit River	Pac Gas & Electric Co	34,000	5170	1965	Water Supply & Hydropower
McCloud	McCloud River	Pac Gas & Electric Co	35,300	380	1965	Hydropower
Shasta	Sacramento, McCloud & Pit.	US Bureau of Reclamation	4,552,000	6665	1945	Flood Management
Whiskeytown	Clear Creek	US Bureau of Reclamation	241,100	201	1963	Water Supply
East Park	Little Stony Creek	US Bureau of Reclamation	51,000	102	1910	Water Supply
Stony Gorge	Stony Creek	US Bureau of Reclamation	50,350	735	1928	Water Supply
Black Butte	Stony Creek	USACE	143,700	741	1963	Flood Management

Modeled Reservoirs in the Feather and Yuba River Basins				
Reservoir	**Tributary**	**Owner**	**Storage Capacity (ac-ft)**	**Drainage Area (sq mi)**
<u>Feather River</u>				
Mountain Meadows	Hamilton Creek	PGE	24,800	158
Almanor	NFk Feather Creek	PGE	1,308,000	503
Butt Valley	Butte Creek	PGE	49,800	86.2
Antelope	Indian Creek	DWR	22,566	71
Bucks Lake	Bucks Creek	PGE	103,000	29.5
Frenchman	Last Chance Creek	DWR	55,477	82
Lake Davis	Big Grizzly Creek	DWR	83,000	44
Little Grass Valley	SFk Feather River	OWID	93,010	27.3
Sly Creek	Lost Creek	OWID	65,050	23.9
Oroville	Feather River	DWR	3,538,000	3,611
<u>Yuba above Marysville</u>				
New Bullards Bar	NFk Yuba River	YCWA	960,000	489
Jackson Meadows	MFk Yuba River	NID	52,500	37.11
Bowman	Canyon Creek	NID	64,000	28.91
Fordyce	Fordyce Creek	PGE	48,900	30
Spaulding	SFk Jackson Creek	PGE	74,773	118
Scotts Flat	Deer Creek	NID	49,000	20
Merle Collins	Dry Creek	BVID	57,000	72.3

TABLE 26

Oroville Release Schedule		
Actual or Forecasted Inflow (Whichever is Greater) (cfs)	Flood Control Space Used (acre-ft)	Required Releases (cfs)
0 – 15,000	0 – 5,000	Power demand
0 – 15,000	Greater than 5,000	Inflow
15,000 – 30,000	0 – 30,000	Lesser of 15,000 or maximum inflow
0 – 30,000	Greater than 30,000	Maximum inflow for flood
30,000 – 120,000	N/A	Lesser of maximum inflow or 60,000
120,000 – 175,000	N/A	Lesser of maximum inflow or 100,000
Greater than 175,000	N/A	Lesser of maximum inflow or 150,000

TABLE 27

New Bullards Bar Release Schedule		
Actual Inflow (cfs)	Flood Control Space Used (ac-ft)	Required Releases (cfs)
0 – 50,000	0 – 170,000	Inflow
50,000 – 120,000	0 – 170,000	Inflow
Greater than 120,000	0 – 170,000	Inflow up to 180,000
Note – Emergency spillway release diagram used when the combination of the rate of rise and pool elevation dictate.		

TABLE 28

Downstream Flow Target Reductions			
Reservoir (cfs)	Downstream Location (cfs)	Target Flow	Reduced Target Flow
Oroville	Yuba City	180,000	174,000
	Below Yuba R. Confluence	300,000	280,000
	Below Bear R. Confluence	320,000	312,000
New Bullards Bar	Marysville	120,000/180,000	106,000/154,000

9. RESERVOIR OPERATIONS MODELING (HEC-ResSim)

Methodology

Reservoir routing for the Feather River system was accomplished using both HEC-5 and the ResSim modeling package produced by the Hydrologic Engineering Center (USACE, 2007). HEC-5 models were constructed for the entire Sacramento River Basin for the Comprehensive Study. A ResSim model for the Feather-Yuba system has been completed by HEC. The spatial extent of this model is shown in Plate 22. ResSim was used to model the Feather River system from Oroville down to Nicolaus. The Comprehensive Study HEC-5 model was used to model the Sacramento River system down to the confluence with the Feather River (Verona). Output hydrographs from both of these models were used as input into the hydraulic models which cover the majority of the main river system (Feather and Sacramento rivers). Hydrograph input locations to the hydraulic model include:

- Feather River below Oroville Dam
- Honcut Creek
- Yuba River at Englebright
- Deer Creek on the Yuba River
- Dry Creek on the Yuba River
- Bear River at Wheatland
- Dry Creek on the Bear River
- Sacramento River at Vina Bridge
- Big Chico Creek
- Stony Creek
- Butte Creek
- Cache Creek
- Putah Creek

The intent of the HEC-5 to ResSim model conversion was to replicate the results of the Comprehensive Study HEC-5 models using ResSim; therefore, all hydrologic routing parameters and methods, starting storage assumptions, and operational rules found in the Comprehensive Study HEC-5 models were incorporated into the ResSim model. All of the reservoirs included in both the headwater and lower basin Comprehensive Study HEC-5 models for the Feather and Yuba River basins are included in this ResSim model (see Table 25 for a complete listing of these reservoirs).

Model Changes

A number of modifications were made to the ResSim model delivered to the Sacramento District by HEC prior to use in the Lower Feather Floodplain Mapping Study. The Comprehensive Study starting storage assumptions for the headwater reservoirs listed in Table 20 were based on the average reservoir storages prior to the December-January 1997, March 1995, and February 1986 flood events. In a floodplain mapping study, storage capability below the normal pool elevation of dams operated primarily for purposes other than flood control should not be considered because the availability of

such storage is uncertain. Therefore, the storages for all but two of the headwater reservoirs were set to gross pool. The storage for both Bucks Lake and Lake Almanor has never exceeded gross pool. Therefore, the maximum storage that has occurred at the lakes for months of December-March was used as the starting storage.
Slight modifications were also made to the ramp-up criteria scripted for Oroville. The Water Control Plan for Oroville specifies a release schedule that is a function of both flood spaced used and actual/forecasted inflow (Table 26).

The original ResSim model developed by HEC did not incorporate the forecasted inflow component of this release schedule. For example, releases would be restricted to 60,000 cfs until an actual inflow exceeded 120,000 cfs. At this time releases would begin to ramp up to the next specified flow value in the schedule (100,000 cfs for this example). In reality, releases would begin to ramp up to 100,000 cfs much earlier than this if a forecasted inflow greater than 120,000 cfs was known. All events greater than the 10% flood have peak flows greater than the largest value in the release schedule (175,000 cfs); so, for these events, Oroville releases were modeled to allow releases to ramp up freely to the maximum objective flow of 150,000 cfs at a rate of 5,000 cfs per hour. This situation is better understood by reviewing tables 26, 27 and 28 above.

Another change to the ResSim model involved travel times. Total travel time from Oroville Dam down to Yuba City was increased from 8 hours to 16 hours, which is consistent with the published travel times used by the Department of Water Resources and is in better agreement with what has been observed.

Lastly, changes were made to the model to incorporate a forecast uncertainty component to the local flow. The original models assumed complete certainty in local flow contributions downstream of a reservoir. This assumption yields high operational efficiency when operating for downstream flow criteria. In reality, however, local flow contributions could be greater or less than what was forecasted. Because of the possibility that local flows could be more than what is forecasted, reservoir releases are typically less than what the calculated releases would be based on the forecasted information. The magnitude of forecast uncertainty can vary from basin to basin and also from storm to storm. The Corps standard is to incorporate a 20% uncertainty in local flow contributions when operating for downstream flow targets. This uncertainty percentage was modeled in ResSim by reducing all downstream flow targets by 20% of the local flow contributing to that specific location. These modifications are listed in Table 28.

Model runs were also simulated assuming complete certainty in local flow contributions for all frequency events. Results from both scenarios were compared for each flood event. The scenario producing the larger of the two flows was selected for the hydraulic analysis. Generally, the complete certainty scenario was selected for events in which the reservoirs were able to satisfy downstream flow criteria, and the 20% uncertainty scenario was selected for those events in which the downstream flow criteria were exceeded.

RESULTS

Discussion of results will focus on the area in which the synthetic storms are centered, the Feather-Yuba system, even though the spatial extent of the storms covered the entire Sacramento River Basin.

Yuba River Basin

Seven reservoirs were modeled within the Yuba River Basin. New Bullards Bar, located on the North Fork of the Yuba River, is the only reservoir that has dedicated flood space. New Bullards Bar, which contains 170,000 acre-feet of flood space, operates to flow targets at Marysville. The flow criteria at Marysville is 180,000 cfs except when the Feather River is experiencing high flows. When the flows in the Feather River upstream of the Yuba River confluence are high, the flow target at Marysville is reduced to 120,000 cfs. This adjustment is made to assure that 300,000 cfs is not exceeded at the confluence of the Yuba River with the Feather River. New Bullards Bar is able to maintain its objective flow of 50,000 cfs for all events through the 2-percent chance exceedence event. For events larger than the 2-percent chance exceedence event, New Bullards Bar outflow exceeds 50,000 cfs. However, the 300,000 cfs flow target at the confluence is still met for the 1-percent chance exceedence event. See Table 29 for a summary of peak flows.

TABLE 29

Effects of Headwater Regulation

Location	Annual Percent Chance Exceedence	Unregulated Peak Flow (cfs)	Regulated Peak Flow (cfs)	% Peak Reduction Due to Regulation
MF + SF of Yuba	10%	38,800	34,100	12.2
	2%	76,400	68,500	10.3
	1%	96,200	87,300	9.3
	0.2%	149,200	137,000	8.2
Deer Creek	10%	4,900	4,600	5.9
	2%	8,700	8,200	5.9
	1%	10,100	9,500	5.9
	0.2%	13,000	12,400	4.9
Dry Creek	10%	4,900	4,600	5.9
	2%	8,700	8,200	5.9
	1%	10,100	9,500	5.9
	0.2%	13,000	11,600	10.9
Oroville Inflow	10%	153,700	135,900	11.6
	2%	284,100	253,100	10.9
	1%	349,600	311,500	10.9
	0.2%	520,300	464,600	10.7

Notes:
% Peak Reduced = ((Maximum Unregulated Inflow)-(Maximum Regulated Inflow))/(Maximum Unregulated Inflow) X 100%
Values are from model simulations of the Feather River Storm Centering A

TABLE 30

Regulated Peak Flows by Hydrologic Routing					
% Chance Exceedance	Feather R. at Oroville	North Yuba R. at New Bullards Bar Dam	Yuba R. at Marysville	Feather R. at Shanghai Bend	Feather R. At Nicolaus
10	100,000	44,400	92,400	200,000	219,000
2	150,000	50,000	150,000	293,000	323,000
1	150,000	66,100	155,000	296,000	323,000
0.2	327,000	150,000	313,000	607,000	668,000

Note - Values at downstream locations are a result of Muskingum hydrologic routing which assumes infinite channel capacity and neglects backwater effects and channel geometry. Hydraulic model output will differ from these results.

The other six reservoirs modeled in the Yuba Basin, known as headwater reservoirs, are much smaller and do not have any dedicated flood space. Even though the model simulations began with the majority of the reservoirs at gross pool, effects of peak attenuation for many locations along the Yuba River was still evident due to surcharge effects (Table 27). Average peak flows along the Middle and South forks of the Yuba River were attenuated by 8.8% for the 1-, 0.5-, and 0.2-percent chance exceedence events.

Feather River Basin

A total of 9 headwater reservoirs were modeled in the watershed above Oroville. Only 20% of the natural flow hydrograph at Oroville was routed through these headwater reservoirs. However, these reservoirs still had a significant impact on attenuating flows into Oroville (Table 27). Average peak inflows to Oroville were reduced by 10.8% for the 1-, 0.5-, and 0.2-percent chance exceedence events.

Oroville Reservoir has a maximum flood space reservation of 750,000 acre-feet, and is required to maintain flow targets at multiple downstream locations. It is also required to maintain flows at or below 180,000 cfs above the Yuba River confluence, 300,000 cfs below the Yuba River confluence, and 320,000 cfs below the Bear River confluence. These criteria were met for all events except the 0.5% chance exceedence event. In these two events releases specified by the Emergency Spillway Release Diagram (ESRD) were triggered. See Table 28 for a summary of peak flow results.

10.0 BEAR RIVER MODEL

10.1 Purpose of Study

The hydrologic analysis described in this section is for the Bear River (a tributary to the Feather River in Northern California). The hydrology developed in this report will be used to support the Sutter Basin feasibility study on the Bear River mainstem and its lower tributaries including Yankee Slough, UP Intercept Canal, and Dry Creek.

10.2 Scope of Study

This study covers the unincorporated areas of Sutter and Yuba Counties, California within the Bear River Watershed. A detailed map of the study area is shown on Plate 26. Products derived include the 10-, 2.0-, 1.0-, and 0.2-percent chance exceedence flood hydrographs for the Bear River at Wheatland, Yankee Slough at Swetzer Road, UP intercept canal at Plumas Lake and Dry Creek at the Best Slough split and Jasper Lane. The above index points coincide with the upstream end of the levees on each stream. Determining interior runoff behind the levees was not within the scope of this hydrologic analysis.

10.3 Basin Description and Reservoir Regulation

The Bear River Basin is located on the western slope of the Sierra Nevada Mountains. The basin is bounded on the north by the Yuba River Basin and has its confluence with the Feather River about 15 miles south of Marysville. The Bear River drains approximately 550 square miles of mountain, foothill, and valley areas. Elevation varies from 6,000 feet to 60 feet above sea level. A topographic map is shown on Plate 27.

Vegetation at the uppermost elevations, where high mean annual rainfall occurs, is covered with dense forest. Much of the Bear River watershed above Wheatland consists of rolling hills vegetated by grass and oak trees. Grazing is the main use for this land. The Dry Creek watershed consists mainly of rolling hills used for grazing or pasture. Beale Air Force Base, located in the middle of the Dry Creek watershed, is urbanized but only constitutes a small percentage of the total land use. The UP Intercept watershed consists of a mix of pasture, irrigated cropland (including rice farming), and urban areas. The main land-use in the Yankee Slough watershed is irrigated cropland.

There are three major reservoirs on the Bear River. New Camp Far West, constructed in 1963, is the most downstream reservoir, has a drainage area of 283 square miles, and is located in the low foothills. The dam is operated by South Sutter Water District for power, irrigation, and recreation. It has a 300 foot long ungated spillway and storage capacity is 104,000 acre-feet. The next reservoir is located 18 miles upstream at Lake Combie. This reservoir is relatively small and only has about 5,000 acre-feet of storage capacity. Rollins Reservoir is the uppermost major reservoir in the watershed, was completed in 1965, and drains the uppermost 104 square miles of the watershed. It has a 300 foot long ungated spillway and a storage capacity of 66,000 acre-feet. This dam is operated by the Nevada Irrigation District. All three reservoirs are operated to fill and spill as early in the rain season as possible; therefore, the only flood control provided is for early season storms that occur while the reservoirs are filling and surcharge storage during spillway flow. The Comprehensive Study in 2001 modeled the Bear River watershed with an HEC-5 Reservoir Model that included Camp Far West and Rollins Dams. Lake Combie was not modeled since storage capacity is minimal. The Comprehensive Study HEC-5 model of the watershed indicates that the reservoirs attenuate the natural peak flow at Bear River at Wheatland by about 11% during the 1% chance exceedence event. This attenuation is due to reservoir surcharge during uncontrolled spillway flow.

10.4 Principal Flood Problems

General rainstorms cause flooding on the mainstem of the Bear River and the larger local tributaries. Due to the relatively low elevation of most of the watershed, snowmelt runoff in the spring does not cause flooding. Localized cloudburst storms would only cause high flows on the smaller drainage basins such as the Linda-Olivehurst area and Yankee Slough. Some melting of the snowpack does occur during general rainstorms such as the January 1997 flood event.

10.5 Flood Protection Measures

Levees have been built along Bear River, Yankee Slough, Dry Creek, Best Slough and the UP Intercept Canal. Except for one reach on upper Yankee Slough (right bank), these levees are part of the Sacramento Flood Control Project. They are maintained by local reclamation districts. The three major upstream reservoirs on the Bear River only provide incidental storage that helps to attenuate the peak of major flood events or store floodwater early in the season before the reservoirs have filled.

10.6 Study Results of Hydrologic Analysis

Peak flood discharges for the 10-, 2.0-, 1.0-, and 0.2-percent chance exceedence events were obtained by using a HEC-HMS (USACE, 2010) rainfall-runoff model that was developed for the Bear River Basin and its tributaries. The subbasin delineation for this model is shown on Plate 31. Table 32 lists peak flows when storms are centered over the specific areas above the outlet point.

TABLE 31

TABLE 1: SUMMARY OF PEAK DISCHARGES					
FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. mi)	PEAK DISCHARGE (CFS EXCEEDENCE FREQUENCY			
		10%	2.0%	1.0%	0.2%
Bear River	292				
At Wheatland		25500	39400	44300	54700
Dry Creek					
Above Best Slough Split	82	9510	13700	15600	19800
At Jasper Lane	101	7470	10900	12500	15900
Best Slough					
Below Dry Creek Split	NA	3330	4810	5460	6920
UP Intercept Canal					
At Plumas Lake	87.2	2780	5060	6290	9630
Olivehurst Canal					
At Plumas Lake	9.46	706	1040	1190	1550
Yankee Slough					
At Swetzer Road	28.4	926	1950	2480	4050

TABLE 32

TABLE 2: SUMMARY OF COINCIDENT PEAK DISCHARGES					
FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. mi)	PEAK DISCHARGE (CFS EXCEEDENCE FREQUENCY			
		10%	2.0%	1.0%	0.2%
Bear River					
At Wheatland	292	25500	39400	44300	54700
Dry Creek					
Above Best Slough Split	82	6990	10500	12000	15500
At Jasper Lane	101	5850	8850	10200	13200
Best Slough					
Below Dry Creek Split	NA	2450	3670	4220	5440
UP Intercept Canal					
At Plumas Lake	87.2	2640	4890	6090	9390
Olivehurst Canal					
At Plumas Lake	9.46	594	900	1040	1360
Yankee Slough					
At Swetzer Road	28.4	761	1720	2220	3760

In addition to computing storm centerings at the above locations, coincident discharges for local tributaries during a centering on the mainstem of the Bear River were computed. Table 30 lists coincident peak discharges at tributary index points when the Bear River at Wheatland gage is experiencing a specific frequency event. Coincident peaks are to be used when specific centerings on the Bear River mainstem are being evaluated.

The Comprehensive Study (USACE, 2002) calculated 1- through 30-day duration frequency curves for the Bear River at Wheatland. The curves were adopted for this study. A peak flow frequency curve was also created for this analysis. Unregulated peak flow values for the Wheatland gage exist for 1929 to 1963, while unregulated flows for the 1- through 30-day durations as calculated by the Comprehensive Study exist for 1929 to 1998. This data was input into HEC's Regional Frequency Computation Program (USACE, 1992). The program derives peak flow statistics based on correlation with the other durations. The 1-day skew was adopted for the peak curve. The adopted peak flow curve along with the other durations derived by the Comprehensive Study are shown in Plate 29. Table 33 displays the unregulated peak flow frequency values adopted for this study.

TABLE 33

Table 8: **Unregulated** Bear River at Wheatland

Peak Flow in CFS	Percent Chance Exceedence
61100	0.2
54700	0.5
49600	1.0
44000	2.0
36100	5.0
29700	10.0

10.7 Coincident Flow on the Feather River

The Bear River hydrologic study conducted as part of the Lower Feather River FPMS computed design hydrographs assuming storms were centering on each tributary as shown in table 29. Then a second set of hydrographs were produced that assumed a storm centered on the Bear River at Wheatland, near the centroid of the basin, shown in table 30. The Sacramento – San Joaquin Comprehensive study and this feasibility study are using two storm centerings: one at the Feather River at Shanghai Bend, and the second at the latitude of Sacramento.

Therefore, the Bear River hydrographs from the Lower Feather River FPMS must be adjusted to match the Bear River at Wheatland flows for the Sacramento and Shanghai Bend storm centering used in this feasibility study. Ratios were computed as the Bear River Shanghai Bend or Sacramento centering peak flow divided by the Bear River hydrology study peak flow. These ratios were then applied to the hydrographs at the other locations including: Dry Creek, Best

Slough, UP intercept, and Yankee Slough, in the Bear River basin for which hydrographs were required in the hydraulic flood routings.

Note: the hydrograph for Dry Creek was not available in the Lower Feather FPMS or the Sacramento centering of the Comp Study. Therefore the hydrograph for Dry Creek for the Sacramento centering was derived from the Shanghai Bend centering by ratio of their peak flows.

The peak flows and ratios for the Bear River hydrology coincident storm centering, and the Comp Study Shanghai Bend and latitude of Sacramento centerings are shown in table 34.

TABLE 34

Table of Peak Flows and Ratios of Peak Flows for the Bear River								
AEP	1/2	1/10	1/25	1/50	1/100	1/200	1/500	Notes
Bear River at Wheatland								
Peak Flow	9251	26290	35828	43049	49201	54664	61972	Comp Study SAC centering
Peak Flow	6000	17100	27800	34600	41400	47700	55300	Shanghai-Yuba FPMS
Peak Flow	8500	25500	33500	39400	44300	49000	54700	Bear River Coincident Flow table
Ratio SAC-BR hydro	1.0884	1.0310	1.0695	1.0926	1.1106	1.1156	1.1330	Ratio of Comp Study SAC to Bear River Coincident peak flows
Ratio SHY-BR hydro	0.7059	0.6706	0.8299	0.8782	0.9345	0.9735	1.0110	Ratio of Comp Study SHY to Bear River Coincident peak flows
Ratio SAC - SHY	1.5419	1.5374	1.2888	1.2442	1.1884	1.1460	1.1207	Ratio of Comp Study SAC to SHY peak flows
Dry Creek at Jasper Lane								
	1700	4600	6200	7300	8300	9300	10500	Comp Study SAC centering
	1100	3000	4800	5900	7000	8100	9400	Shanghai-Yuba FPMS
	-	5850	-	8850	10200	-	13200	Bear River Coincident Flow table
Note: the hydrograph for Dry Creek was not available in the Lower Feather FPMS or the Sacramento centering of the Comp Study. Therefore the hydrograph for Dry Creek for the Sacramento centering was derived from the Shanghai Bend centering by ratio of their peak flows.								
Best Slough blw Dry Creek Split								
	1244	2521	3364	4015	4682	5293	6159	Comp Study SAC centering
	810	1640	2610	3230	3940	4620	5500	Shanghai-Yuba FPMS
	1140	2450	3150	3670	4220	4740	5440	Bear River Coincident Flow table
UP Intercept Canal								
	1089	2726	4084	5344	6765	8371	10644	Comp Study SAC centering
	710	1770	3170	4300	5690	7300	9500	Shanghai-Yuba FPMS
	-	2640	-	4890	6090	-	9390	Bear River Coincident Flow table
Yankee Slough								
	268	784	1312	1883	2471	3194	4258	Comp Study SAC centering
	170	510	1020	1510	2080	2790	3800	Shanghai-Yuba FPMS
	-	761	-	1720	2220	-	3760	Bear River Coincident Flow table

11. Interior Drainage Analysis

11.1. Background

The interior drainage analysis was performed by Peterson-Brustad Incorporated (PBI) a consultant to the Sutter Butte Flood Control Agency (SBFCA). The purpose of the SBFCA analysis was to serve as a submittal to FEMA in conformance with 44CFR65.10 requirements, and to support compliance with the State of California Urban Level of Protection criteria. A supplemental hydraulic analysis was also conducted to be used for the design of replacement levee culverts.

The modeling process consisted of using HEC-HMS to analyze 1% and 0.5% annual exceedance probability (AEP) rainfall-runoff and develop hydrographs at key concentration points in the interior of the Sutter basin, and using FLO-2D to analyze flood depths and boundaries.

A FLO-2D model with a 1,000-foot by 1,000-foot grid size was developed by Peterson Brustad, Inc. (PBI) for the U.S. Army Corps of Engineers' (USACE) Sutter Basin Feasibility Study and later modified to add key interior drainage channels and features. Hydrographs from HEC-HMS were input at concentration points into the FLO-2D model, and FLO-2D was used to route the floods, estimate residual floodplains, and estimate residual flood depths. In this instance, "residual" means floodplains which will exist following accreditation of all levees protecting the Sutter Basin, due to rainfall on the interior areas. These residual floodplains could later be modified through local land use changes or drainage improvement projects. The FLO-2D model and interior floodplain mapping will be discussed in the Hydraulics appendix.

The large grid size is expected to reveal areas of significant SFHA flooding, however, it should be noted that smaller areas of shallow flooding may be missed.

The design storm rainfall analysis was discussed above in section 6.2

11.1.2. Location

The study area includes approximately 340 square miles of Sutter and Butte Counties in Northern California. It is primarily bounded by the Feather River to the east and by the Sutter Bypass and Sutter Buttes in the west. Its southern boundary is at the confluence of the Feather River and the Sutter Bypass. The study area includes the cities of Live Oak, Gridley, Biggs, Yuba City, and the town of Sutter. Plate 30 shows the study area and its main features.

11.2. HEC-HMS MODELING

11.2.1. Model Development

11.2.1. Subbasin Delineation

The first step in developing the HEC-HMS model involved the delineation of drainage shed boundaries. Plate 30 provides an overview of the drainage sheds identified for this study. A total of 16 main sheds covering approximately 340 square miles were identified within the interior drainage study boundary. The main sheds were further divided into a total of 77 subbasins as described below.

Live Oak Slough

The Live Oak Slough watershed includes 2 subsheds covering 16 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on drainage boundaries identified in the City of Live Oak Master Drainage Study (Live Oak, 2011), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Morrison Slough

The Morrison Slough watershed includes 2 subsheds covering 15 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on drainage boundaries identified in the City of Live Oak Master Drainage Study (Live Oak, 2011), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011). RD-777 The RD-777 watershed includes 3 subsheds covering 11 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on drainage boundaries identified in the City of Live Oak Master Drainage Study (Live Oak, 2011), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Snake River

The Snake River watershed includes 10 subsheds covering 32 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County, 2010), USGS DEMs (USGS, 2001), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Sutter

The Sutter watershed includes 3 subsheds covering 16 square miles and drains to the Sutter Bypass through DWR Pump Station #3. Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County, 2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Little Blue Creek

The Little Blue Creek watershed includes 2 subsheds covering 6 square miles and drains to the Sutter Bypass through DWR Pump Station #2 (O'Banion Pump Station). Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter

County, 2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Lower Snake River

The Lower Snake River watershed includes 4 subsheds covering 20 square miles and drains to the Sutter Bypass through DWR Pump Station #2 (O'Banion Pump Station). Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County,2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

West Interceptor Canal

One subshed covering 8 square miles flows from the Sutter Buttes directly into the West Interceptor Canal which drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on USGS DEMs (USGS, 2001), (DWR LiDAR data is not available over the Sutter Buttes) and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Sand Creek

The Sand Creek watershed includes 2 subsheds covering 9 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on USGS DEMs (USGS, 2001), DWR LiDAR data (DWR, 2011) and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Sutter City Canal

The Sutter City Canal watershed includes 2 subsheds covering 4 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on USGS DEMs (USGS, 2001), DWR LiDAR data (DWR, 2011) and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Live Oak Canal

The Live Oak Canal watershed includes 3 subsheds covering 15 square miles and drains to the Sutter Bypass through DWR Pump Station #2 (O'Banion Pump Station). Subsheds were delineated based on drainage boundaries identified in the West Yuba City Master Drainage Study (Yuba City, 2006) and the storm drain system outlined in the Sutter County Master Drainage Study (Sutter County, 1979).

Gilsizer Slough

The Gilsizer Slough watershed includes 9 subsheds covering 46 square miles and drains to the Sutter Bypass through DWR Pump Station #2 (O'Banion Pump Station). Subsheds were delineated based on drainage boundaries identified in the West Yuba City Master Drainage

Study (Yuba City, 2006) and the storm drain system outlined in the Sutter County Master Drainage Study (Sutter County, 1979).

Chandler

The Chandler watershed includes 2 subsheds that cover 16 square miles and drains to the Sutter Bypass through DWR Pump Station #1 (Chandler Pump Station). Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County, 2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

RD-823 (Hamatani Ranch)

The RD-823 watershed includes 2 subsheds covering 8 square miles and drains to the Feather River through a private pump station (Hamatani Ranch Pump Station). Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County, 2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Butte Sink

There are 11 subbasins in the northern portion of the study area that drain west to the Butte Sink. These subbasins total 94 square miles and were delineated based the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

East Biggs

The East Biggs subbasin totals 6.01 square miles. The Butte Canal makes up its western boundary and, based on a phone conversation with the director of the Joint Water Board, this section of the Butte Canal has the ability to capture storm runoff from this area. This subbasin was modeled, but its runoff was not conveyed beyond the Butte Canal boundary.

Feather River

Although most of the interior lands drain in a southwesterly direction away from the Feather River's west levee, there are 19 subsheds covering 25 square miles that drain directly to the Feather River through levee culverts or pump stations. These sheds are independent from the rest of the HEC-HMS model and were delineated to assist SBFCA in the design of replacement levee culverts. Sheds were identified based on DWR LiDAR data (DWR, 2011), the City of Live Oak Master Drainage Study (Live Oak, 2011), the West Yuba City Master Drainage Study (Yuba City, 2006), the Sutter County Master Drainage Study (Sutter County, 1979) and telephone conversations with City of Yuba City officials.

11.3.1.7. Pump Stations and Detention Ponds

Ten stormwater pump stations were included in the analysis (see Plate 30). Three DWR pump stations discharge stormwater to the Sutter Bypass. Capacities for these pump stations were obtained from the DWR Sutter Maintenance Yard (DWR, 2009).

One private pump station (Hamatani Ranch Pump Station) is identified in the Sutter County General Plan (Sutter County, 2010) and discharges to the Feather River. A utilities inventory (Flowserve Inc, 2010) conducted along the Feather River's west levee identified this pump station as a Byron Jackson 17HQH pump. Its pump capacity was obtained from a BJ 17HQH pump curve (Flowserve Inc, 2010).

Six pump stations that drain areas in and around Yuba City and discharge to the Feather River were included in the analysis. Five of these pumps are operated by the City of Yuba City. Capacities for these pumps and their associated detention ponds were estimated by the City of Yuba City. An additional pump station operated by the Gilsizer Drainage District also drains Yuba City. Pump and pond capacities for this pump station were obtained from the Gilsizer Drainage District. Ponds are pumped dry after each storm, so ponds were assumed empty at the start of each simulation.

Pump station data are summarized in Table 35.

Table 35. Pump station capacities.

Pump Station	Details
DWR PS#1	Total Capacity: 280 cfs 4 pumps @ 70 cfs each
DWR PS#2	Total Capacity: 786.6 cfs 6 pumps @ 131.1 cfs each
DWR PS#3	Total Capacity: 182.2 cfs 4 pumps @ 45.55 cfs each
Hamatani Ranch PS	Total Capacity: 9.3 cfs 1 pump @ 9.3 cfs
Yuba City Pump Station #1	Total Capacity: 6,820 gpm (15.2 cfs) 1 pump @ 1,950 gpm; 1 pump @ 770 gpm; 1 pump @ 4,100 gpm Pond Capacity: 9 Acre-Feet (AF)
Yuba City Pump Station #2	Total Capacity: 7,300 gpm (16.3 cfs) 2 pumps @ 3,000 gpm; 1 pump @ 1,300 gpm Pond Capacity: 46 Acre-Feet (AF)
Yuba City Pump Station #3	Total Capacity: 9,800 gpm (21.8 cfs) 3 pumps @ 40 horsepower each Pond Capacity: 68.9 Acre-Feet (AF)
Yuba City Pump Station #4	Total Capacity: 900 gpm (2.0 cfs) Pond Capacity: 15 Acre-Feet (AF)
Yuba City Seepage Pump Station	Total Capacity: 9,700 gpm (21.6 cfs) 1 pump @ 3,270 gpm; 1 pump @ 6,430 gpm Total Capacity: 47,500 gpm (105.8 cfs)
Gilsizer Drainage District Pump Station	2 pumps @ 10,000 gpm; 1 pumps @ 5,000 gpm; 1 pumps @ 22,500 gpm Pond Capacity: 70 Acre-Feet (AF)

[a] Estimated based on horsepower and capacities of similarly sized pumps in Yuba City.

11.3.3. Model Results

Once calibrated, the HEC-HMS model was run with the four design storm events described above in section 6.2. The simulations were extended several days beyond the storm event to ensure that hydrographs had time to return to low-flow conditions and runoff had time to travel to the model's outlet points. Table 36 and Table 37 provide a summary of peak flow and runoff volume results at several key locations in the study area.

In the absence of gage records, high water marks, or other physical tools for model verification, PBI verified results through discussions with several area officials from the City of Yuba City, Sutter County, and Gilsizer Drainage District, as well as with residents within the basin who recalled flooding that took place during the 1997 and 2006 events.

TABLE 36

Summary of peak flow results [cfs].					
Location	Drainage Area [sq.mi.]	100yr-24hr	100yr-96hr	200yr-24hr	200yr-96hr
Live Oak Slough					
at Highway 99	5.97	90	54	110	67
at East Interceptor Canal confluence	18.06	470	120	580	140
RD777 Canal					
at Sheppard Rd	4.66	330	150	410	180
Morrison Slough					
d/s of Sutter/Butte County Line	5.35	290	150	350	190
Snake River					
West Fork at Sutter/Butte County Line	3.87	210	160	250	180
East Fork at Sutter/Butte County Line	2.85	220	170	260	190
u/s of Clark Rd.	29.75	1,900	1,600	2,300	1,900
at Morrison Slough confluence	45.34	2,600	2,300	3,100	2,700
Interceptor Canal					
at RD777 Canal confluence	28.52	1,000	440	1,300	540
at Snake River confluence	74.95	3,700	2,900	4,400	3,400
at Wadsworth Canal entrance	95.44	4,900	4,100	5,900	4,800
Wadsworth Canal Outlet	96.12	4,900	4,200	5,900	4,900
Sutter Main Canal					
DWR Pump Station #3 Inflow	16.26	1,200	520	1,500	650
Little Blue Creek					
at Highway 20	1.43	91	53	110	60
Live Oak Canal					
at Highway 20	4.37	150	100	180	120
at Bogue Rd	10.01	440	220	530	280
Lower Snake River					
at Highway 20	3.08	400	120	480	140
at Little Blue Creek confluence	15.78	780	540	940	630
at Live Oak Canal confluence	31.91	1,600	1,000	2,100	1,200
Gilsizer Slough					
at Lincoln Rd.	6.85	380	380	430	420
at Bogue Rd.	8.36	510	460	560	500
at Oswald Rd.	14.04	700	510	820	560
at George Washington Blvd.	38.28	1,200	690	1,600	810
DWR Pump Station #2 Inflow	87.25	3,100	2,600	3,800	3,000
Chandler Main Drain					
DWR Pump Station #1 Inflow	10.68	540	460	680	520
RD-823 Main Drain					
at Highway 99	3.58	110	21	150	31
Hamatani Ranch Pump Station Inflow	7.63	210	180	270	210
Average Unit Peak Flows [cfs/acre]		0.08	0.05	0.1	0.06

Table 37

Summary of runoff volume results [acre-feet].					
Location	Drainage Area [sq.mi.]	100yr-24hr	100yr-96hr	200yr-24hr	200yr-96hr
Live Oak Slough					
at Highway 99	5.97	340	340	400	410
at East Interceptor Canal confluence	18.06	890	610	1,100	700
RD777 Canal					
at Sheppard Rd	4.66	330	610	390	700
Morrison Slough					
d/s of Sutter/Butte County Line	5.35	330	350	400	460
Snake River					
West Fork at Sutter/Butte County Line	3.87	390	1,100	440	1,200
East Fork at Sutter/Butte County Line	2.85	250	540	290	620
u/s of Clark Rd.	29.75	2,700	6,500	3,100	7,400
at Morrison Slough confluence	45.34	4,200	9,000	4,900	10,000
Interceptor Canal					
at RD777 Canal confluence	28.52	1,700	1,900	2,000	2,200
at Snake River confluence	74.95	6,100	11,000	7,100	13,000
at Wadsworth Canal entrance	95.44	7,800	15,000	9,200	17,000
Wadsworth Canal Outlet	96.12	7,800	15,000	9,200	17,000
Sutter Main Canal					
DWR Pump Station #3 Inflow	16.26	1,200	2,100	1,400	2,400
Little Blue Creek					
at Highway 20	1.43	140	380	150	420
Live Oak Canal					
at Highway 20	4.37	370	470	430	530
at Bogue Rd	10.01	770	930	900	1,100
Lower Snake River					
at Highway 20	3.08	250	520	290	600
at Little Blue Creek confluence	15.78	1,400	3,600	1,600	4,000
at Live Oak Canal confluence	31.91	2,700	5,600	3,100	6,400
Gilsizer Slough					
at Lincoln Rd.	6.85	980	1,700	1,100	1,900
at Bogue Rd.	8.36	1,200	2,100	1,300	2,300
at Oswald Rd.	14.04	1,400	2,300	1,500	2,500
at George Washington Blvd.	38.28	2,100	2,900	2,500	3,200
DWR Pump Station #2 Inflow	87.25	6,500	12,000	7,500	14,000
Chandler Main Drain					
DWR Pump Station #1 Inflow	10.68	940	1,900	1,100	2,100
RD-823 Main Drain					
at Highway 99	3.58	120	160	160	180
Hamatani Ranch Pump Station Inflow	7.63	520	1,300	600	1,400
Average Unit Runoff Volumes [AF/acre]		0.13	0.24	0.15	0.27

12. Analysis of Alternatives by Hydrology

The ring levee and J-levee (the levee) around Yuba City are the two alternatives that required additional hydrologic analysis. The fix-in-place, and other similar levee alternatives will not require a change in the hydrology effecting those alternatives.

For the preliminary screening, an estimate of the runoff within the levee was developed using the rational method of rainfall-runoff analysis. Rainfall depths were extracted from the design rainfall analysis by David Ford Consulting Engineers Inc (Ford) for this study. The Ford analysis is based on rainfall depth-area-duration statistics developed by Jim Goodrich, the former California State Climatologist, and kept up-to-date on the Department of Water Resources (DWR) web site. Areas within the levee were developed from Google Earth sketches of the proposed alternative alignment. 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 whole area inside the levee. The area used was 24.23sq.mi. within the levee. A 1-day, 10-year precipitation volume of 2.82 inches, and a rainfall-runoff coefficient of 0.5 was used. Pumps were sized based on this average flow rate. These estimates have been used in the study to this point. Refinements will be made as shown below.

The interior drainage analysis performed by Peterson-Brustad Inc (PBI) for SBFCA using HEC-HMS and FLO2D later determined the 100-year and 200-year 24-hour storm duration flow at two locations. The two locations are natural drainage outlets that must pass through the levee, and include Gilsizer Slough and Live Oak Slough. The discharge and volume at these two locations is shown in tables 33 and 34 to be: 440 and 530 cfs for the 24-hour, 100- and 200-year return periods respectively at Live Oak Slough. And, 1200 and 1600 cfs for the 24-hour, 100- and 200-year return periods respectively at Gilsizer Slough.

The pump size required must be determined in conjunction with an accompanying detention basin. The larger the detention basin, the smaller the required pump size. A detailed analysis of the interior drainage within the ring levee alternatives was done by PBI. In addition, pump sizes and detention basin sizes were calculated. Those results may be found in the Interior Drainage Analysis by Peterson-Brustad, Inc. (SBFCA, 2012).

13. Results

The results of the design rainfall analysis, the discharge probability of the Sutter Bypass and Feather River systems, the Cherokee and Wadsworth Canal systems, and of the Sutter basin interior areas tributary to the Wadsworth canal and the Sutter Bypass are shown above. For further information see the individual reports, Technical Memorandum, and Memorandum for Record.

14. Conclusions

This summary report provides information for the determination of a feasible project within the Sutter Basin, California. This is the complete hydrology appendix document for the Sutter Basin Feasibility Study Draft Report. The information summarized herein is detailed in technical memorandums, and memorandum for record. Those memos are cited in the text above and shown in the references below.

15. REFERENCES:

A number of existing reports and references have been utilized as part of the Pilot Study effort. The following contain the most relevant information for the current Pilot Study hydrology effort.

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Legend

- Sutter Basin Study Area
- Sacramento Basin
- Watershed Boundary
- Lake or Reservoir
- Designated Floodway
- River or Stream
- City

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

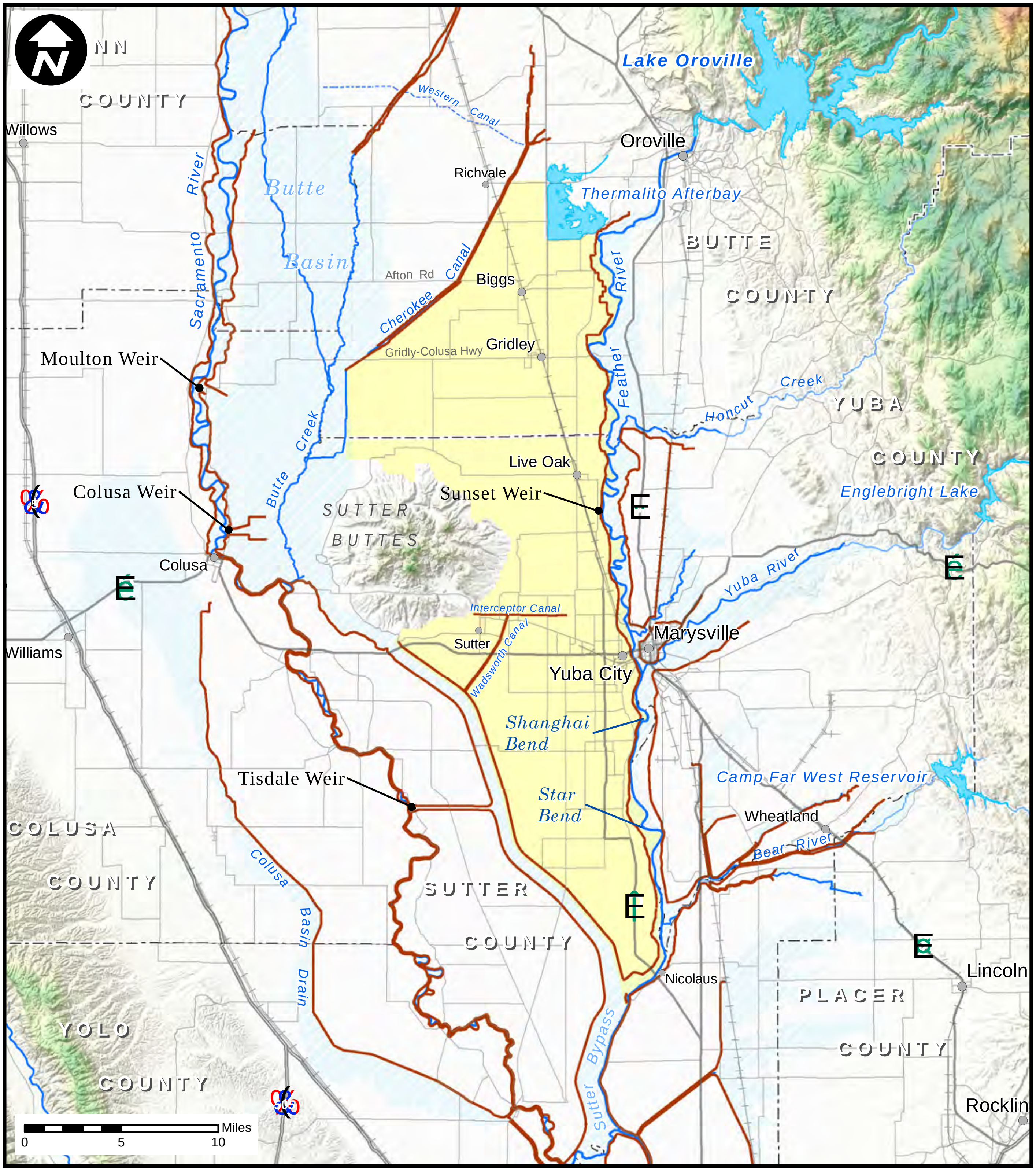
SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 1



Legend

Study Area Extent	Highway
Designated Floodway	Major Road
Lake or Reservoir	Railroad
River or Stream	County Boundary
Federal Levee	City or Town

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

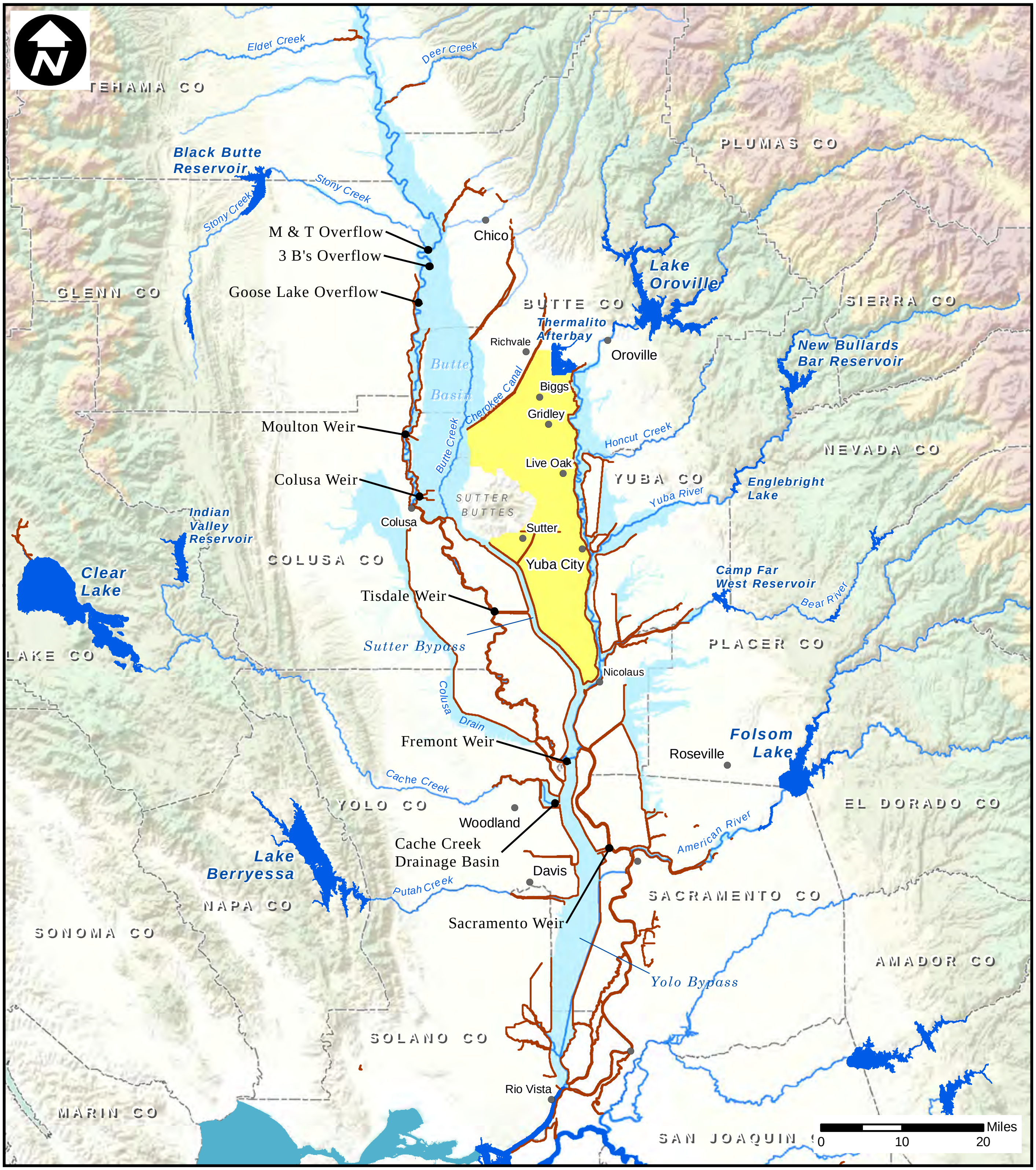
STUDY AREA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 2



Legend

- Study Area Extent
- Designated Floodway
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

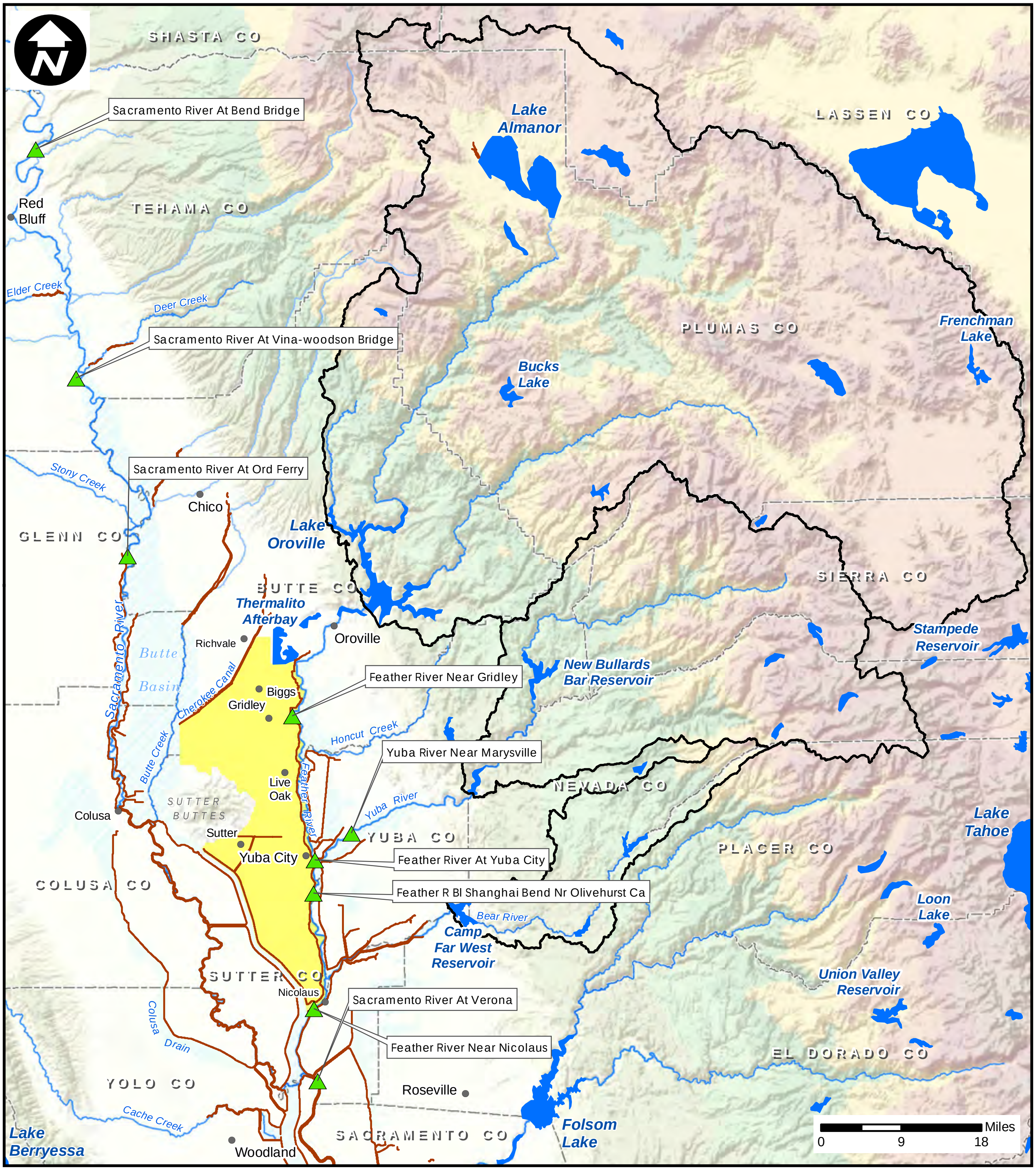
SACRAMENTO RIVER FLOOD CONTROL PROJECT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 3



Legend

- Stream Gage
- Study Area Extent
- Watershed Boundary
- Designated Floodway
- Federal Levee
- Lake or Reservoir
- River or Stream
- County Boundary
- City

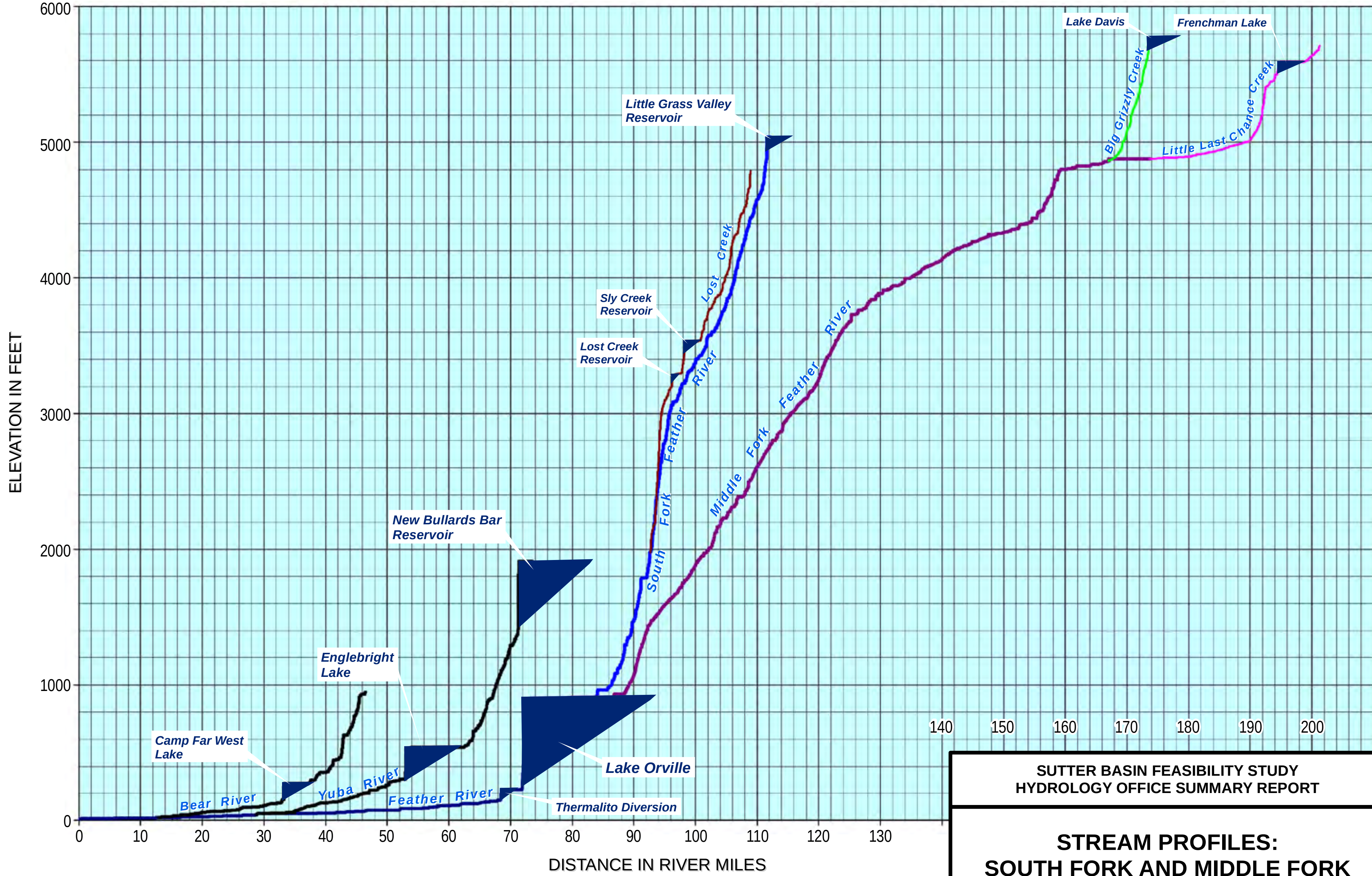
SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

UPPER WATERSHED BASINS TOPOGRAPHY AND STREAM GAGES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012



Prepared by Jim Mars

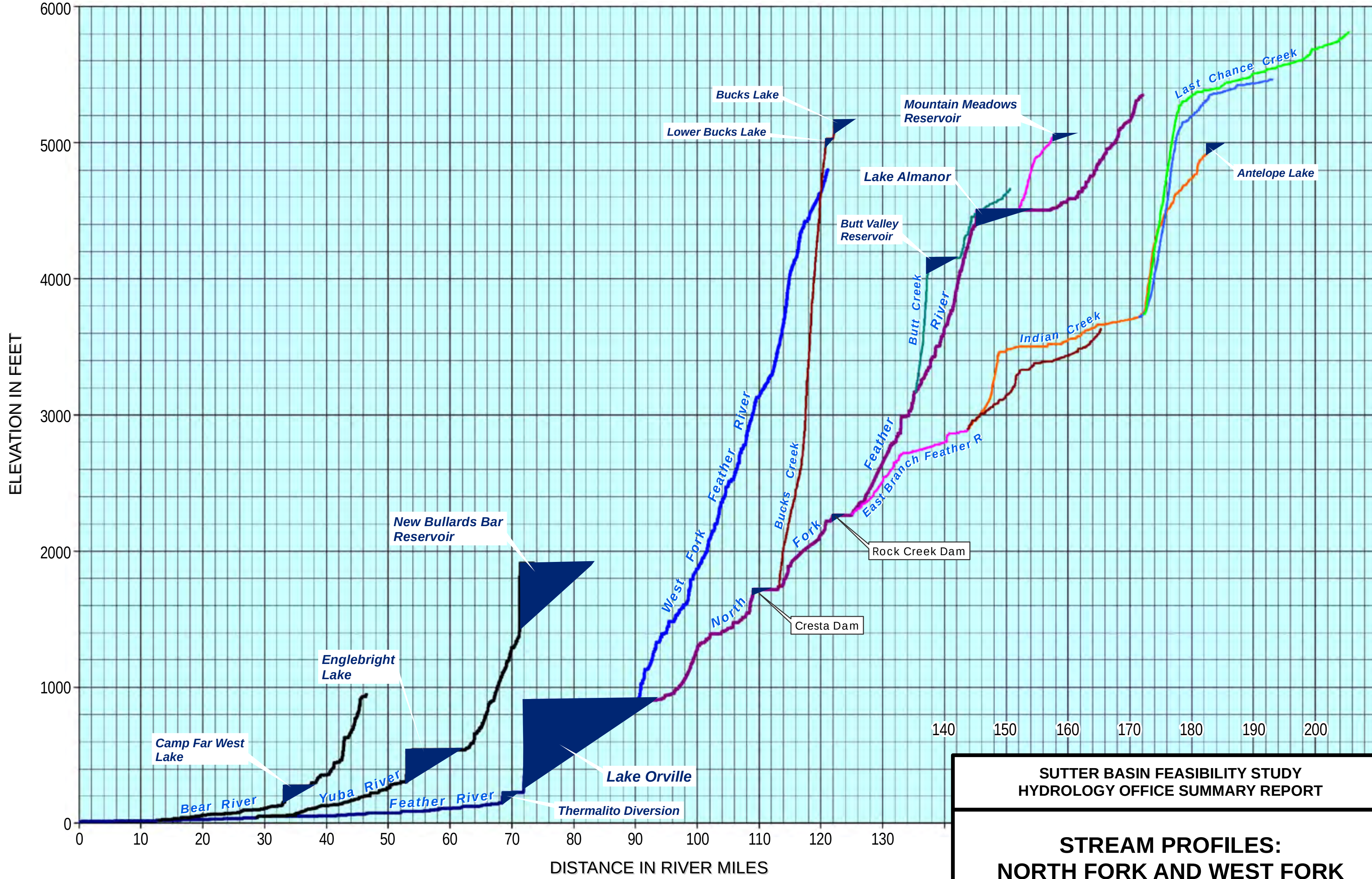
SUTTER BASIN FEASIBILITY STUDY
HYDROLOGY OFFICE SUMMARY REPORT

STREAM PROFILES: SOUTH FORK AND MIDDLE FORK FEATHER RIVER

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

NOV 2012

PLATE 5.1



Prepared by Jim Mars

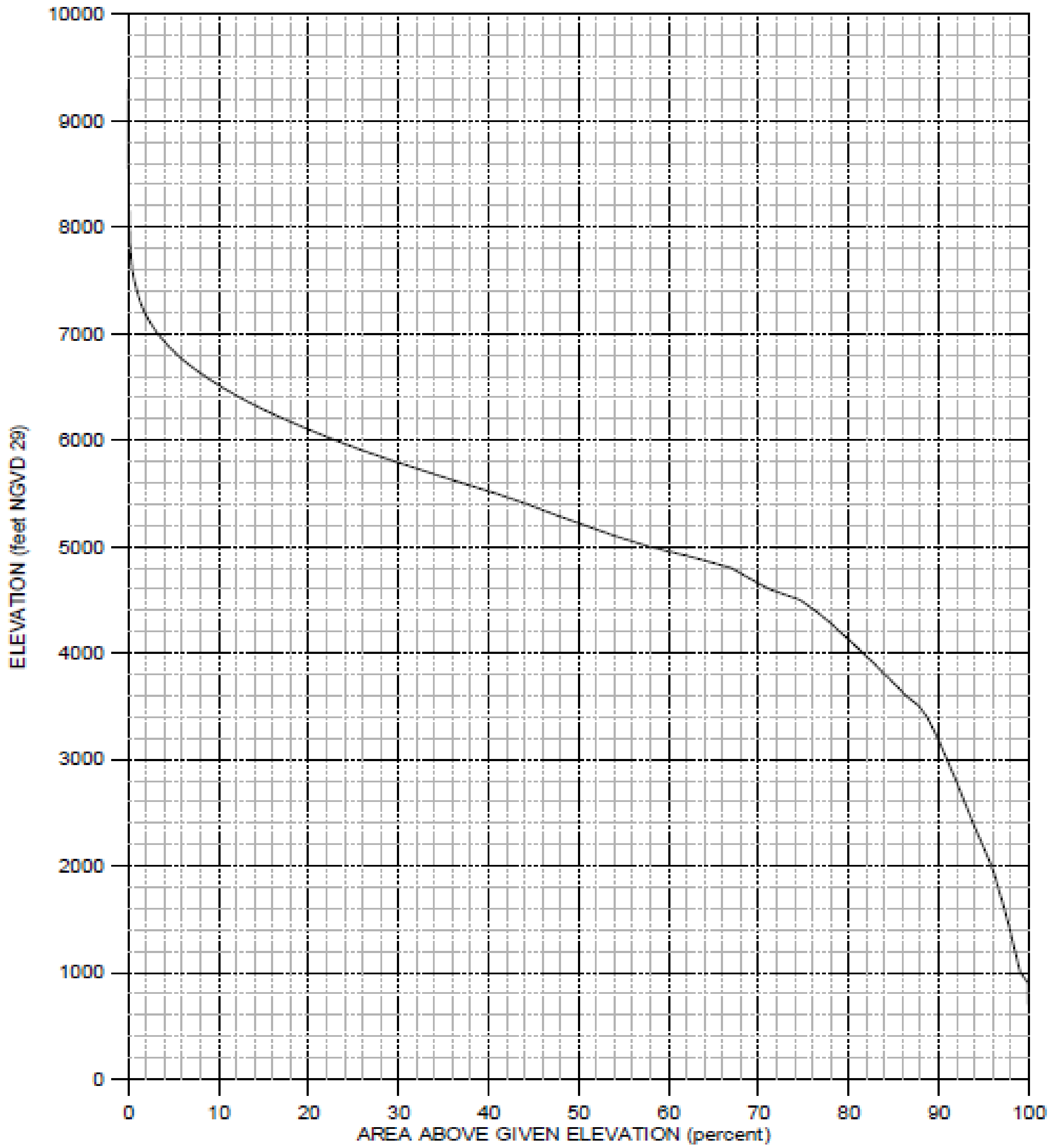
SUTTER BASIN FEASIBILITY STUDY
HYDROLOGY OFFICE SUMMARY REPORT

STREAM PROFILES:
NORTH FORK AND WEST FORK FEATHER RIVER

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

NOV 2012

PLATE 5.2



NOTES:

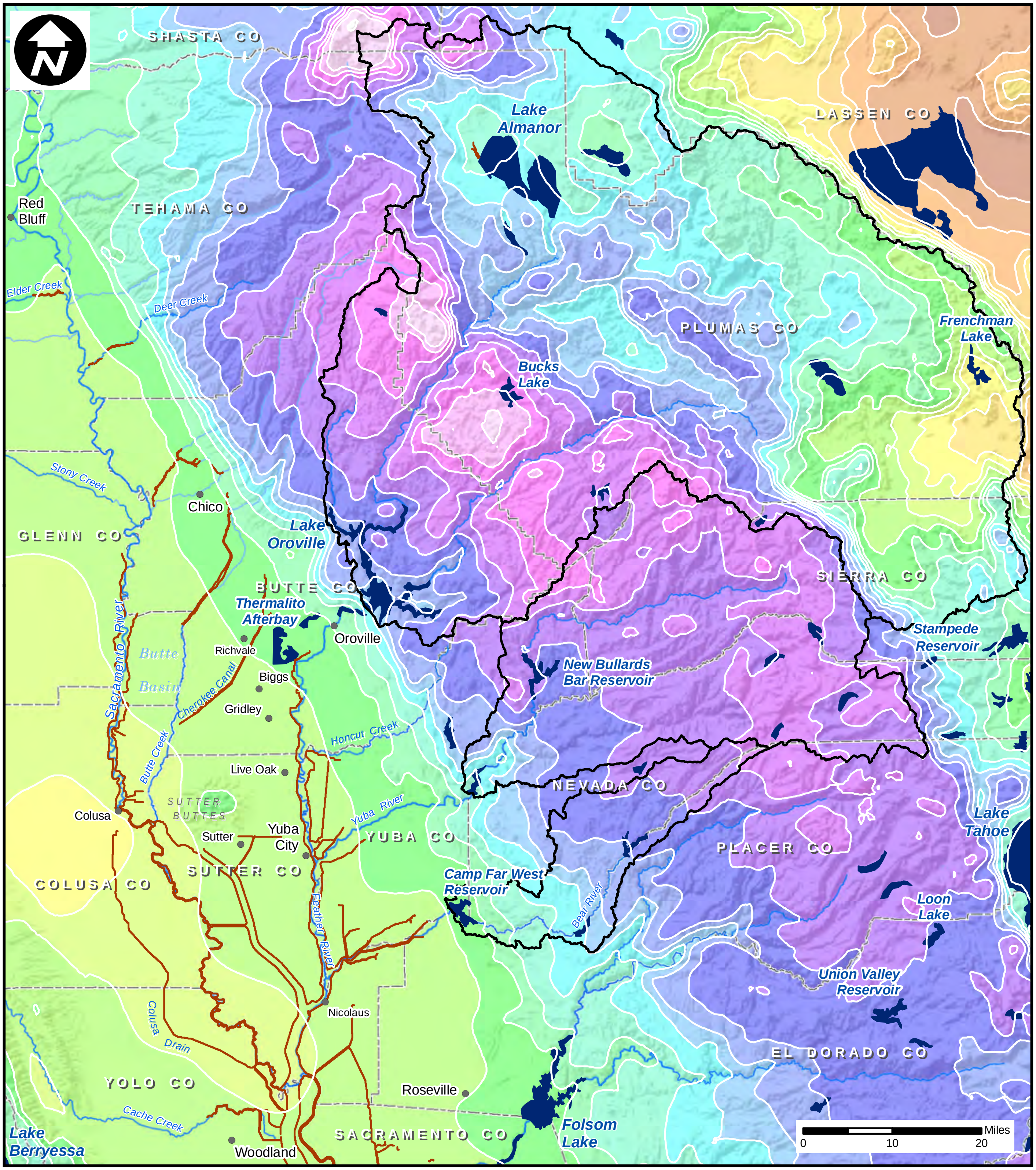
Watershed above Oroville Dam (3,602 square miles)

Source: Oroville Water Control Manual, Revised Feb 2005

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

AREA-ELEVATION CURVE

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

- Watershed Boundary
- Federal Levee
- Lake or Reservoir
- River or Stream
- County Boundary
- City

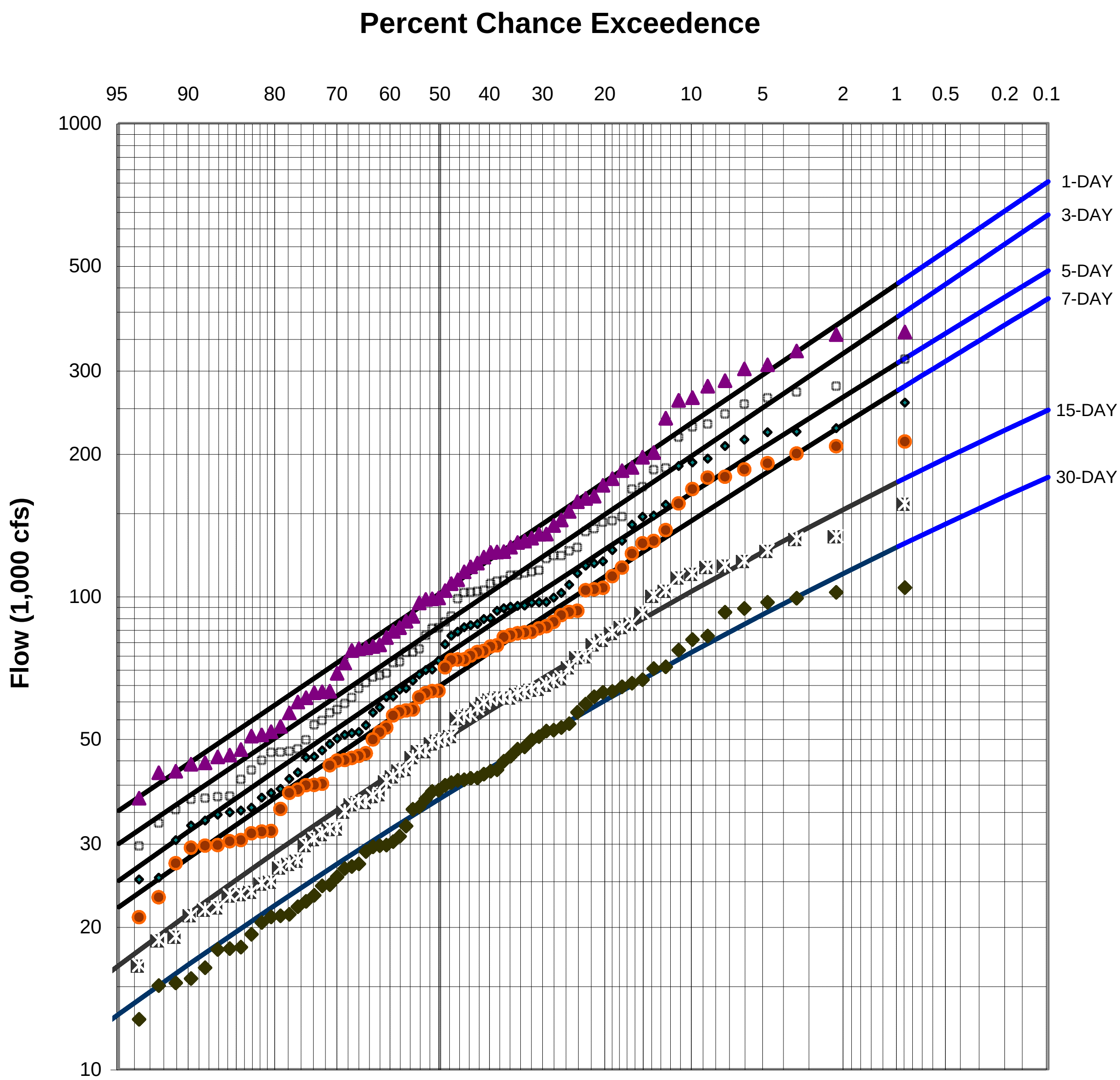
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

UPPER WATERSHED BASINS NORMAL ANNUAL PRECIPITATION AND CLIMATOLOGICAL GAGES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	5.009	0.281	0.0
3-day	4.939	0.281	0.0
5-day	4.866	0.279	-0.1
7-day	4.809	0.278	-0.1
15-day	4.680	0.267	-0.3
30-day	4.562	0.258	-0.3

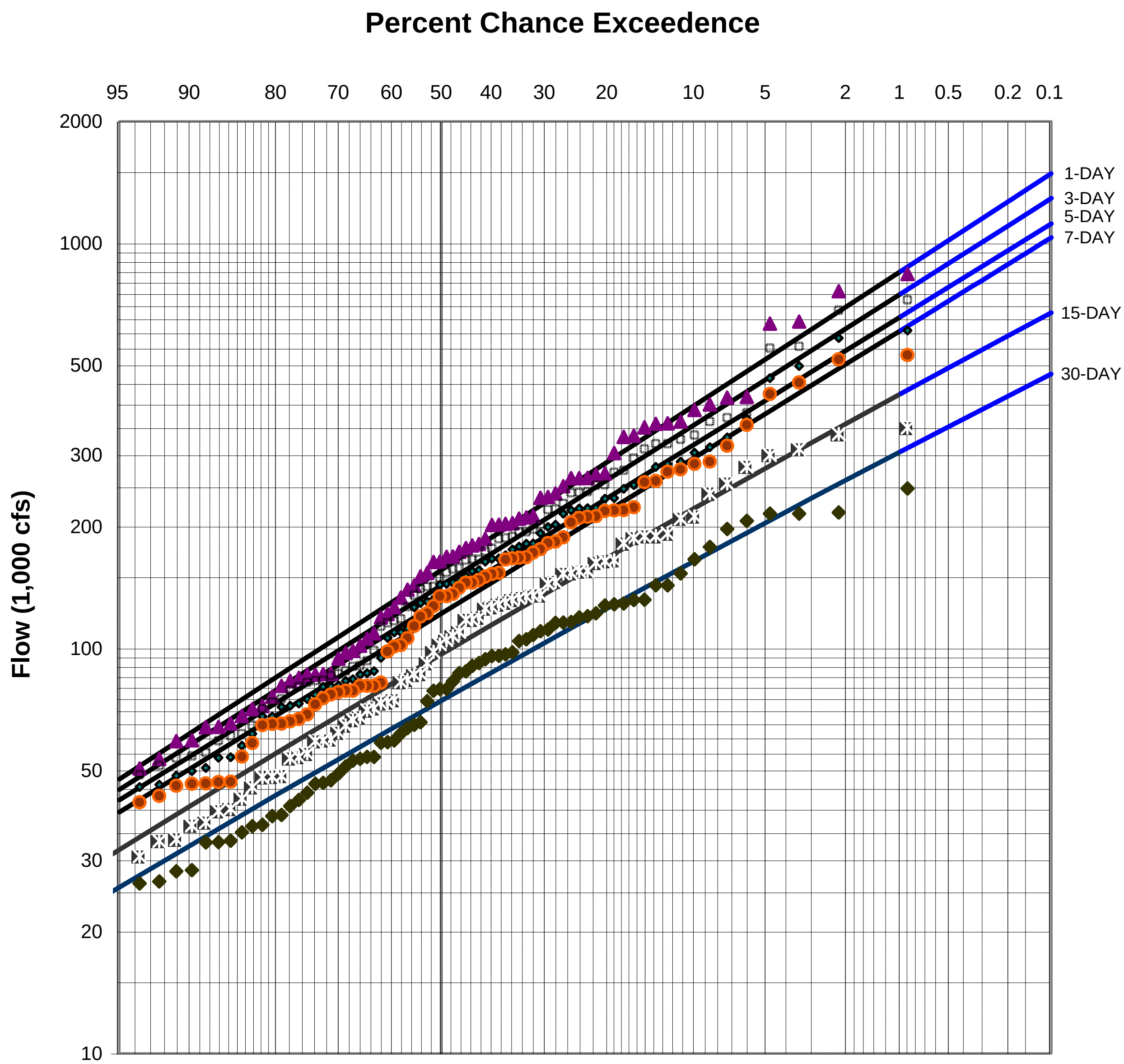
NOTES:

1. Adjusted USGS gage 11388700 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. WY 1977 censored as low outlier.
3. Median plotting positions.
4. Drainage area: approx. 12,050 sq. mi.
5. Period of record: 1922-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
SACRAMENTO RIVER AT ORD FERRY (LATITUDE)
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	5.196	0.316	0.0
3-day	5.158	0.308	0.0
5-day	5.120	0.301	0.0
7-day	5.088	0.300	0.0
15-day	4.983	0.287	-0.1
30-day	4.869	0.274	-0.2

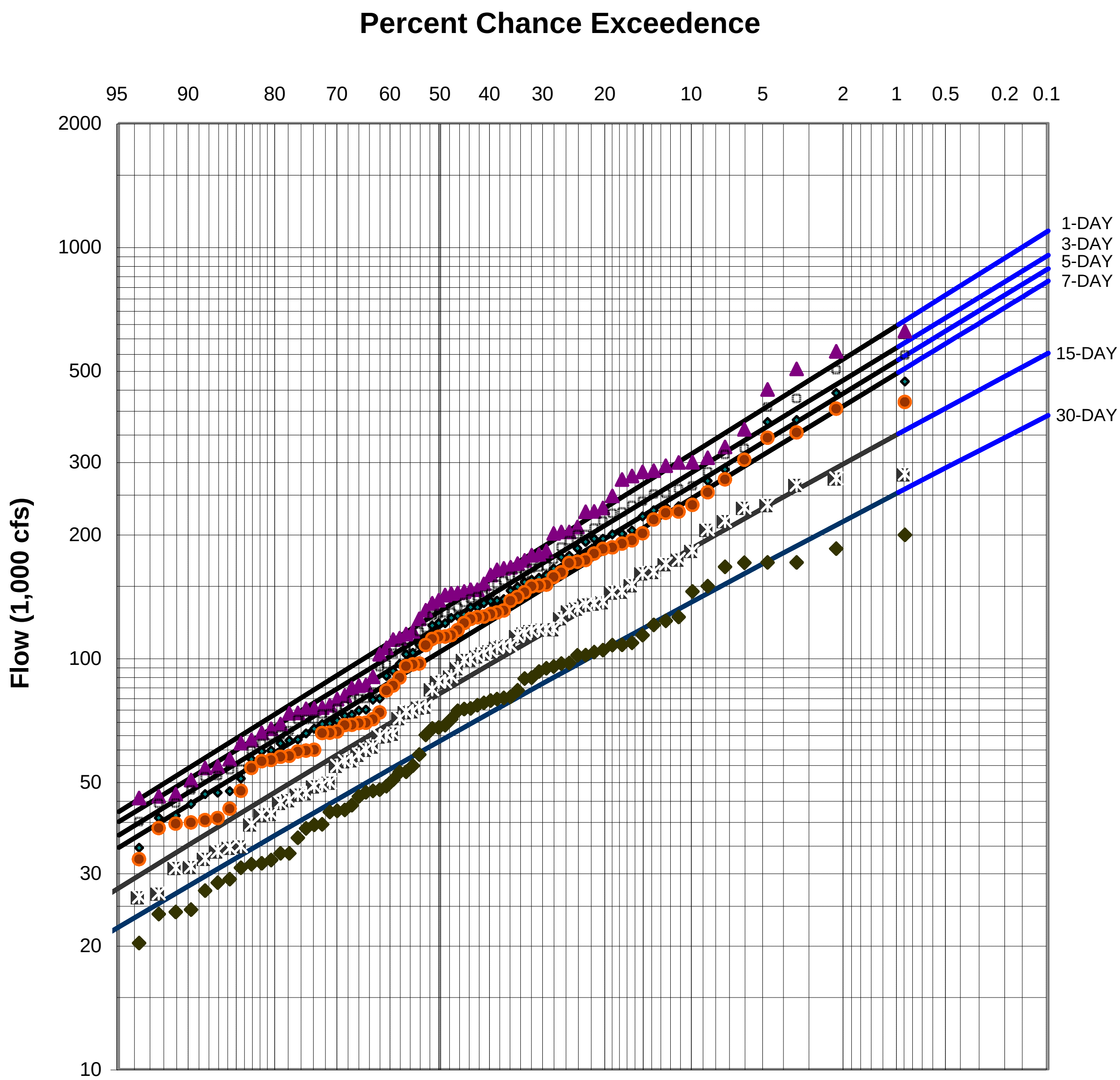
NOTES:

1. Adjusted USGS gage 11447500 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. WY 1977 censored as low outlier.
3. Median plotting positions.
4. Drainage area: approx. 26,150 sq. mi.
5. Period of record: 1922-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
SACRAMENTO RIVER AT SACRAMENTO (LATITUDE)
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	5.117	0.298	0.0
3-day	5.081	0.291	0.0
5-day	5.048	0.291	0.0
7-day	5.018	0.291	0.0
15-day	4.912	0.281	-0.1
30-day	4.796	0.269	-0.2

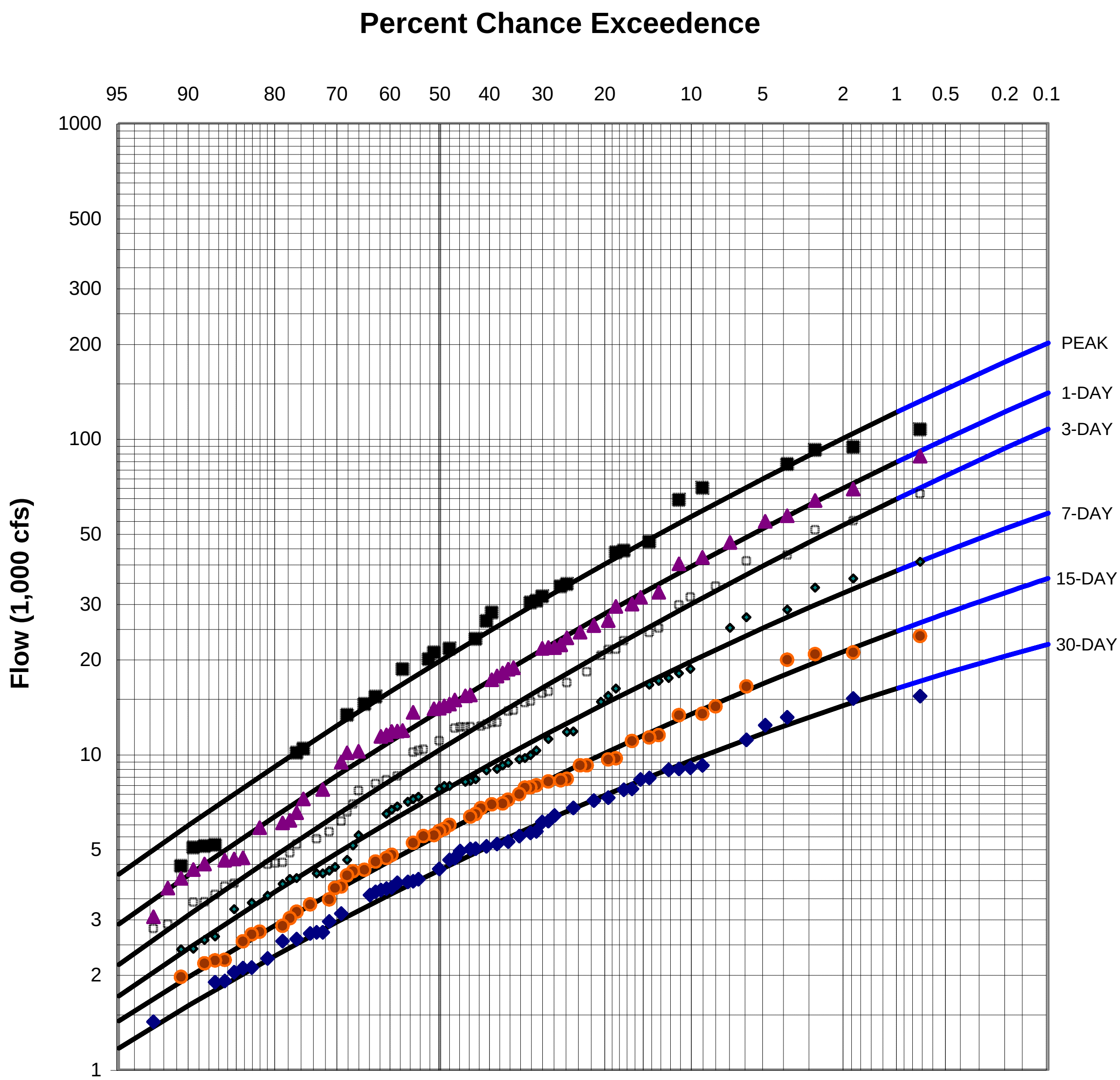
NOTES:

1. Adjusted USGS gage 11425500 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. WY 1977 censored as low outlier.
3. Median plotting positions.
4. Drainage area: approx. 21,251 sq. mi.
5. Period of record: 1922-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
SACRAMENTO RIVER AT VERONA (LATITUDE)
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
Peak	4.280	0.383	-0.3
1-day	4.122	0.383	-0.3
3-day	3.999	0.386	-0.3
7-day	3.858	0.357	-0.4
15-day	3.727	0.327	-0.4
30-day	3.611	0.306	-0.5

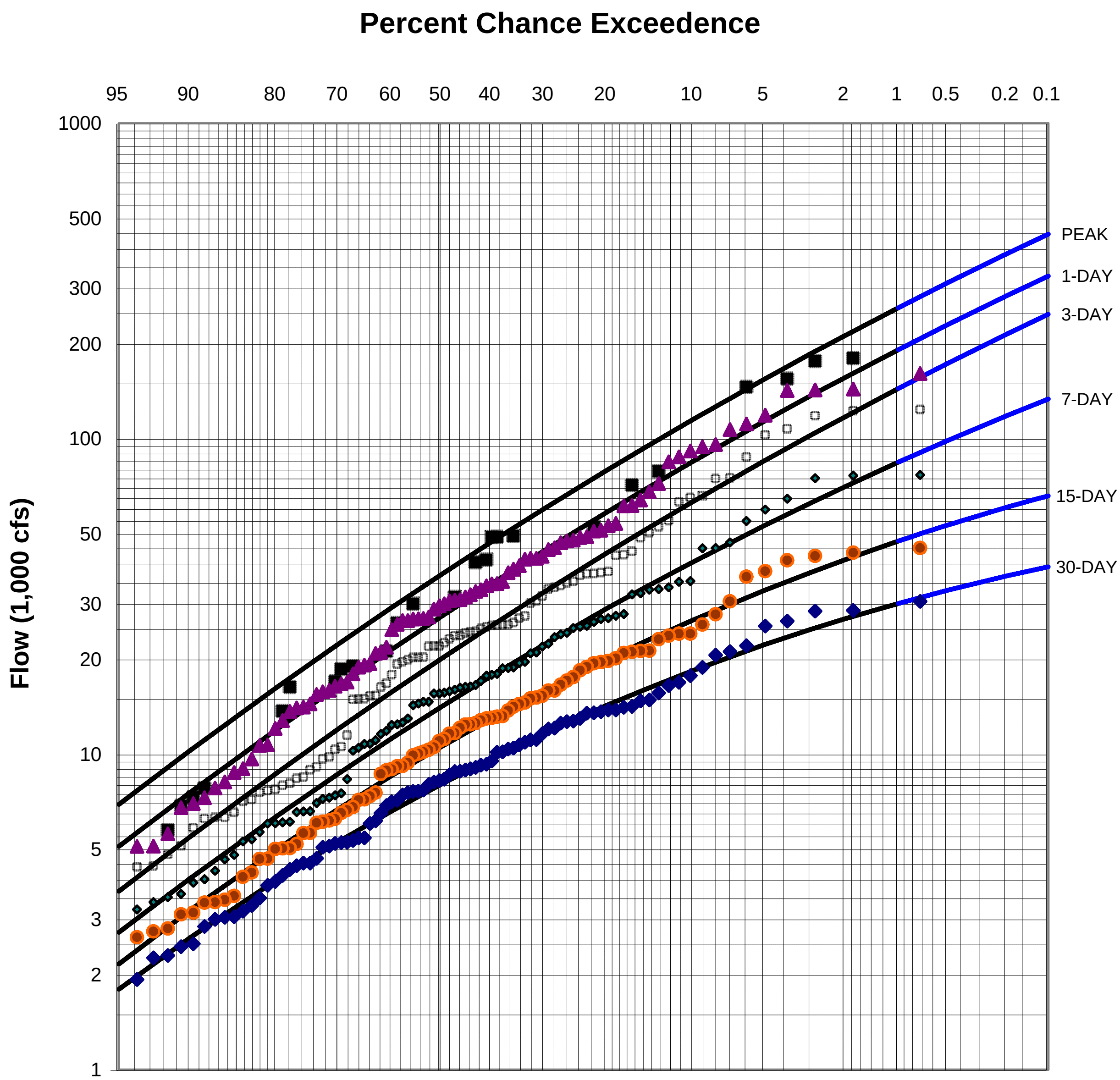
NOTES:

1. Statistics adjusted based on correlation with Yuba River near Marysville station (94 years).
2. Median plotting positions.
3. Drainage Area: 489 sq. mi.
4. Period of record: 1938-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
NORTH YUBA AT NEW BULLARDS BAR DAM
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

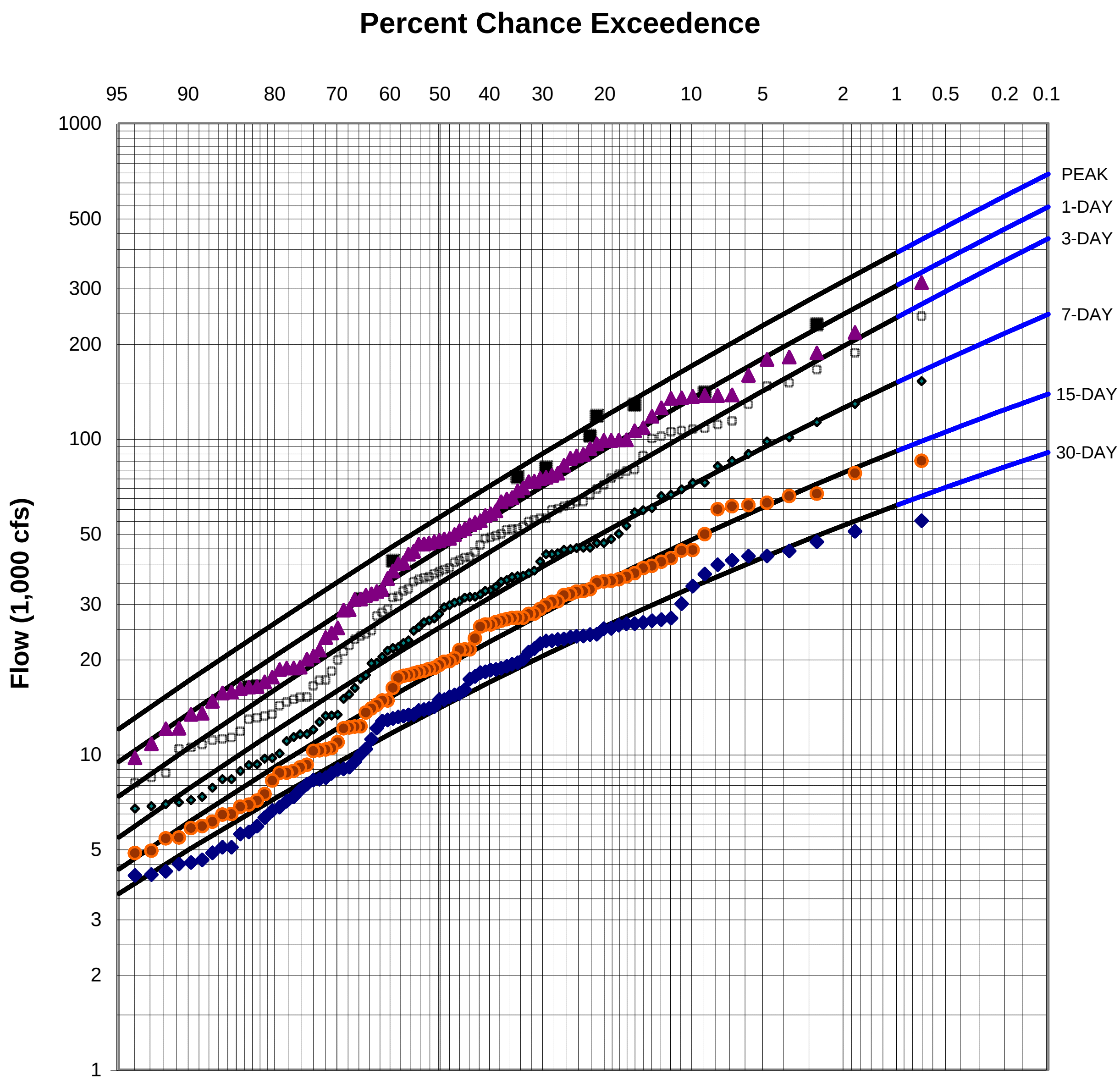
	Mean	Std.Dev.	Skew
Peak	4.550	0.411	-0.3
1-day	4.417	0.411	-0.3
3-day	4.283	0.416	-0.3
7-day	4.125	0.394	-0.4
15-day	3.989	0.364	-0.6
30-day	3.867	0.337	-0.7

NOTES:
1. Median plotting positions.
2. Peak data available for 25 years of record.
3. Drainage area: 1,339 sq. mi.
4. Period of record: 1904-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
YUBA RIVER NEAR MARYSVILLE
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
Peak	4.743	0.390	-0.2
1-day	4.639	0.390	-0.2
3-day	4.533	0.392	-0.2
7-day	4.387	0.377	-0.3
15-day	4.250	0.351	-0.4
30-day	4.129	0.326	-0.4

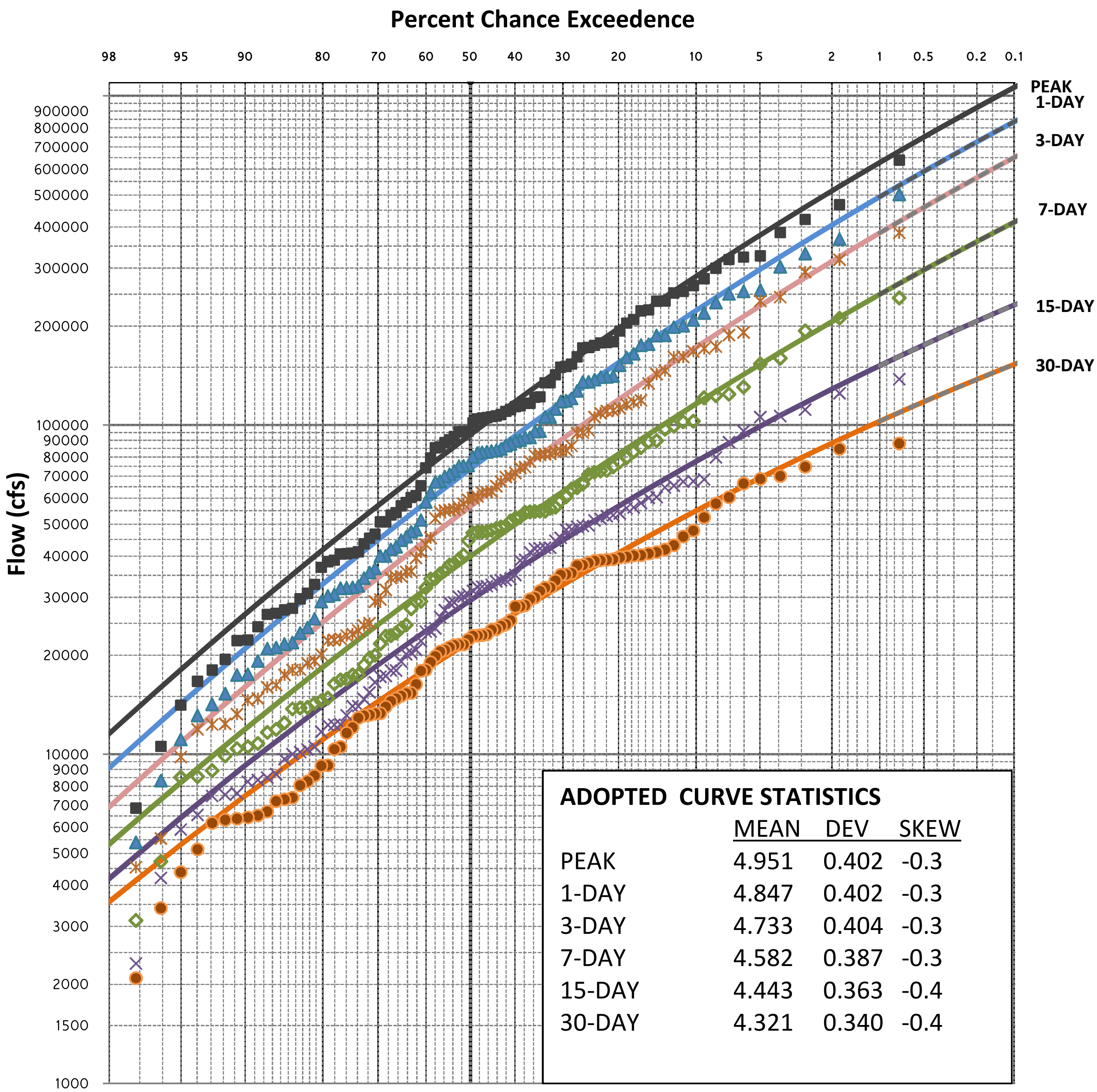
NOTES:

1. Median plotting positions.
2. Peak data available for 11 years of record.
3. Drainage area: 3,624 sq. mi.
4. Period of record: 1901-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
FEATHER RIVER AT OROVILLE DAM
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED CURVE STATISTICS

	MEAN	DEV	SKEW
PEAK	4.951	0.402	-0.3
1-DAY	4.847	0.402	-0.3
3-DAY	4.733	0.404	-0.3
7-DAY	4.582	0.387	-0.3
15-DAY	4.443	0.363	-0.4
30-DAY	4.321	0.340	-0.4

NOTES:

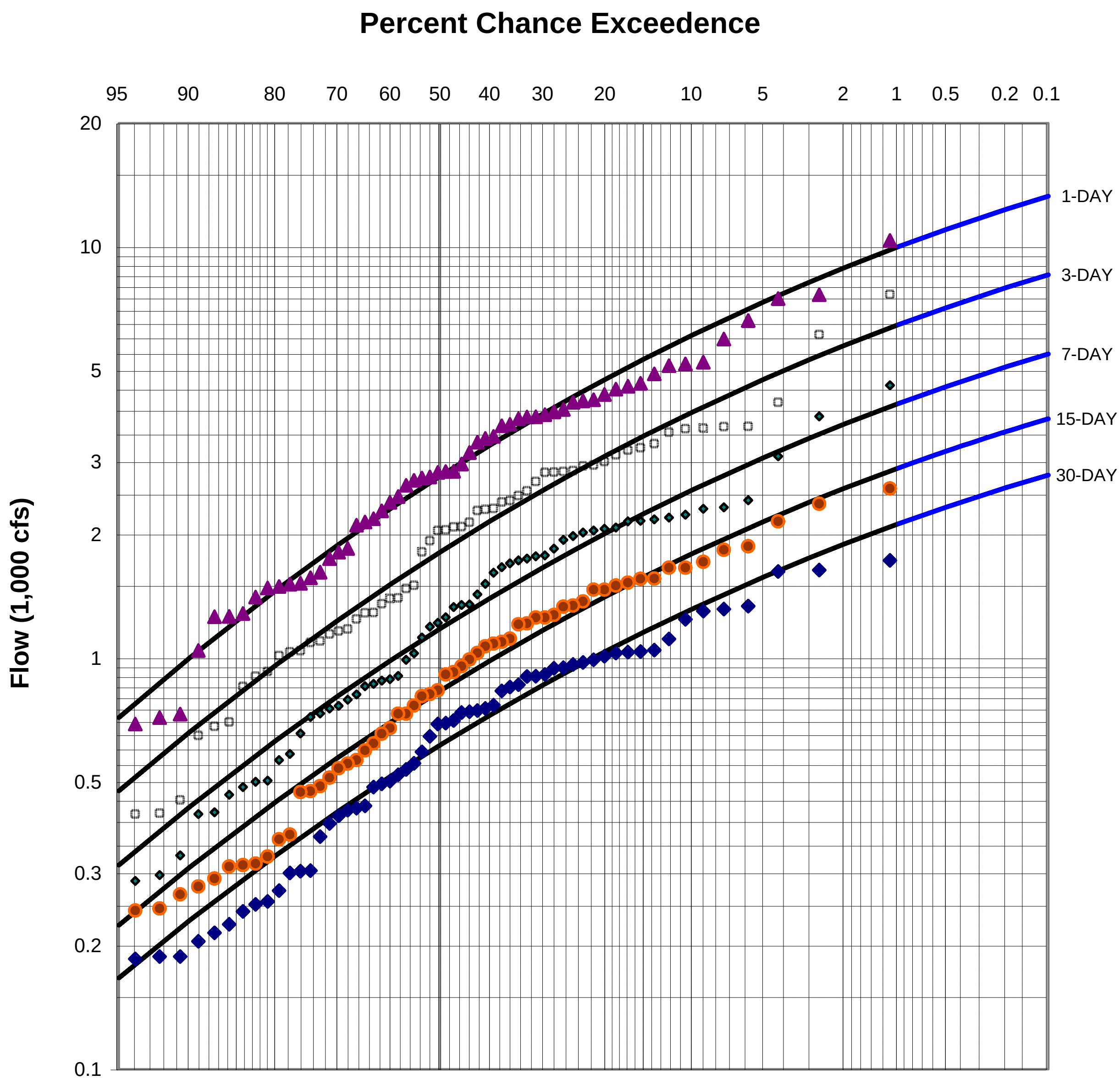
1. Median plotting positions.
2. Computed Probability
3. Drainage area: 5313 sq. mi.
4. 94 years of record (1904 to 1997)

MODIFIED BY BJW MAY 2002

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

RAINFLOOD FREQUENCY CURVES
FEATHER RIVER AT SHANGHAI BEND
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	3.414	0.311	-0.6
3-day	3.230	0.308	-0.6
7-day	3.044	0.305	-0.6
15-day	2.893	0.302	-0.6
30-day	2.761	0.300	-0.6

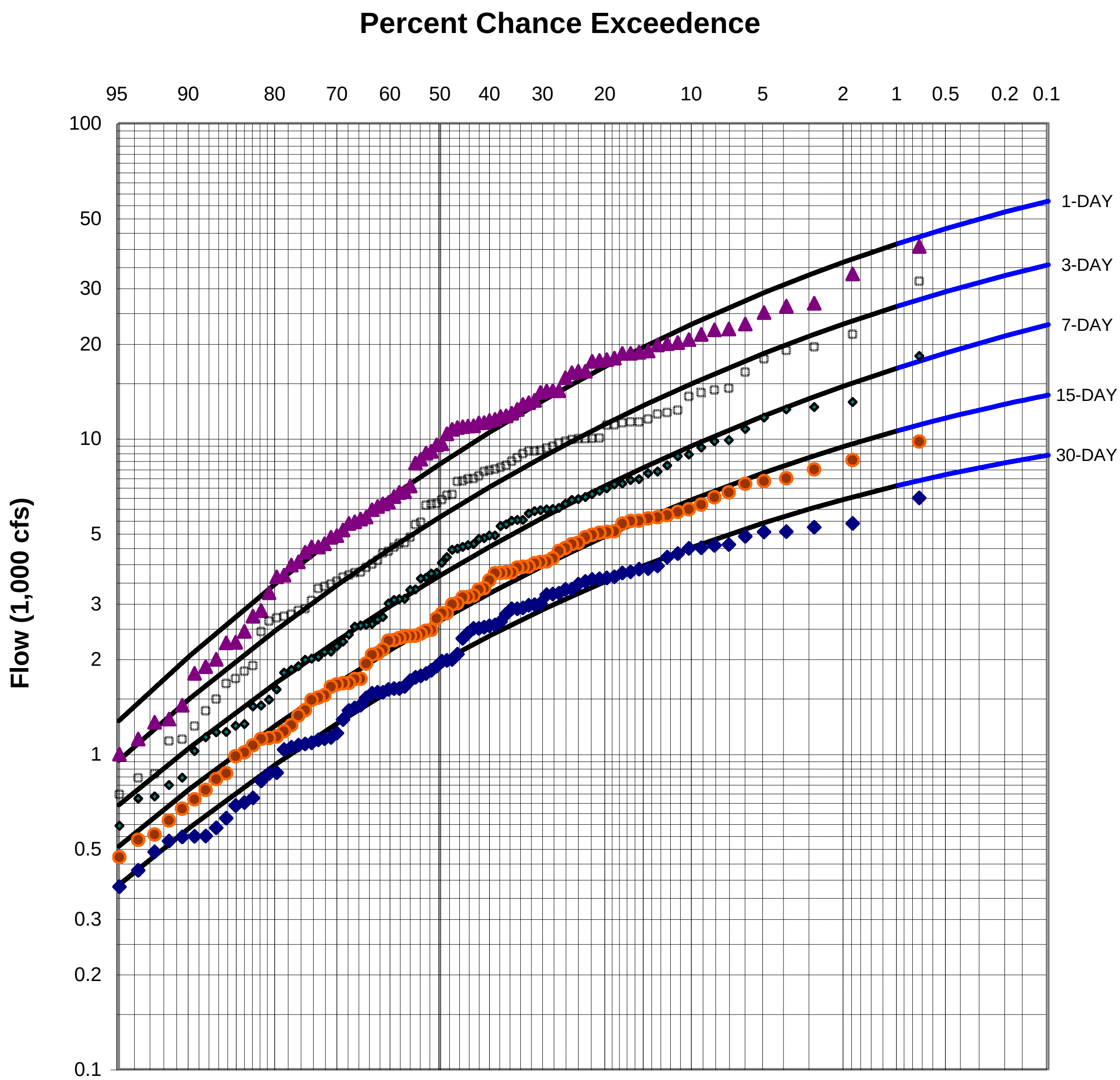
NOTES:

1. Adjusted USGS gage 11418500 to account for daily change in storage at upstream reservoir (potential channel, out-of-channel, or storage losses neglected).
2. WY 1977 censored as low outlier.
3. Median plotting positions.
4. Drainage area: 84.6 sq. mi.
5. Period of record: 1936-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
DEER CREEK NEAR SMARTVILLE
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	3.872	0.420	-0.7
3-day	3.707	0.399	-0.7
7-day	3.527	0.380	-0.7
15-day	3.379	0.367	-0.8
30-day	3.244	0.357	-0.9

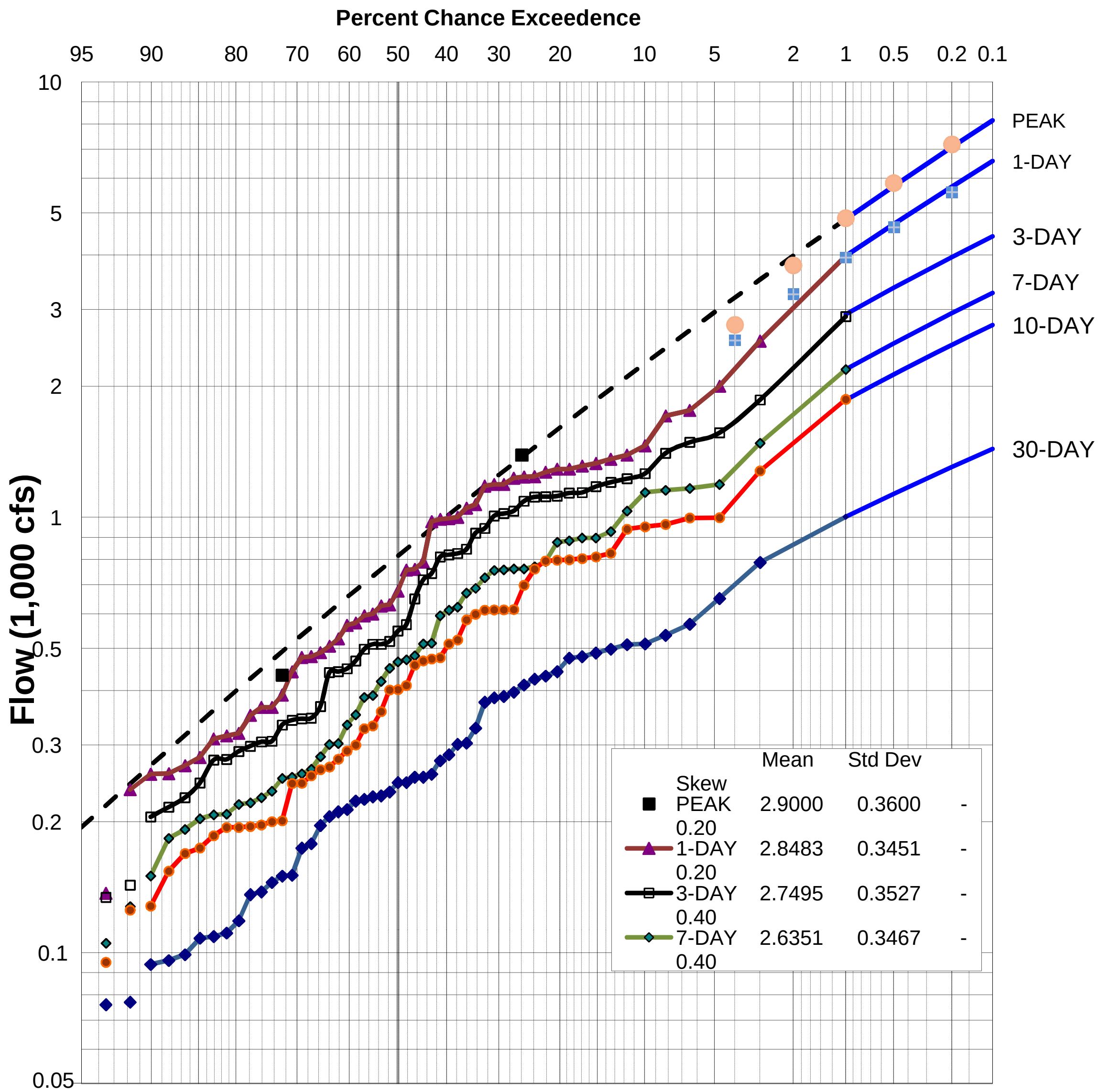
NOTES:

1. Adjusted USGS gage 11424000 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Statistics adusted based on correlation with Van Trent (1906-27) and Yuba R at Smartville (1928).
3. Median plotting positions.
4. Drainage area: 292 sq. mi.
5. Period of record: 1906-1998.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
BEAR RIVER NEAR WHEATLAND
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Notes:

1. Recorded flows use median plotting positions for the 56 years of record from 1939 to 1996.
2. Drainage area about 96 sq. mi. for DWR Station A05929.
3. Modeled values from SBFCA HMS model June 2012 with precipitation reflecting The 1-, 3-, 7-, 10-, and 30-day data was plotted to extend the historical data up to the 0.1-percent exceedance frequency of the estimated best fit curve.
4. The peak flow curve was manually adjusted to best fit the historical and modeled data and the 1-day volume curve. Model Runs reflect 10 Year Flows in the Sutter Bypass with storm precipitation reflecting the frequency of the flows reflected on the flow volume frequency curve.
5. The plotted curves to the right of the 1-percent exceedance frequency are manually

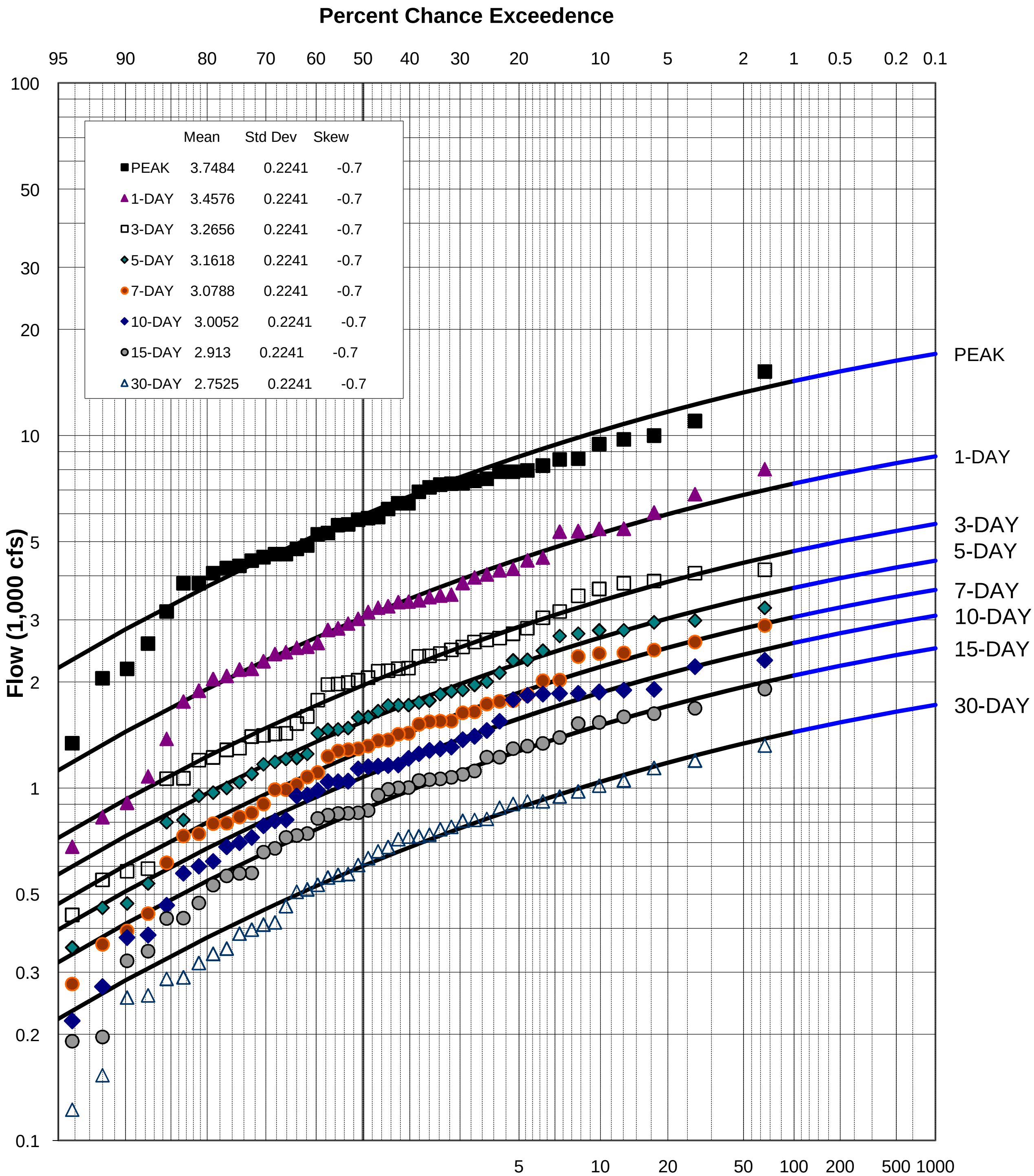
RAIN FLOOD FREQUENCY CURVES
UNREGULATED CONDITIONS

WADSWORTH CANAL NR SUTTER
SACRAMENTO RIVER BASIN.

WATER YEARS 1939 ~ 1996

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 17



NOTES:

1. WY 1977, 1972, 1990 are low outliers.
2. Median plotting positions
3. Drainage area about 94 sq. mi.
4. 46 years of record
5. DWR Station A02984

DEC 2008

SUTTER BASIN, CALIFORNIA

Sutter Basin Hydrology Study

CHEROKEE CANAL NEAR RICHVALE, CA

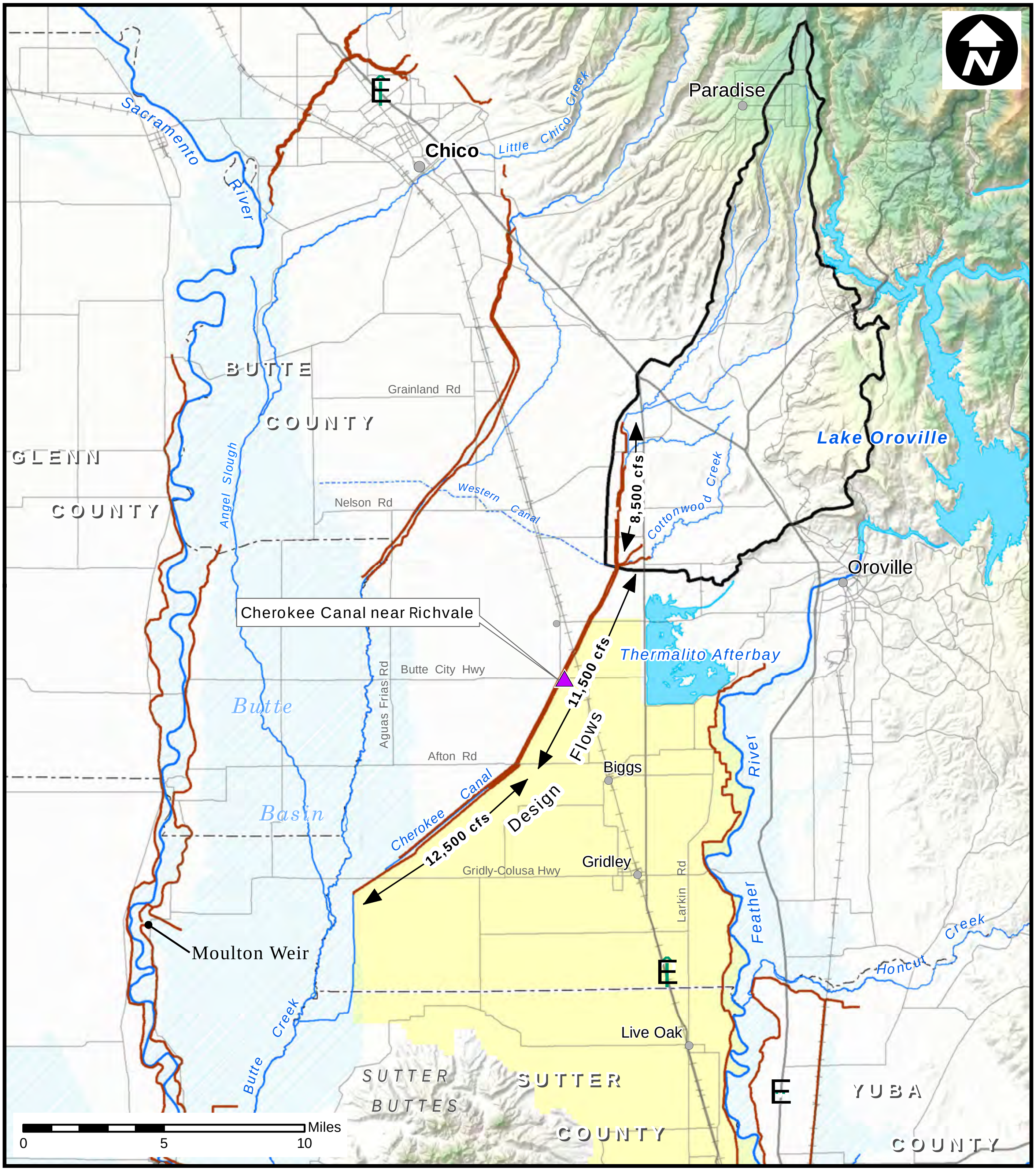
RAIN FLOOD FREQUENCY CURVES

WATER YEARS 1961-2006

U.S. ARMY CORPS OF ENGINEERS

SACRAMENTO DISTRICT

PLATE 18



Legend

- Stream Gage
- Sutter Basin Study Area
- Watershed Boundary
- Designated Floodway
- Lake or Reservoir
- River or Stream
- Federal Levee
- Highway
- Major Road
- Railroad
- County Boundary
- City or Town

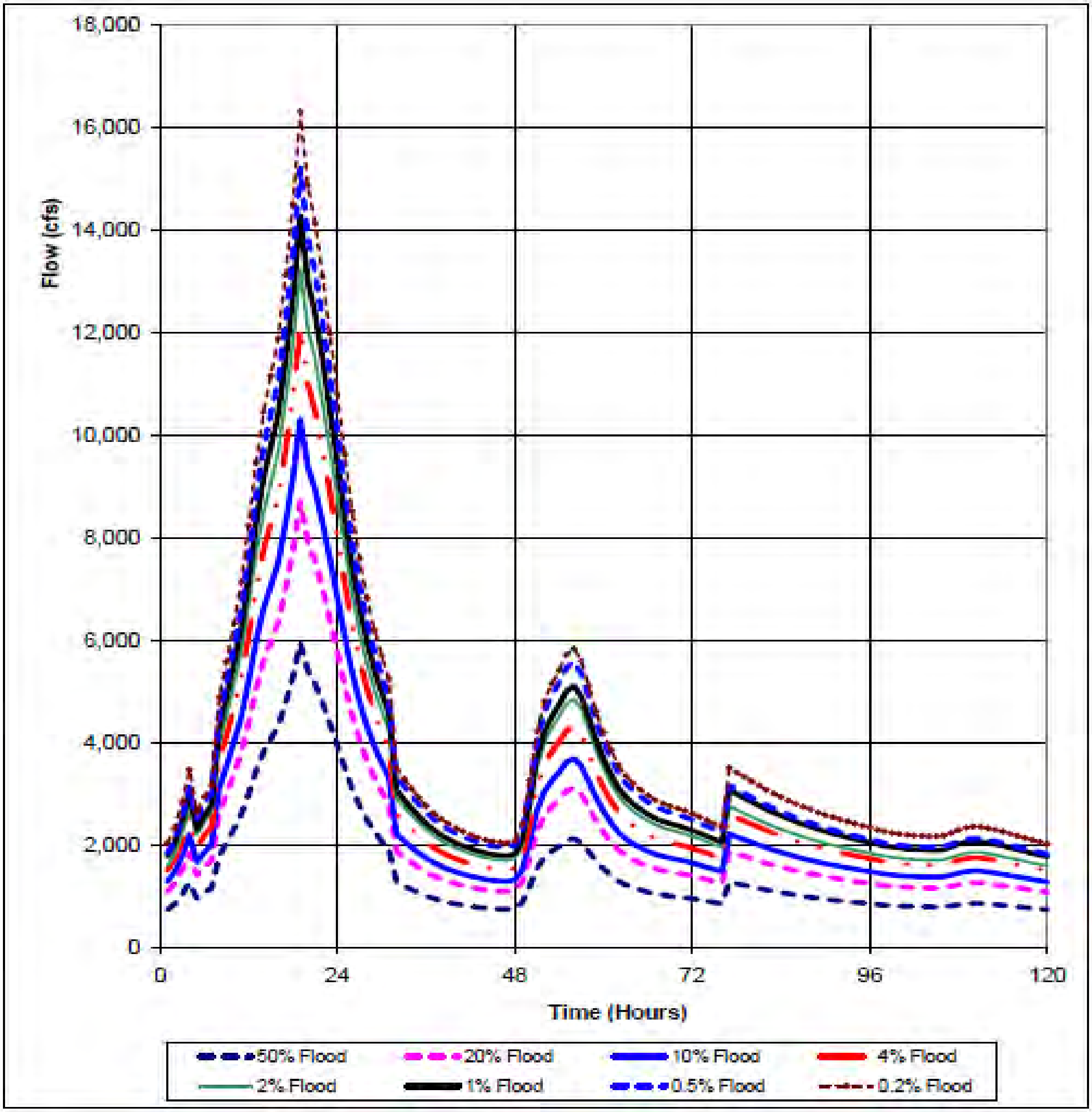
SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL WATERSHED AND TOPOGRAPHY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012



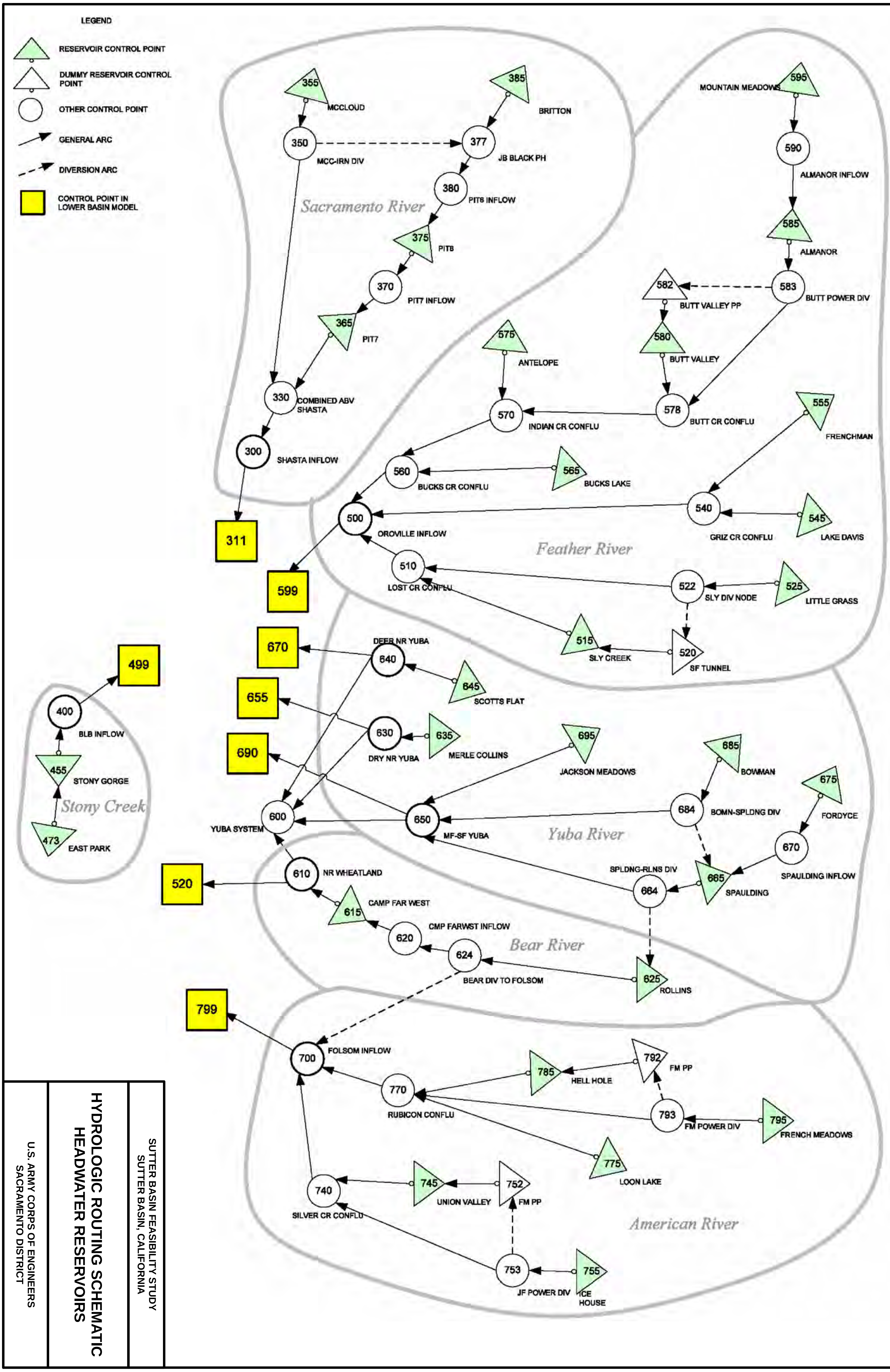
Source: Sutter County Feasibility Study, 2004

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL
SYNTHETIC 8-FLOOD SERIES
5-DAY WAVE HYDROGRAPHS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 20



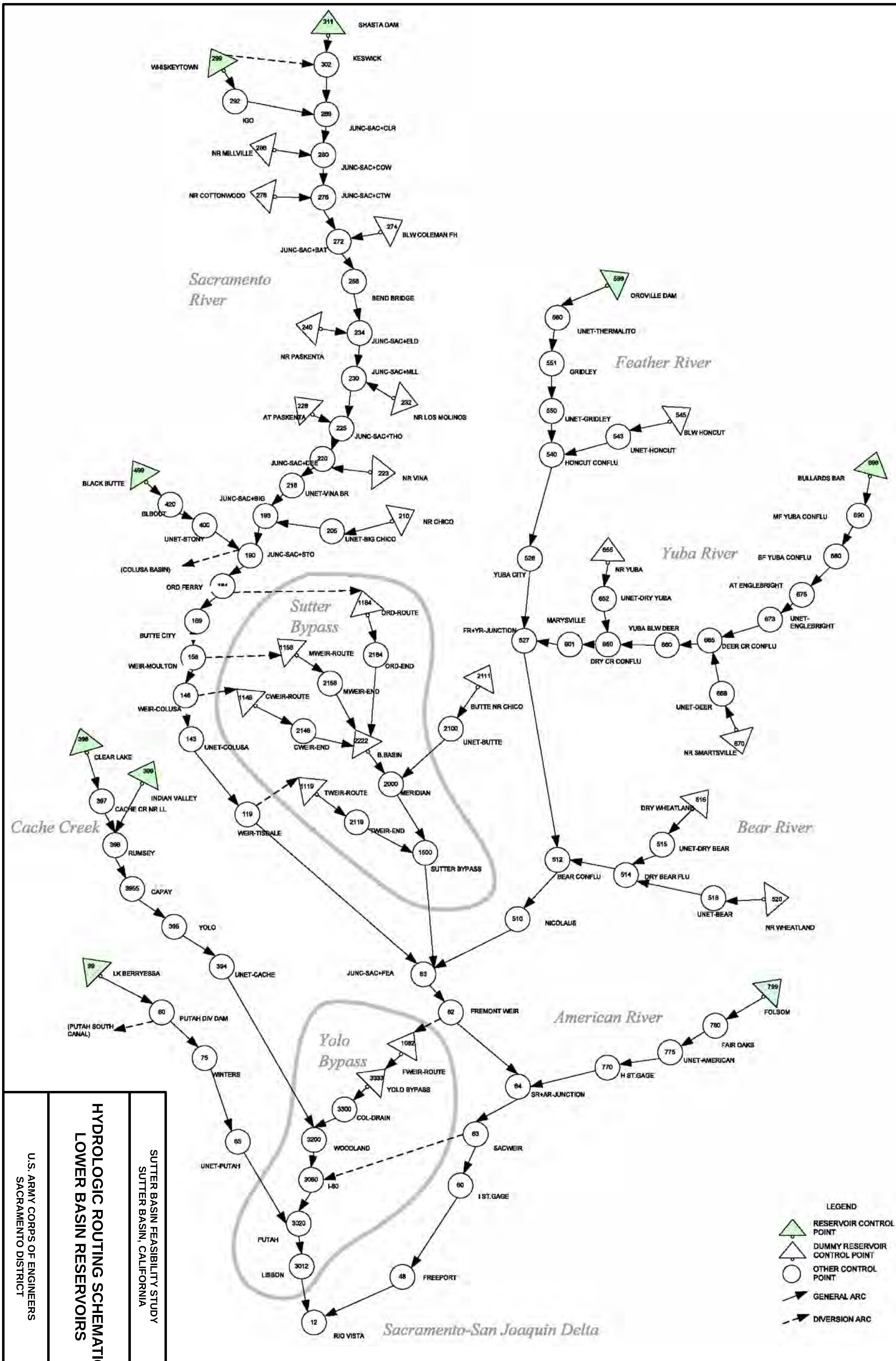
SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

HYDROLOGIC ROUTING SCHEMATIC HEADWATER RESERVOIRS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

NOV 2012

PLATE 21



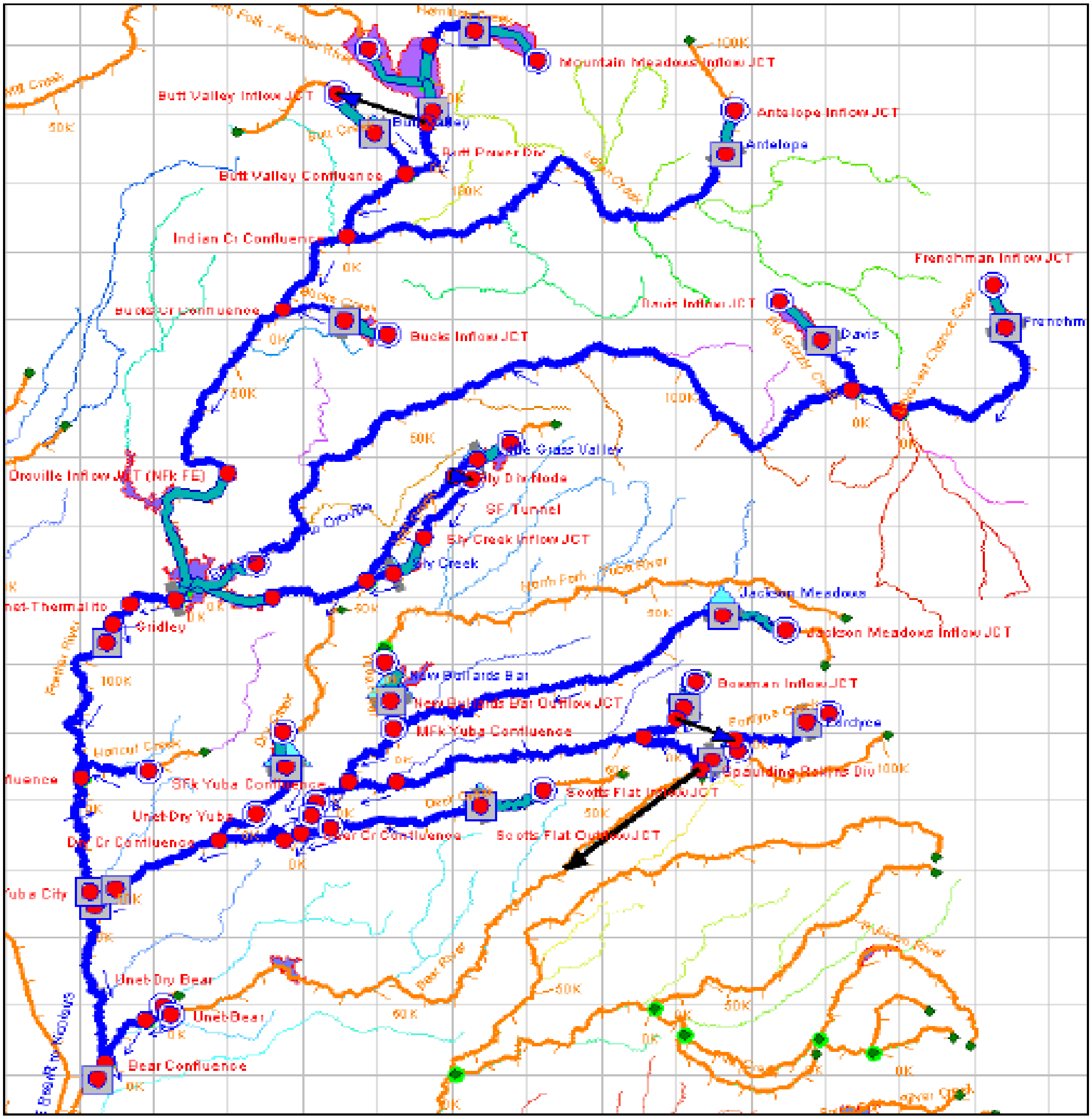
SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

HYDROLOGIC ROUTING SCHEMATIC LOWER BASIN RESERVOIRS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

NOV 2012

PLATE 22



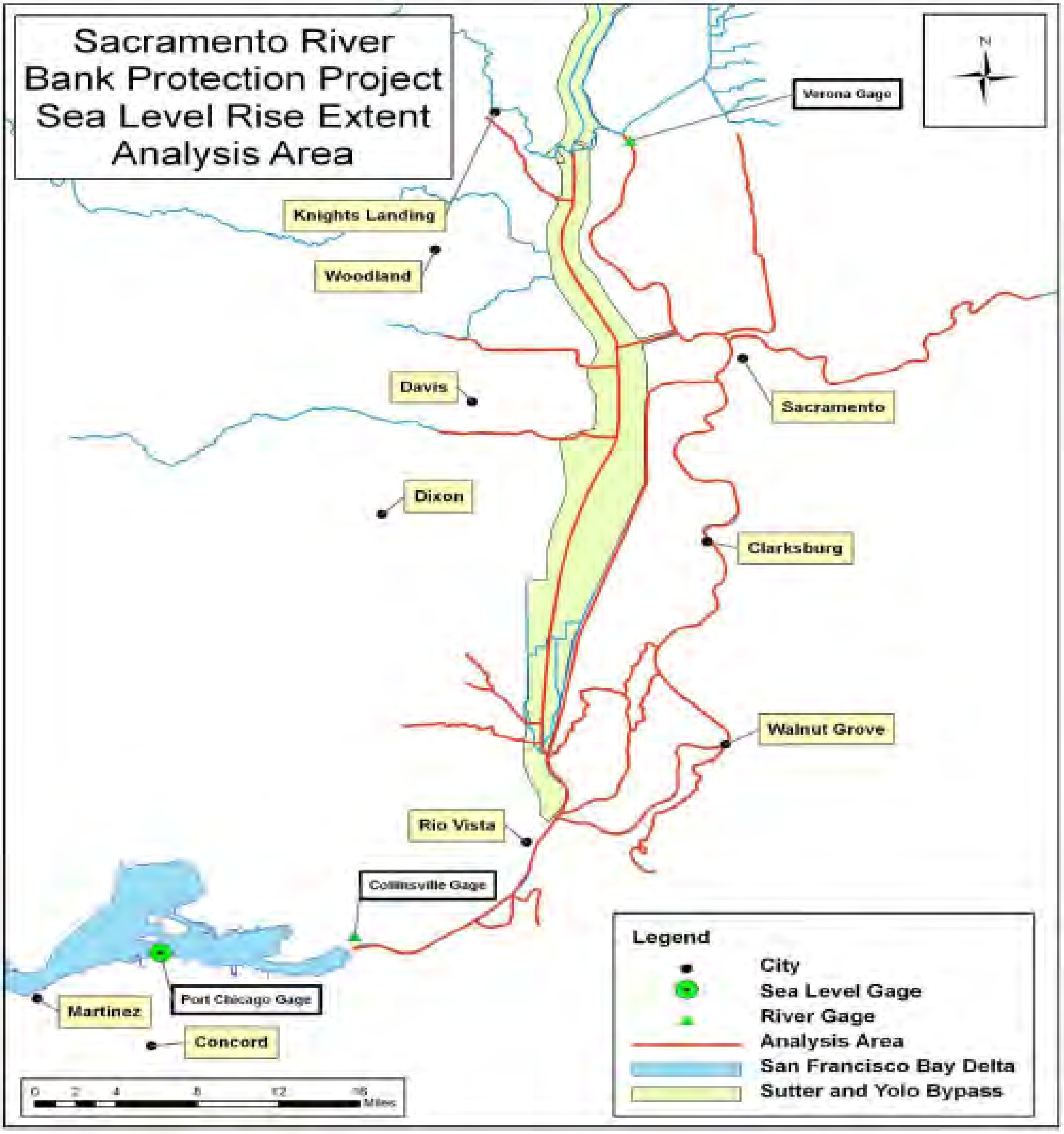
Source: Lower Feather River FPMS, 2004

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

ResSim Model Schematic

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 23

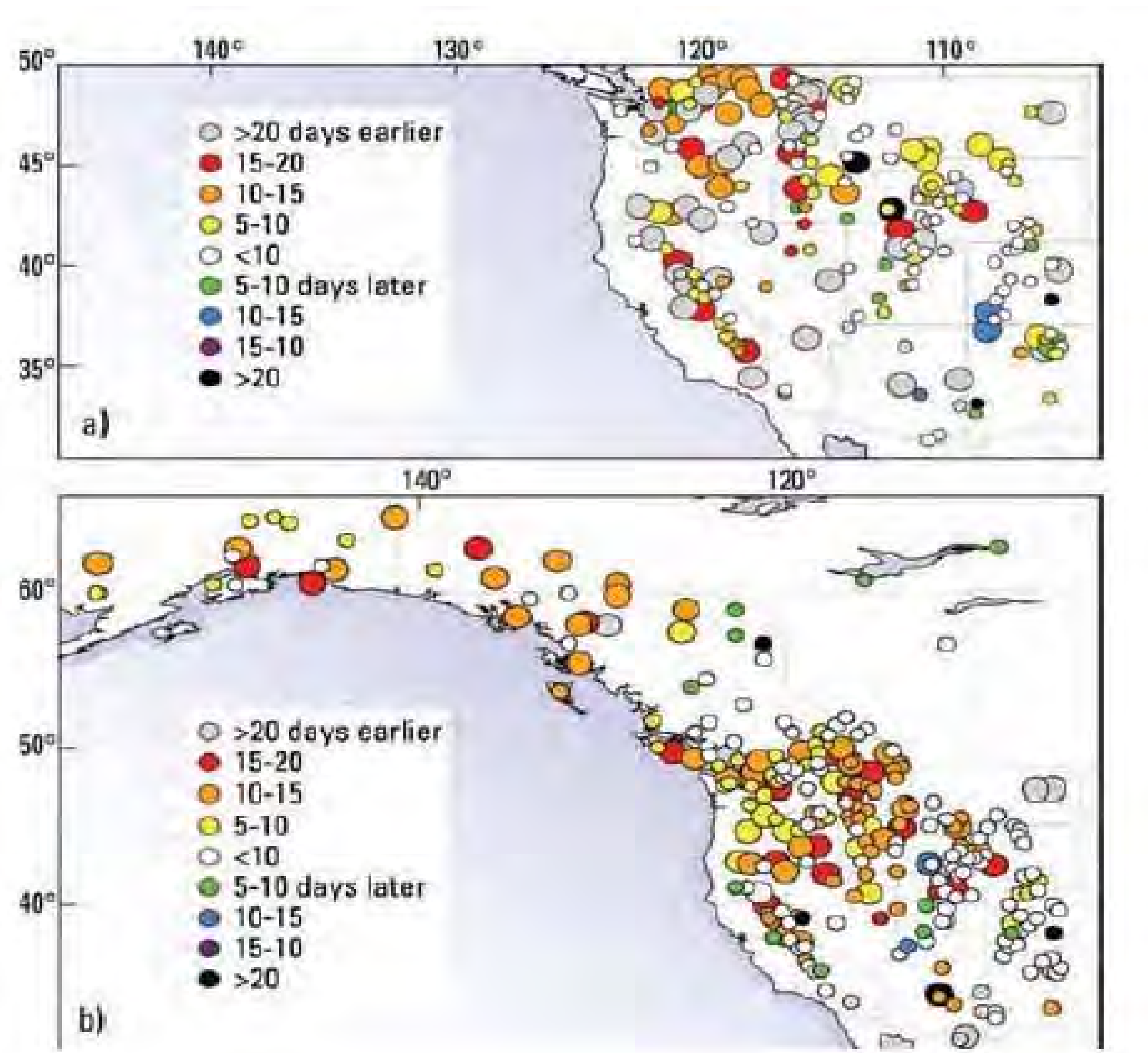


Source: Sacramento Bank Protection Project, 2011

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

Sea Level Rise Extent
Analysis Area

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



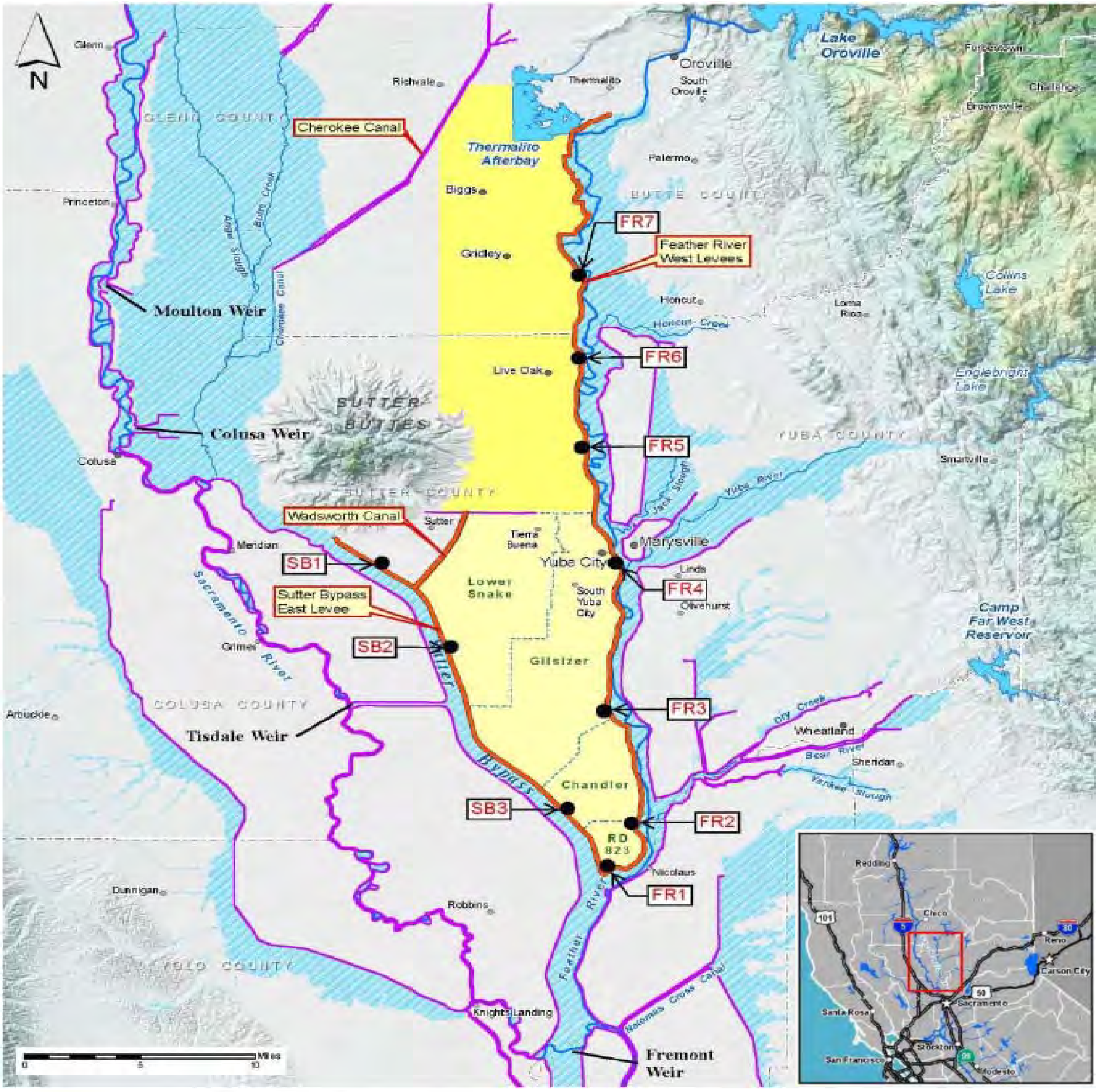
Trends in (a) yearly dates of spring snowmelt onset and (b) centers of volume of yearly streamflow hydrographs in rivers throughout western North America, based on U.S. Geological Survey streamgages in the United States and an equivalent Canadian streamflow network. Large circles indicate sites with trends that differ significantly from zero at a 90-percent confidence level; small circles are not confidently identified.

Source: USBR, Managing Water in the West, 2011.

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

Climate Change Trends

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

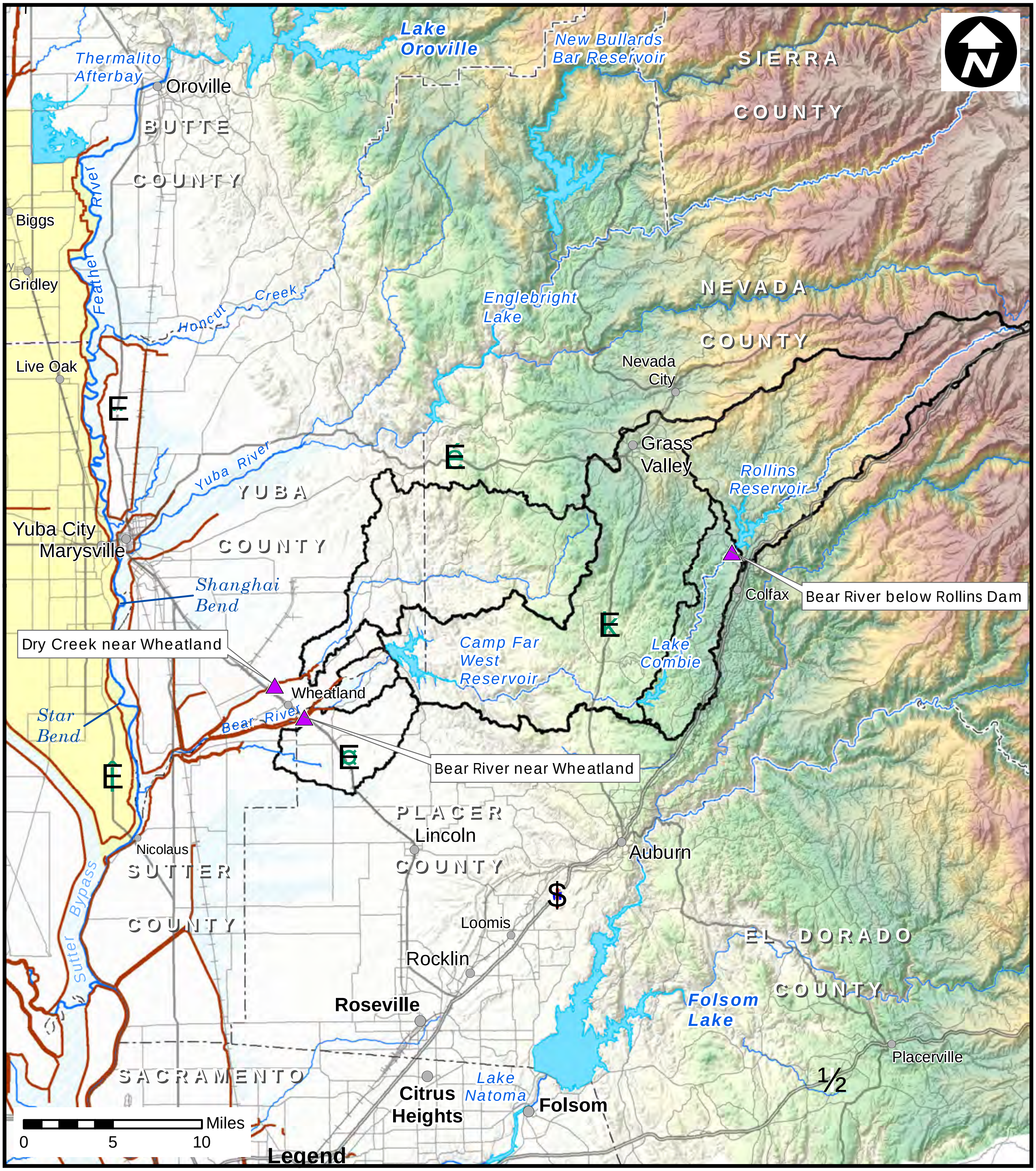


Source: Ford, Wave Runup Analysis, 2011.

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

WAVE RUNUP STUDY AREA
WITH INTERIOR DRAINAGE AREAS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

USGS Stream Gages - CA

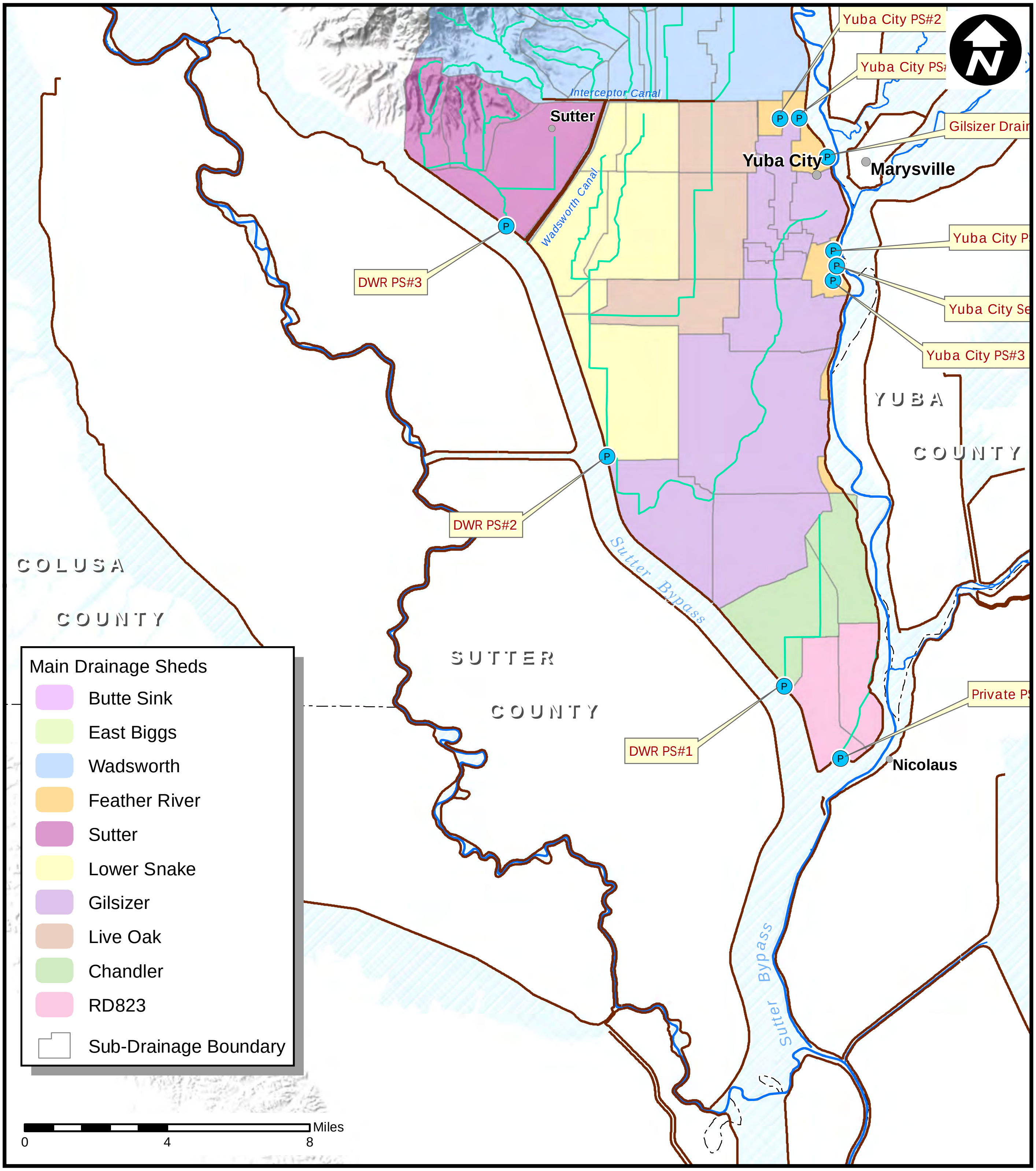
- USGS Stream Gages - CA
- Sutter Basin Study Area
- Watershed Boundary
- Designated Floodway
- Lake or Reservoir
- River or Stream
- Federal Levee
- Highway
- Major Road
- Railroad
- County Boundary
- City or Town

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BEAR RIVER WATERSHED AND TOPOGRAPHY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars



Legend

P	Pump Station		City or Town
	Drainage Flowline		County Boundary
	River or Stream		Federal Levee
	Lake or Reservoir		Designated Floodway

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

HEC-HMS SUBBASINS and PUMP STATIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 28

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

HYDRAULIC DESIGN APPENDIX

July 2013

Revised: 06 October 2013

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62. 1% (1/100) ACE Floodplain Alternative SB-7 Fix-in-Place Sunset Weir to Laurel Ave.
63. 0.5% (1/200) ACE Floodplain Alternative SB-7 Fix-in-Place Sunset Weir to Laurel Ave.
64. 0.2% (1/500) ACE Floodplain Alternative SB-7 Fix-in-Place Sunset Weir to Laurel Ave.

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Attachments

Attachment A. Memorandum for File: Sutter Basin Pilot Feasibility Study, Hydraulic Analysis of Refined Alternatives. 8 June 2012

Attachment B. Final Geotechnical Fragility Curves, February 2013.

Acronyms and Abbreviations

ACE	Annual Chance of Exceedance
CNRFC	California Nevada River Forecast Center
CVFED	Central Valley Floodplain Evaluation and Delineation
CVFPP	Central Valley Flood Protection Plan
DWR	Department of Water Resources
FRM	Flood Risk Management
HEC	Hydrologic Engineering Center
HTOL	Hydraulic Top of Levee
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
NLDB	National Levee Database
NWS	National Weather Service
PBI	Peterson Brustad Incorporated
RD	Reclamation District
SD	Standard Deviation
SBFCA	Sutter Butte Flood Control Agency
TRLIA	Three Rivers Levee Improvement Authority
ULDC	Urban Levee Design Criteria (State of California)
USGS	United States Geological Survey
USACE	United States Army Corps of Engineers
UPRR	Union Pacific Railroad
VE	Value Engineering

1.0 Introduction

1.1 Purpose and Scope

The purpose of this report is to describe the hydraulic analysis conducted in support of the Sutter Basin Feasibility Study. This report documents the analysis of the final array of alternatives. Analysis of the draft array of alternatives is described in Attachment A.

1.2 Background

The U.S. Army Corps of Engineers, together with the State of California and Sutter Butte Flood Control Agency (SBFCA) conducted this feasibility study to select a plan that reduces flood risk and provides ancillary Ecosystem Restoration and Recreation Benefits within the study area. The goal of the study is to identify a cost effective, technically feasible and locally acceptable project that best reduces flood risk and flood damages and complies with all Federal, State, and local laws and regulations.

1.3 Location

The Sutter Basin study area is located within the State of California approximately 25 miles north of Sacramento. A map of the watershed is included as Plate 1 and a map of the study area is included as Plates 2 and 3. The study area covers approximately 300 square miles and is approximately 43 miles north-south and 9 miles east-west. The study area includes the communities of Yuba City, Live Oak, Gridley, Biggs, and Sutter. Based on 2010 census data and floodplain mapping presented herein, approximately 95,000 people reside within the study area 0.2% (1/500) Annual Chance Exceedance (ACE) Floodplain. Yuba City is the largest community in the study area with a population of approximately 67,000 within the 0.2% (1/500) ACE Floodplain. A map of population density within the study area is provided in Plate 4 and tabulated in Table 1. The majority of land use in the study area is related to agricultural with rice and orchards comprising approximately 64.5% of land use. A map of land use types in the study area is presented in Plate 5 and tabulated in Table 2. 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.

Table 1. 2010 Population, Sutter Basin Study Area

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	251
Yuba City Urban	0	67351	67368	67368	67368	67368	67368
Biggs Urban	0	19	1452	1452	1452	1452	1763
Gridley Urban	0	0	6379	6379	6379	6379	6379
Live Oak Urban	0	0	8362	8362	8362	8362	8362
Sutter County Rural	1089	4837	6260	6314	6323	6354	6378
Butte County Rural	0	9	4776	4788	4788	4793	4899
Total	1089	72216	94597	94663	94672	94707	95400

Table 2. Land Use Types, Sutter Basin Feasibility Study Area

Land Use Type	Acres	Percent of Total
Abandoned	0	0.0
Burned Over Areas	0	0.0
Citrus and Subtropical	960	0.5
Deciduous Fruits and Nuts	61,230	31.2
Entry Denied	0	0.0
Field Crops	3,310	1.7
Grain and Hay Crops	4,520	2.3
Idle	4,800	2.4
Barren and Wasteland	50	0.0
Native Classes Unsegregated	0	0.0
Non-irrigated Idle	0	0.0
Riparian Vegetation	10,580	5.4
Not Surveyed	0	0.0
Native Vegetation	13,110	6.7
Water Surface	2,000	1.0
Pasture	5,810	3.0
Rice	65,360	33.3
Semi Agricultural and Incidental to Ag	2,620	1.3
Truck, Nursery and Berry Crops	3,080	1.6
Urban	6,410	3.3
Commercial	640	0.3
Industrial	1,490	0.8
Urban Landscape	600	0.3
Residential	5,120	2.6
Vacant	4,520	2.3
Vineyards	70	0.0
Outside	0	0.0
Total	196,260	100.0
Sources: DWR 2004 Butte County Land Use Survey DWR 2005 Sutter County Land Use Survey		

1.4 Plan Selection Process

The final array of alternative plans described in this report were selected through a risk informed planning process involving multi-disciplinary analysis at increasing levels of detail. At each level of screening and analysis the level of detail was improved and the relative uncertainty was assessed. Measures and alternatives were carried forward if the level of detail was insufficient to screen it out.

Throughout this process the concept of absolute accuracy versus relative accuracy was considered in alternative comparisons. Although it would appear that every plan should be compared to the most accurate assessment of existing conditions, this is not necessary because the relative accuracy between plans is sufficient to select the most optimal plans to move forward.

Conceptual alternatives were developed from a broad array of measures at a qualitative level of detail. The conceptual alternatives were developed during a planning Charrette attended by the project sponsors and subject matter experts. Development of the conceptual alternatives is described in the Sutter Basin Feasibility Study report.

An array of draft alternatives were derived from the conceptual alternatives and evaluated at an increased level of detail. This level of detail included qualitative and quantitative engineering analyses. Analyses included floodplain hydraulic modeling, cost estimating, and economic benefit estimations. The level of detail was limited to that required to decide which plans to carry forward. Results were evaluated at a combined Value Engineering (VE) study and planning charette attended by the project sponsors and subject matter experts.   At the conclusion of the VE and planning charette, refinements to the draft array of alternatives were identified for further, more detailed analysis.   Selection of the draft array of alternatives is described in Progress Document 1.

Final alternatives were selected from the draft alternatives in the next level of detail. This level of detail included additional qualitative and quantitative engineering analyses. Analyses included refined channel hydraulic modeling, cost estimating, and economic benefit estimations. The level of detail was limited to that required to decide which plans to carry forward. Results were presented to the vertical team at Decision Point 2.   At the conclusion of the Decision Point, a final array of alternatives was identified for further analysis. A summary of the hydraulic analysis performed for the draft array of alternatives is described in Attachment A. Additional details are described in internal memorandums on file within the Sacramento District Hydraulic Analysis Section.

1.5 Datum

As required by ER 1110-2-8160 all elevations provided herein are referenced to the NAVD88 vertical datum. All horizontal data provided herein are referenced to the North American Horizontal Datum of 1983 (NAD83) Horizontal datum. All horizontal coordinates are projected to the California State Plane Zone II coordinate system. River miles presented in this study are based on the March 2002 Sacramento and San Joaquin River Basins Comprehensive study (Comp Study). Project stationing presented in this study is based on the Feather River West Levee Project Stationing defined by SBFCA.

Historical elevation data were converted to NAVD88 from their original legacy reference datum. The method of conversion followed the requirements in ER 1110-2-8160 and the uncertainty in the conversion is accounted for in the study results.

The following generalized conversion is provided to compare NAVD88 elevations provided in this study to previous studies presented in the legacy NGVD29 datum. Expressed as an equation, Elevation (NGVD29) = Elevation (NAVD88) minus 2.40 feet. The conversion between NAVD88 and NGVD29 ranges from 2.3 to 2.4 feet in the study area.

2.0 Study Area

2.1 Watershed

The Sutter Basin study area is situated within the Sacramento River watershed. A map of the Sacramento River watershed is included as Plate 1.   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 River and Bear Rivers. These watersheds drain the eastern 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.

2.2 Topography

A topographic map of the study area is presented in Plate 2. Elevations within the study area range from 110 ft NAVD88 in the north to 30 ft NAVD88 in the south. The study area has a general slope from northeast to south west. The general slope of the study area is interrupted by two major embankment features which impact hydraulic conveyance within the 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.

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.

a. 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 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 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 board for any encroachments that could reduce or impede flood flows or would reclaim any of the floodplain within the Butte Basin (DWR, 2010).

b. 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, Feather River to Sacramento River.

c. 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.

d. 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 between 1959 and 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 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 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 flood protection from a 4% (1/25) ACE event and mitigated sediment transport problems within its watershed.

e. 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 northeast part of Butte and Sutter Counties south to the Sutter Bypass.

(1) <u>West Interceptor Canal</u>. 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) <u>East Interceptor Canal</u>. 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 it 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) <u>Wadsworth Canal</u>. 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.

f. Interior Drainage. 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.

2.4 Stream Gages.

A list of stream gages applicable to the study area is provided in Table 3. The stream gages are operated by the United States Geological Survey (USGS) and California Department of Water resources. Stream gages are shown on Plate 6.

Table 3 Stream Gages, Sutter Basin Study Area

Gage Name	Area (Sq Mi)	Agency	Gage Number	Period of Record	Type
Bear R Nr Wheatland Ca	292	USGS	11424000	1928-2010	S,Q
Bear River at Pleasant Grove	300	DWR	A06535	1987-2010	S,Q
Butte Creek near Gridley	NA	DWR	A04150	1991-1999	S,Q
Butte Slough at Outfall Gates near Colusa	NA	WDL	A02967	1992-2010	S
Butte Slough near Meridian	NA	WDL	A02972	1981-2010	S,Q
Cherokee Canal nr Gridley	NA	DWR	A00910	1991-1998	S,Q
Cherokee Canal nr Richvale	NA	DWR	A02984	1976-2010	S,Q
Camp Far West Reservoir	NA	DWR	A65105	1998-2010	Q
Colusa Weir Spill to Butte Basin near Colusa	NA	WDL	A02981	1975-2010	S,Q
Deer C Nr Smartville CA	84.6	USGS	11418500	1935-2010	S,Q
Feather River at Nicholaus	5,921	DWR	A05103	1942-2010	S,Q(P)
Feather River at Oroville	3,624	USGS	11407000	1902-2010	S,Q
Feather River at Yuba City	3,974	DWR	A05135	1964-2010	S
Feather River near Gridley	3,676	DWR	A05165	1964-2010	S,Q
Moulton Weir Spill to Butte Basin nr Colusa	NA	DWR	A02986		
Sacramento R at Ord Ferry	12,030	DWR	A02570	1922-2010	S,Q
Sacramento R at Colusa Ca	12,090	USGS	11389500	1941-2010	S,Q
Sacramento R at Verona Ca	21,251	USGS	11425500	1929-2010	S,Q
Sacramento R Blw Wilkins Slough nr Grimes Ca	12,915	USGS	11390500	1931-2010	S,Q
Sacramento River at Butte Slough Outfall Gates	NA	DWR	A02400	1992-2004	S
Sacramento River at Fremont Weir (East)	NA	DWR	A02160	1935-2010	S
Sacramento River at Fremont Weir (West)	NA	DWR	A02170	1934-2010	S
Sacramento River at Knights Landing	14,535	DWR	A02200	1982-2010	S
Sacramento Slough near Karnak	NA	DWR	A02925	1981-2010	S
Sutter Bypass at R.D. 1500 P.P. near Karnak	NA	DWR	A02927	1975-2010	S
Sutter Bypass Channel at Pumping Plant #1	NA	DWR	SB1	2008-2010	S
Sutter Bypass Channel at Pumping Plant #2	NA	DWR	SB2	2008-2010	S
Sutter Bypass Channel at Pumping Plant #3	NA	DWR	SB3	2008-2010	S
Tisdale Weir near Grimes	NA	DWR	A02960	1975-2010	S,Q
Willow Slough near Nicolaus	NA	DWR	A02943	1991-2010	S
Yolo Bypass nr Woodland Ca	NA	USGS	11453000	1939-2011	S,Q
Yuba R blw Englebright Dam near Smartsville	1,108	USGS	11418000	1941-2011	S,Q
Yuba R Nr Marysville CA	1,339	USGS	11421000	1940-2011	S,Q
Wadsworth Canal near Sutter (lower)	96	DWR	A05927	1982-1997	S,Q
Wadsworth Canal near Sutter (upper)	96	DWR	A05929	1976-1997	S,Q
Note: S-Stage, Q-Discharge, NA- Not Available, (Partial Record)					

2.5 Historical Floods.

The Feather River near Oroville gage provides an indicator of large historical floods within the study area. The largest fifteen floods from 1951 to 2010 are presented in Table 4. 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.

Table 4
Fifteen Largest Annual Maximum Floods
WY1951-WY2010, Feather River at Oroville

Measured				Regulated Peak Flow (CFS)	Unregulated Peak Flow (CFS)	Notes
Annual Ranking	Water Year	Date of Peak	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	1965	12/23/1964	158,000	150,000	260,000	Note 1
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		59500	
15	1970	1/25/1970	56,300	56,300	117,700	
Note 1/ Dec 1964 Flood regulated by a partially completed Oroville Dam.						

a. 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 killing 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.

b. 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.

b. November 1982 - March1983. 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 percent 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.

c. 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.

d. 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.

e. 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, killing one person, destroying 180 homes and businesses, and prompting 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 (USACE, 1998).

f. December 2005 - January 2006. Between 28 December 2005 and 9 January 2006, the State of California experienced a series of severe storms which impacted the levees within the Sacramento District's boundaries. 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. The State of California Department of Water Resources and/or their maintaining agencies conducted the actual flood fight activities while the U.S. Army Corps of Engineers provided technical assistance to the State.

2.5 Climate Change.

The primary impacts of climate change on Flood Risk Management projects are related to changes in flood frequency estimates, changes in sea level, and their associated uncertainties. The primary climate change consideration within the study area is related to the potential changes in flood frequency estimates. An evaluation of project performance related to changes in climate and flood frequency estimates was conducted using the HEC FDA program and is described in the Hydrology Appendix. Appendix C of EC 1165-2-212 provides a flow chart for evaluating sea level change for a potential project. Based on Step 1 of the flow chart, an evaluation of sea level rise is not required. The study area is approximately 30 feet above mean sea level. Base on sea level trends provided in EC 1165-2-212. Sea level rise would have no impact on the study area up to the year 2100.

3.0 Alternative SB-1 (Without Project Conditions)

3.1 Project Assumptions

a. Levee Design. All existing federal levees are assumed to be maintained to the 1957 design top of levee. The 1957 design 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 1957 design water surface profile is described on the drawing set, Sacramento River Flood Control Project, California, Levee and Channel Profiles, Drawing File Number 50-10-3334, 15 March 1957. The 1957 design water surface is labeled on the drawing set as the Project Design Flood Plane.

The derivation of the 1957 water surface profiles is described in the memorandum "Levee and Channel Profiles, Sacramento River Flood Control Project" dated 1 July 1957. The 1957 design freeboard is described in the Operations and Maintenance manuals dated 1951. The Sacramento River Flood Control Project adopted multiple existing levees of varying height. The Operations and Maintenance manuals indicates the adopted levee segments met or exceeded the design freeboard. The 1957 design profile and freeboard are described in detail in memorandum on file in the Sacramento District Hydraulic Analysis Section.

b. TRILIA Feather River Setback Levee. The hydraulic analysis of without project conditions includes the setback levee along the left bank of the Feather River constructed by the Three Rivers Levee Improvement Authority (TRILIA).

c. Feather River Star Bend Setback Levee. The without project conditions assumes the levee setback levee on the right bank near Star Bend has not been constructed.

d. Interior Drainage Facilities. The hydraulic analysis assumes all drainage facilities are maintained to their design capacities.

e. Operation and Maintenance. The hydraulic analysis assumes vegetation conditions within the channel will be maintained with similar hydraulic conditions as the existing conditions.

3.2 Hydrology

a. Sutter Bypass, Feather River and Butte Basin. Hydrology for the Sutter Bypass, Feather River, and Butte Basin was based on the Sacramento-San Joaquin Comprehensive study (Comp Study) and Lower Feather River Floodplain mapping study. The Sacramento-San Joaquin Comprehensive study included the entire Sacramento and San Joaquin Valleys. The Lower Feather River Floodplain mapping study was based on the Comprehensive study but included revisions to flow frequencies and hydrographs on the Feather River. Balanced 30-day regulated flow hydrographs developed 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) was used in the hydraulic analysis.

The synthetic hydrology investigated unregulated flood frequencies at mainstem and tributary locations throughout the Sacramento Basin. The flood frequency analysis involved evaluations of long term historical records at the stream gages. The unregulated flow frequency statistics and period of record for the Sacramento River at Bend Bridge, Feather River at Oroville, and Feather River at Shanghai Bend were used to estimate hydrologic uncertainty in the Sutter Basin Feasibility Study. The adopted statistics and period of record for the unregulated conditions are provided in Tables 5, 6, and 7.

Table 5
Rain Flood Frequency, Sacramento River at Ord Ferry
Unregulated Conditions

Flood Duration	Adopted Log Mean	Adopted Log Standard Deviation	Adopted Log Skew	Record (Years)	
				Years Evaluated	Years Used
1-Day	5.009	0.281	0.0	1922-1997 (1977 censored)	75
3-Day	4.939	0.281	0.0	1922-1997 (1977 censored)	75
5-Day	4.866	0.279	-0.1	1922-1997 (1977 censored)	75
10-Day	4.809	0.278	-0.1	1922-1997 (1977 censored)	75
15-Day	4.680	0.267	-0.3	1922-1997 (1977 censored)	75
30-Day	4.562	0.258	-0.3	1922-1997 (1977 censored)	75
1977 censored as a low outlier					

Table 6
Rain Flood Frequency, Feather River at Oroville
Unregulated Conditions

Flood Duration	Adopted Log Mean	Adopted Log Standard Deviation	Adopted Log Skew	Record (Years)	
				Years Evaluated	Years Used
Peak	4.743	0.390	-0.2	11 years	11
1-Day	4.639	0.390	-0.2	1901-1997	97
3-Day	4.533	0.392	-0.2	1901-1997	97
7-Day	4.387	0.377	-0.3	1901-1997	97
15-Day	4.250	0.351	-0.4	1901-1997	97
30-Day	4.129	0.326	-0.4	1901-1997	97

Table 7
Rain Flood Frequency, Feather River at Shanghai Bend
Unregulated Conditions

Flood Duration	Adopted Log Mean	Adopted Log Standard Deviation	Adopted Log Skew	Record (Years)	
				Years Evaluated	Years Used
Peak	4.951	0.402	-0.3	1904-1997	94
1-Day	4.857	0.402	-0.3	1904-1997	94
3-Day	4.733	0.404	-0.3	1904-1997	94
7-Day	4.582	0.387	-0.3	1904-1997	94
15-Day	4.443	0.363	-0.4	1904-1997	94
30-Day	4.321	0.340	-0.4	1904-1997	94

Seven storm centerings were formulated in the Comp Study to represent the many different possibilities of aerial storm distributions and antecedent watershed conditions. For each centering, synthetic 30-day natural flow hydrographs were computed at locations throughout the Central Valley. Typically, each tributary basin contained one hydrograph location. Many of these sites were inflow points to major flood management projects (i.e., Feather River at Oroville Dam). These natural flow hydrographs represent flood time series produced by a wholly unimpaired drainage area. The unimpaired hydrographs do not reflect the influence of headwater reservoirs. The hydrographs were balanced so the average flow for all durations matched the given frequency. For example, the peak, 1-day, 3-day, 5-day, 15-day, and 30-day volumes match the given frequency event.

A 3-step process was required to conduct simulations of reservoir regulations for each storm centering. To begin the sequence, the headwaters reservoirs upstream of the flood control reservoirs were simulated. Then, using the resulting storage time series for select headwater facilities, top of conservation storage for those flood damage reduction projects with established credit space agreements were computed. Next, using the results of the headwater simulations and the computed top of conservation series, the lower basin reservoir models were simulated, thereby completing the reservoir simulation procedure.

A regulated set of hydrographs was obtained from “hand off” points in the lower basin reservoir simulation model. These hydrographs were used as the input to the HEC-RAS unsteady flow models in the feasibility study. A review of the seven storm centerings found that peak stages along the Sutter Bypass and Feather Rivers are generated by either the Sacramento River storm centering or Shanghai Bend storm centering. Therefore, these are the only two centerings modeled in the feasibility study. In order to determine the peak stage for a given frequency event both storm centerings are modeled. The set of unregulated flow hydrographs provided at hydraulic model boundary locations shown on Plate 6 and listed in Table 8.

Table 8 Regulated Boundary Condition Hydrographs

Model Boundary	Name
1	BEAR RIV BLW CAMP FAR WEST
2	BEST SLOUGH AT FORTY MILE ROAD
3	BUTTE SLOUGH AT WEST BUTTE ROAD
4	CACHE C A YOLO CA (#11452500)
5	YUBA - DRY CREEK AT HWY 20
6	BEAR RIVER - DRY CREEK AT JASPER LN
7	FEATHER RIVER AT OROVILLE (#11407000)
8	HONCUT CREEK AT HWY 70
9	JACK SIMMERLY AT WOODRUFF LN
10	KLRC AT KNIGHTS LANDING
11	NATOMAS CROSS CANAL AT GARDEN HWY
12	SACRAMENTO R A COLUSA CA (#11389500)
13	SACRAMENTO R A VERONA CA (#11425500)
14	UP INTERCEPT SA REEDS
15	WADSWORTH CANAL AT HWY 20
16	YANKEE SLOUGH AT SWETZER ROAD
17	YOLO BYPASS NR WOODLAND CA (#11453000)
18	YUBA RIVER AT RS 13.84

b. Wadsworth Canal. Flow frequency analysis for Wadsworth Canal is described in the Feasibility Study Hydrology Appendix. Wadsworth canal is an unregulated stream. The Wadsworth Canal unregulated frequency curve was developed from graphical frequency analysis of gage records at Wadsworth Canal near Sutter (DWR stream gage A05929) following Bulletin 17B guidelines. The analysis was based on mean daily flows from 1939 to 1996. The years 1976 and 1977 were screened as low outliers and were not used in the analysis. The peak flow frequency was estimated from the mean daily flows. A 37 year equivalent period of record is recommended for the peak flow frequency to account for the additional hydrologic uncertainty. A table of peak unregulated flows for Wadsworth Canal is provided in Table 9. These flows represent a storm centered over the Wadsworth canal drainage area.

Table 9
Flow Frequency, DWR Gage Wadsworth Canal near Sutter

Peak Discharge by ACE (cfs)						
50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
820	2,250	3,200	4,000	4,830	5,750	7,070

The water surface profile of Wadsworth Canal is influenced by inflow from the East and West Interceptor Canals and the coincident downstream stage in the Sutter Bypass. Inflow from Wadsworth canal is approximately 1% of the flow in the Sutter Bypass. Therefore, inflow from Wadsworth Canal has negligible impact on stages in the Sutter Bypass during the flood season. Stage and flow frequency estimates for the Sutter Bypass were obtained from the Sutter Bypass and Feather River model. Peak flow and stage frequency estimates are provided in Tables 10 and 11 respectively.

Table 10
Flow Frequency, Sutter Bypass below Wadsworth Canal

Scenario	Peak Flow (FT-NAVD88)						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
A. No Overtopping or Failure	57,600	102,800	127,200	156,100	185,400	229,500	328,900
B. Overtopping without Failure	Same	Same	Same	Same	Same	228,300	255,000
HEC-RAS model, Sutter Bypass, Wads-Tisdale, Section 84.14							

Table 11
Stage Frequency, Sutter Bypass at Wadsworth Canal Confluence

Scenario	Peak Stage (FT-NAVD88)						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
A. No Overtopping or Failure	46.87	50.64	52.75	54.42	56.19	58.53	63.21
B. Overtopping without Failure	Same	Same	Same	Same	Same	58.45	59.82
HEC-RAS model, Sutter Bypass, Wads-Tisdale, Section 84.14							

c. Cherokee Canal. Hydrologic analysis conducted for Cherokee Canal is described in the report “Sutter, Basin California, General Investigation Feasibility Study, Cherokee Canal Hydrology Appendix, Cottonwood Creek to Afton Road Butte County, California”, August 2010. Flood frequency curves and a suite of 30 day balanced hydrographs were developed for the Cherokee Canal near Richvale Gage (DWR stream gage A02984). The frequency analysis was conducted using Bulletin 17b methods based on 46 years of record from 1961 to 2006. Flood frequency statistics for the Cherokee Canal near Richvale Gage are provided in Table 12. A table of discharges by frequency and duration is provided in Table 13.

Table 12
Flood Frequency Statistics, DWR Gage Cherokee Canal near Richvale

Flood Duration	Log Mean	Log Standard Deviation	Log Skew (Adopted)	Record (Years)	
				Years Evaluated	Years Used
Peak	3.7484	0.2241	-0.70	46	46
1-Day	3.4576	0.2241	-0.70	46	46
3-Day	3.2656	0.2241	-0.70	46	46
5-Day	3.1618	0.2241	-0.70	46	46
10-Day	3.0052	0.2241	-0.70	46	46
15-Day	2.9130	0.2241	-0.70	46	46
30-Day	2.7525	0.2241	-0.70	46	46

Table 13
Flood Frequency, DWR Gage Cherokee Canal near Richvale

Flood Duration	Duration Average Discharge by ACE (CFS)						
	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Peak	5,900	10,300	12,100	13,200	14,300	15,200	16,300
1-Day	3,040	5,280	6,190	6,870	7,310	7,780	8,340
3-Day	1,960	3,390	3,980	4,360	4,700	5,000	5,360
5-Day	1,540	2,670	3,130	3,430	3,700	3,940	4,220
10-Day	1,070	1,860	2,180	2,390	2,580	2,750	2,950
15-Day	870	1,510	1,770	1,940	2,090	2,220	2,380
30-Day	600	1,040	1,220	1,340	1,440	1,540	1,650

Balanced 30-day hydrographs were developed 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) ACE events. The hydrographs were developed using the same methodology as described in the Comp Study. The 5-day flood pattern for the synthetic hydrographs was based on the 30 December 2005 to 4 January 2006 flood. The 30-day hydrograph was then constructed from 6 waves, each 5 days in duration. The highest wave volume is distributed into the fourth, or main, wave. The second and third highest volumes precede and follow the main wave, respectively. The fourth highest volume is distributed into the 2nd wave, and the 5th highest is distributed into the final of the 6 waves. The 6th and smallest wave volume is distributed into the 1st wave of the series. The shape of each wave is identical and the magnitude is determined by the total volume that the wave must carry.

d. Interior Drainage. An interior drainage 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. The maps are further described in the analysis of alternatives below.

3.3 Hydraulic Models

Without project conditions were evaluated using an uncoupled 1-d and 2-d modeling approach that is standard procedure on multiple studies within the Sacramento District. River stages and profiles were simulated using a 1-dimensional HEC-RAS model because RAS incorporates more detailed hydraulic capabilities for channel flow. Levee breaches were simulated using the same HEC-RAS model because the levee breach capabilities are more detailed in RAS than FLO-2D. These breaches were then transferred to a 2-dimensional FLO-2D model of the floodplain. The FLO-2D model has more detailed capabilities than HEC-RAS for simulating the distribution of the breach hydrographs on the floodplain. This process leverages the most robust capabilities of both models. Ideally, this would be conducted using a coupled 1-d and 2-d model but that capability is not readily available with standard models used by the district.

Five separate hydraulic models that were adapted from existing hydraulic models utilized for studies within the Sacramento Valley. These existing models were reviewed and determined to be adequate for the Sutter Basin Feasibility Studyl analysis. 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 Comp Study. Inundation depths from levee breach simulations were evaluated using a FLO-2D 2-dimensional unsteady flow model of the study area.

Three types of hydraulic model computer programs were used for this analysis. The computer model HEC-RAS calculates steady or unsteady gradually varied flow in natural and manmade channels by performing step-backwater calculations of the 1-D flow energy equation through a series of input geometric cross-sections with empirically defined hydraulic roughness coefficients. The computer model, UNET is a predecessor to HEC-RAS and has similar functionality and assumptions. The computer model FLO-2D is a 2-dimensional, dynamic flood routing model that simulates movement of water across the ground surface while reporting volume conservation. It numerically routes flood hydrographs over a system of grid elements, and predicts the area of inundation and floodwave attenuation.

a. Sutter Bypass and Feather River. 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. A map of the HEC-RAS hydraulic model domain showing cross sections and hydrograph boundary locations is provided as Plate 6.

(1) Cross Sections. The model contains a total of 1,382 cross sections. The cross sections are spaced at roughly ¼-mile intervals along the river reaches. Cross section geometry data were obtained from the 1999 Sacramento-San Joaquin Comprehensive Study (NAVD88 datum update). The hydraulic model geometry includes the sloped levee face except at star bend and Three River Levee Improvement Authority (TRLIA) setbacks on the Feather River. This is an appropriate assumption because the sloped portion of the levee is an extremely small fraction of the overall cross sectional area.

(2) Storage Areas. The model contains a total of 53 storage areas throughout the domain.

(3) Bridges and Inline Structures. The model contains a total of 33 bridges, 3 inline structures and 2 major weir diversions (Fremont and Tisdale). The Highway 99 Bridge was modified over the period of the feasibility study. The model represents the widened bridge.

(4) Lateral Stuctures (Levees). The HEC-RAS model utilizes the lateral weir option to simulate overtopping of the levee crest. The structures were manually coded into each HEC-RAS cross section based upon Top of Levee (TOL) elevation data from the USACE National Levee Database (NLDB) survey data. The lateral structure outflow is linked to the storage areas described above.

(5) Blocked Obstructions. Blocked obstructions were used throughout the model to eliminate the cross section area on the landward side of the levee. The landward areas are modeled as storage areas and lateral weirs along the crest of the levee control the flow over and into and out of the storage areas. The blocked obstructions are needed because the cross sections extend approximately 100 feet landward of the levee and this is not a conveyance area under this approach. The levee card is not suitable in this case because the conveyance area on the landward side of the cross section would become conveyance area once overtopped. The heights of the blocked obstructions were made sufficiently high to contain a 0.2% ACE flood event.

(6) Ineffective Flow Areas. Ineffective flow areas were incorporated into the model to simulate areas where water is stored, but is not active conveyance area.

(7) Manning's Roughness Values. Manning's n-values were selected based on model calibration to high water marks collected during the January 1997 and December 2005 - January 2006 flood events. Boundary condition inflows for the model calibration were based on DWR and USGS stream gage records. Manning's roughness values range from 0.031 to 0.07 in the main channel and 0.05 to 0.10 in the overbanks. The model calibration is described below.

(8) Upstream Boundary Conditions. Upstream boundary conditions are a set of regulated flow hydrographs. The boundary locations are shown on Plate 6 and listed in Table 3.

(9) Downstream Boundary Conditions. The PBI Sutter Basin model includes two downstream boundary conditions; 1) the Sacramento River at Verona and 2) the Yolo Bypass near Woodland. Both boundary conditions consist of rating curves developed from stream gage data.

A stage-discharge rating curve was developed for the downstream boundary at the Sacramento River at Verona gage. The current USGS rating at the gage was found to be at the low end of historical data. The USGS stage-discharge rating was modified to reflect the average conditions expected throughout the life of the project. The resulting curve is provided as Plate 7.

A stage-discharge curve was developed for the Yolo Bypass near Woodland Gage. The published USGS Yolo Bypass near Woodland gage rating curve could not be used for the boundary condition because it incorporates an adjustment for Sacramento Weir inflow into the Yolo Bypass. The gage, however, is located upstream of the confluence with the Sacramento Bypass. As a result, the USGS rating curve does not represent the stage-flow relationship at the gage. The curve used for the feasibility study was developed by plotting historical discharge measurements and comparing to modeled profiles of the Yolo Bypass. The resulting curve is provided as Plate 8.

(10) Model Calibration. 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.

The differences in the physical configuration of the Feather River between 1997 and 2006 (such as the Shanghai Bend Setback Levee completed in 1999) were taken into account in the calibration process. In addition, due to the fact that both the 2006 and 1997 flood events occurred before the construction of the TRLIA setback levees, the calibration was performed with a HEC-RAS geometry file that does not include the setback levees.

The January 1997 flood event was considered the best flood event to use for calibration due to its size and the quantity of measured data. However, three major levee breaches occurred during the 1997 flood event which introduced significant uncertainty in flow estimates throughout the system. The storm that occurred from December 2005 to January 2006 was smaller in size compared to the 1997 event, but it was large enough to produce overbank flows and reliable measured data throughout the river network with no levee failures.

Manning's n-values were adjusted to duplicate stages for the 2006 flood event. The 1997 flood event was then simulated and adjustments were made to achieve a compromise in modeled versus observed stages for the two calibration events. For the 1997 event the difference between modeled and observed stages ranged from -0.30 feet to +1.92 feet at the 12 stream gages. The greatest deviation between observed stage and the modeled stage occurred at the Sutter Bypass pumping Plant 1 gage.

For the 2006 event the difference between modeled versus observed stages ranged from -0.46 feet to +1.03 feet at the 12 stream gages. The greatest deviation between modeled and observed stages occurred at the Feather River at Yuba City gage. The model overestimated the stage by 1.03 feet. The calibration is described in the PBI report, Design Water Surface Profiles for the Feather River West Levee Project, 26 July 2012.

(11) Stage Uncertainty. The total SD of stage uncertainty was computed at 11 index points on the Feather River and Sutter Bypass. The total SD was found to range from 1.2 feet to 1.7 feet. A SD of 1.5 feet is recommended for all reaches of the Sutter Bypass and Feather River.

Stage uncertainty was estimated following methods described in EM-1110-2-1619. The total stage uncertainty was estimated from natural, model, and sedimentation uncertainty. The following provides a summary of the stage uncertainty analysis. A detailed description of the stage uncertainty analysis is provided in the Sutter Basin Feasibility Study Hydraulics Report prepared by Peterson Brustad Inc. (SBFCA, 2012). The standard deviation (SD) of total stage uncertainty was calculated using the following equations modified from EM1110-2-1619.

$$\mathrm{SD_{total}} = \sqrt{\mathrm{SD^2_{natural}} + \mathrm{SD^2_{model}} + \mathrm{SD^2_{sedimentation}}}$$

$$\mathrm{SD_{model}} = \sqrt{\mathrm{SD^2_{topo}} + \mathrm{SD^2_{n-value}}}$$

The natural uncertainty, *SDnatural*, is the uncertainty of the stage-discharge relationship caused by the natural variation in the physical characteristics of the stream and errors that occur in the stage and discharge measurements.The SD of natural uncertainty is 0.70 feet for the Feather River and 0.55 ft for the Sutter Bypass. The SD for natural uncertainty was based on a review of stage discharge measurements at the DWR stream gage Butte Slough near Meridian (A02972) and USGS gage Sacramento River near Verona (11425500).

The uncertainty in hydraulic model results is highly correlated to the uncertainty in the topographic data used to represent the geometric characteristics of the river reaches. The SD for topographic uncertainty is estimated to be 0.48 ft. This uncertainty value was based on the description of the topographic survey data provided in the Aryes Final Topographic Survey Report (AYRES, 2003)

The SD associated with Manning's roughness was estimated at 11 locations throughout the model. The standard deviation was found to range from 0.78 feet to 1.25 feet. The values were estimated by computing water surface profiles with roughness values increased and decreased by 20 percent.

The SD associated with sedimentation accounts for the sensitivity of the computed water surface profiles to future sediment deposition or scour. A SD of 0.75 feet was estimated for all reaches based on a review of sedimentation reports.

b. Wadsworth Canal. Water surface profiles for Wadsworth Canal were computed using an HEC-RAS steady one-dimensional flow model. A map of the HEC-RAS hydraulic model domain showing cross sections and hydrograph boundary locations is provided as Plate 9. The hydraulic model extends 4.5 miles from the East and West Interceptor Channel to the Sutter Bypass.

(1) Cross Sections. The model contains 36 cross sections from the East and West Interceptor Channels to the Sutter Bypass. Cross section geometry data were obtained from the 1999 Sacramento-San Joaquin Comprehensive Study (NAVD88 datum update). The underwater portion of each cross section was adjusted to reflect recent NAVD88 ground surveyed bathymetric cross section data obtained by the State of California Department of Water Resources in 2010 (DWR, 2011).

(2) Storage Areas. The model is a steady state model used to model profiles. Therefore, the model does not include storage areas.

(3) Bridges and Inline Structures. Bridges and inline structures were coded into the model from field sketches obtained during the 1999 Sacramento-San Joaquin Comprehensive

Study and the State of California Department of Water Resources Central Valley Floodplain Evaluations and Delineation (CVFED) mapping. The five bridges within the model reach are Butte House Road, South-Butte Road, Sutter Bike Trail (old railroad bridge), Colusa Highway (State Highway 20), and Franklin Road.

Topographic and NLDB data in the vicinity of the Sutter Bike Trail bridge indicated a dip in the left and right bank levee profile. A review of photographs indicated the top of levee should tie to the concrete wing walls and railing. The DWR Sutter Yard Field Superintendent indicated this location would be sandbagged during a flood event (DWR, 2013). Therefore, the top of levee was coded into the model at the top of the wing wall elevation.

Weir number 4 located just upstream from South-Butte Road was coded into the model as an inline structure assuming the flash boards were removed. The DWR Sutter Yard Field Superintendent indicated the flash boards would not be in place during the flood season (DWR, 2013).

(4) Levees. The levee crest elevation was specified for each cross section. The top of levee elevation was obtained from the NAVD88 National Levee Database (NLDB) ground survey conducted in 2007-2008.

(5) Blocked Obstructions. Blocked obstructions were used throughout the model to eliminate the cross section area on the landward side of the levee. The landward areas are modeled as storage areas and lateral weirs along the crest of the levee control the flow over and into and out of the storage areas. The blocked obstructions are needed because the cross sections extend approximately 100 feet landward of the levee and this is not a conveyance area under this approach. The levee card is not suitable in this case because the conveyance area on the landward side of the cross section would become conveyance area once overtopped. The heights of the blocked obstructions were made sufficiently high to contain a 0.2% (1/500) ACE flood event.

(6) Ineffective Flow Areas. Ineffective flow areas were incorporated into the model to simulate areas where water is stored, but is not active conveyance area.

(7) Manning's Roughness Values. Manning's roughness values were estimated to be 0.035 for the Wadsworth Canal reach. This value was based on a comparison of channel conditions to photographs in Chow, 1959.

(8) Upstream Boundary Conditions. Model boundary conditions for stage and flow are described in the Model Simulations and Results section.

(9) Downstream Boundary Conditions. Model boundary conditions for stage and flow are described in the Model Simulations and Results section of this report.

(10) Model Calibration. The model was not calibrated due to lack of measured data. Selection of Manning's roughness values are described above.

(11) Stage Uncertainty. The total SD was found to vary between 1.5 feet and 1.6 feet throughout the reach. Stage uncertainty was estimated following methods described in EM-1110-2-1619. The total stage uncertainty was estimated from natural, model, sedimentation uncertainty, and coincident flow uncertainty. The SD of stage uncertainty releated to natural, model, and sedimentation uncertainty was assumed to be the same as the Sutter Bypass (1.5 feet) because water surface profiles in Wadsworth Canal are highly correlated to the stage in the Sutter Bypass.

Additional stage uncertainty was included to account for uncertainty in coincident flow conditions. The maximum stage uncertainty related to coincident flow conditions is assumed to be the difference between the maximum and minimum coincident flow extremes. Equation 5-7 of EM 1110-2-1619 was used to compute the standard deviation of stage uncertainty as 1/4 of the difference between the upper and lower bounds. The stage uncertainty associated with coincident flow varies throughout the reach and is the largest (0.6 feet) near Sutter Butte Road (Comp Study River Mile 3.32). The standard deviation (SD) of total stage uncertainty was calculated using the following equation provided in EM1110-2-1619.

$$\mathrm{SD}_{\mathrm{total}} = \sqrt{\mathrm{SD}^2_{\mathrm{natural}} + \mathrm{SD}^2_{\mathrm{model}} + \mathrm{SD}^2_{\mathrm{sedimentation}} + \mathrm{SD}^2_{\mathrm{coincident\ flow}}}$$

c. Cherokee Canal. Water surface profiles for Cherokee Canal were computed using an HEC-RAS unsteady one-dimensional flow model. A map of the HEC-RAS hydraulic model domain showing cross sections and hydrograph boundary locations is provided as Plate 10. Model geometry was obtained from an existing California Department of Water Resources model developed in 2006. The model reach extends 9 miles from Nelson Road downstream to Highway 162.

(1) Cross Sections. The Cherokee Canal HEC-RAS hydraulic model contains a total of 153 cross sections. The cross sections are spaced at roughly 400-ft intervals. Cross sections are also coded at the upstream and downstream face of each bridge crossing.

The topography included in the DWR 2006 model (excluding the cross sections imported from the URS 2003 model) was obtained from field surveys completed in June and August of 2006 by DWR. Supplemental field surveys were completed by PBI in June and October of 2009 in order to add 4 cross sections downstream of the Highway 162 Bridge.

(2) Storage Areas. The model contains no storage areas.

(3) Bridges and Inline Structures. The model includes 4 bridges, Nelson-Shippee Road, Richvale Road, Union Pacific Railroad, and Highway 162. All of the bridges geometry data within the model were obtained from the 2006 DWR model and reviewed for reasonableness. The bridge deck elevation for all bridges was surveyed to verify the vertical datum was NAVD88.

(4) Lateral Stuctures (Levees). The HEC-RAS model utilizes the lateral weir option to simulate overtopping of the levee crest. The structures were manually coded into each HEC-RAS cross section based upon Top of Levee (TOL) elevation data from the USACE NLDB survey data described above. Lateral structures were not coded in for the reach upstream of Nelson-Shippee Road in order to ensure that all inflows enter the study area. Lateral structure lengths were coded in to be no greater than 1 mile.

(5) Blocked Obstructions. Blocked obstructions were used throughout the model to eliminate the cross section area on the landward side of the levee. The landward areas are modeled as storage areas and lateral weirs along the crest of the levee control the flow over and into and out of the storage areas. The blocked obstructions are needed because the cross sections extend approximately 100 feet landward of the levee and this is not a conveyance area under this approach. The levee card is not suitable in this case because the conveyance area on the landward side of the cross section would become conveyance area once overtopped. The heights of the blocked obstructions were made sufficiently high to contain a 0.2% (1/500) ACE flood event.

(6) Ineffective Flow Areas. The model contains no ineffective flow areas. The ineffective flow areas upstream of the Nelson-Shippee Road Bridge (outside of the study area) were eliminated from the base DWR model in order to stabilize the unsteady flow calculations.

(7) Manning's Roughness Values. The Manning's n-values for the main channel range from 0.033 to 0.059. The Manning's n-values for the channel overbanks range from 0.037 to 0.088. Manning's n-values were selected based on model calibration to high water marks collected during the December 2005 - January 2006 flood events. Boundary condition inflows for the model calibration were based on DWR stream gage records.

(8) Upstream Boundary Conditions. The hydrograph provided for Cherokee Canal was based on stream records below the Cottonwood creek tributary. However, the model extends upstream of Cottonwood creek. The hydrograph was divided and 75% was applied at the upstream end of the model at Nelson Road and 25% was applied at the Cottonwood Creek confluence. This apportionment was based upon the percent differences in the design capacities of the Cherokee Canal upstream and downstream of the Cottonwood Creek confluence. No detailed hydrologic analysis was completed since these sections were outside of the focus study area. A 1-hour time delay was applied to the inflow hydrograph at Cottonwood Creek in order to synchronize the combined peak flows.

(9) Downstream Boundary Conditions. A normal depth (friction slope) boundary condition of 0.00068 was utilized for the model. The friction slope was estimated from the surveyed high water mark elevations in the downstream one-mile of the model.

(10) Model Calibration. Manning's n-values were selected based on model calibration to high water marks collected during the December 2005 - January 2006 flood events. Boundary condition inflows for the model calibration were based on DWR stream gage records. Manning's n-values were adjusted (within reason) to duplicate stages for the event. The calibrated water surface profile was found on average to be within 0.3-ft of known HWM's.

There are two instances within the study focus area where the difference between the known HWM's and the modeled water surface was greater than 0.5-feet. However, considering uncertainty in high water mark data collection, these were considered outliers. A detailed description of the stage model calibration is provided in the Sutter Basin Feasibility Study Hydraulics Report prepared by Peterson Brustad Inc. (SBFCA, 2012).

(11) Stage Uncertainty. The total SD of stage uncertainty was computed at two index points on the Cherokee Canal and a SD of 1.5 feet is recommended. Stage uncertainty was estimated following methods described in EM-1110-2-1619. The total stage uncertainty was estimated from natural, model, sedimentation, and bridge debris loading uncertainty. The following provides a summary of the stage uncertainty analysis. A detailed description of the stage uncertainty analysis is provided in the Sutter Basin Feasibility Study Hydraulics Report prepared by Peterson Brustad Inc. (SBFCA, 2012). The standard deviation (SD) of total stage uncertainty was calculated using the following equation provided in EM1110-2-1619.

$$\mathrm{SD_{total}} = \sqrt{\mathrm{SD^2_{natural}} + \mathrm{SD^2_{model}} + \mathrm{SD^2_{sedimentation}} + \mathrm{SD^2_{bridge\ debris}}}$$

$$\mathrm{SD_{model}} = \sqrt{\mathrm{SD^2_{topo}} + \mathrm{SD^2_{n-value}}}$$

The natural uncertainty, *Snatural*, is the uncertainty of the stage-discharge relationship caused by the natural variation in the physical characteristics of the stream and errors that occur in the stage and discharge measurements. The SD of natural uncertainty is 0.48 feet. The SD for natural uncertainty was based on a review of stage discharge measurements at the DWR stream gage Cherokee Canal nr Richvale (A02984).

The uncertainty in hydraulic model results is highly correlated to the uncertainty in the topographic data used to represent the geometric characteristics of the river reaches. The SD for topographic uncertainty was assumed to be negligible because the cross sections were ground surveyed.

The SD associated with Manning's roughness was estimated at two locations throughout the model. The standard deviation was found to range from 0.73 feet to 0.78 feet. The values were estimated by computing water surface profiles with roughness values increased and decreased by 20 percent.

The SD associated with sedimentation accounts for the sensitivity of the computed water surface profiles to future sediment deposition or scour. A SD of 0.75 feet was estimated for all reaches based on a review of sedimentation reports.

The SD associated bridge debris loading was estimated at two locations throughout the model. The values were estimated by computing water surface profiles with bridge pier widths increased 2 feet. The standard deviation was found to range from 0.02 feet to 0.03 feet.

d. Butte Basin. Water surface elevations within the Butte Basin were obtained from the Sacramento San Joaquin Comprehensive Study UNET model DSS files. All stage data provided in the Comprehensive Study were based on the NGVD29 datum. These data were converted to the NAVD88 vertical datum using a topographic datum conversion surface developed specifically for converting Comp Study topographic data to NAVD88. Model geometry, details and assumptions are described in the Sacramento San Joaquin Comprehensive Study report.

(1) Boundary Conditions. Hydrologic inputs to the comp study UNET hydraulic model consisted of a set of 30-day regulated flow hydrographs for all inflow boundary locations. Sets of boundary condition hydrographs were provided for each of seven ACE events. Storm centering scenarios were provided for each ACE event to determine the maximum water surface elevations within the river channels. The development of regulated flow hydrographs is described in detail in the hydrology appendix.

(2) Model Calibration. The UNET model of the Sacramento River Basin was calibrated to the 1997 flood during the comp study. Inflow hydrographs to the model were created using 1997 flood gage information from major tributaries and flood control structures. Model result hydrographs were compared to gage records and peak stage data where available. The UNET model parameters for Manning's n, weir coefficients, and levee breaches were then adjusted as needed in an iterative procedure to modify the model results to more closely match the calibration data.

(3) Stage Uncertainty. Stage uncertainty was estimated following methods described in EM-1110-2-1619. The total stage uncertainty was estimated from natural, model, sedimentation uncertainty, and coincident flow uncertainty. The SD of stage uncertainty releated to natural, model, and sedimentation uncertainty was assumed to be the same as the Sutter Bypass and Feather River model described above (1.5 feet) because the comp study UNET model data sources and assumptions are nearly identical to the HEC-RAS model.

e. FLO-2D Model. A FLO-2D model was utilized to evaluate water surface elevations resulting from levee breaches within the study area. A detailed description of the model is provided in the report- Sutter Basin Feasiblity Study, Hydraulics Report prepared by Peterson Brustad, Inc. 14 December 2012. A map of the model domain is provided in Plate 11.

(1) Computational Domain**.** The valid computational domain is defined as the Sutter Basin Feasibility study area. The model's domain extends beyond the valid computational domain in order to establish model boundary conditions. All results outside the valid domain were truncated from the results.

(2) Grid Elements**.** A 1,000-ft grid size was selected in order to keep the number of grid elements down to a workable number and to avoid long model run times. The Comp Study and USGS data were used to develop the FLO-2D grid cell elevations, with the Comp Study topography comprising approximately 55% of the FLO-2D grid. The USGS topography is utilized for the areas of the model which Comp Study topography did not cover. Since both the Comp Study and USGS data is based upon NGVD29 datum, the FLO-2D grid cell elevations were converted to NAVD88. This was the best available topographic data at the time of model development. More detailed Lidar topography became available after model simulations had been completed. The more detailed topography was compared against this data set. Although the

uncertainty in absolute elevations may be on the order of 1 to 2 feet, this would have little influence on economic damages which are based on depth.

(3) Channel Elements**.** Two channels were added to the 2009 Sutter Basin FLO-2D model; the Wadsworth Interceptor Canal Unit 1 (West Canal) and Interceptor Canal Unit 2 (East Canal). The channels were included in order to simulate the collection and drainage of runoff out of the basin via the Wadsworth Canal. The Wadsworth Canal is approximately 4.3 miles in length and conveys runoff from southeast of the Sutter Buttes into the Sutter Bypass. The two interceptor channels act as collectors in the model and route flow towards an outflow node that is located at the beginning of the Wadsworth Canal. The outflow node contains a discharge rating curve that is based upon flood depths. This simulates drainage water flowing through the Wadsworth Canal and out of the basin. The Wadsworth Canal was not modeled as a FLO-2D channel due to model limitations regarding the backwater effects of the Sutter Bypass.

(4) Floodplain Roughness and Area Reduction Factors. Overland n-values and area reduction factors (ARF) were developed for a variety of different land uses. For consistency, the Manning's n and ARF values are based upon reference values utilized in recent USACE FLO-2D studies (which are based upon values listed in the FLO-2D User's Manual, as adapted from the 1990 HEC-1 User's Manual).

(5) Levees and Embankments. Levee elements were added to the FLO-2D model to represent the river channel levees and railroad embankments as found on the floodplain. The model includes the levees & embankments along the Sutter Bypass, Wadsworth Canal, Interceptor Canals, Cherokee Canal Feather River, and UPRR Embankment. The levee crest elevations were determined from the surveyed National Levee Database. The Union Pacific Railroad (UPRR) embankment elevations were based on field survey data obtained by the sponsor in May and June of 2009. The UPRR embankment elevations was input into the model based upon even grades between the survey points. The railroad embankment generally ranges in height from 1 to 7 feet above the existing terrain.

(6) Hydraulic Structures. Hydraulic structures were re-coded into the FLO-2D model using estimated stage-discharge rating curves developed from HEC-RAS, which utilizes a hydraulic gradient based upon the length between the two sides of the embankment. Five estimated rating curves (one for each different bridge length) were developed using HEC-RAS and then coded into FLO-2D.

(7) Pump Stations. Three pumping stations located within the Sutter basin were incorporated into the FLO-2D model. The pumping stations are maintained by the California Department of Water Resources (DWR) Sutter Maintenance Yard. All three pump stations transfer storm water runoff from inside the Sutter Basin into the Sutter Bypass. The plants are modeled as constant flow outflow nodes within the model. The pumping stations are assumed to be inoperable during the 0.2% (1/500) ACE scenario due to extensive flooding and power outages.

(8) Boundary Condition Inflows. The inflow hydrographs for the FLO-2D model consist of levee overtopping and breach hydrographs obtained from HEC-RAS model simulations. A

simulation run time of 720 hours was used in order to allow enough time for the flood waters to collect at the southern portion of the basin.

(9) Boundary Condition Outflows. The purpose of the FLO-2D model is to simulate the movement of breach floodwaters within the study area on the interior side of the Feather River and Sutter Bypass levee system. Therefore outflow elements were specified on the river side of the Sutter Bypass and Feather Rivers and the lowest part of the Butte Basin.

(10) Stage Uncertainty. The total combined standard deviation of stage uncertainty was estimated to be 1.2 feet using the equation above. The uncertainty of computed flood depths for the Sutter Basin FLO-2D model can primarily be attributed to the hydraulic modeling inaccuracies and the levee breach assumptions. The uncertainty was measured for a hypothetical breach along the Feather River at RM 57.17 using the 1% (1/100) ACE flood event (Shanghai storm centering). The uncertainties associated with roughness values and breach widths were evaluated. A detailed description of the stage uncertainty analysis is provided in the Sutter Basin Feasibility Study Hydraulics Report prepared by Peterson Brustad Inc. (SBFCA, 2012). The standard deviation (SD) of total stage uncertainty was calculated using the following equation provided in EM1110-2-1619.

$$\mathrm{SD}_{\mathrm{total}} = \sqrt{\mathrm{SD}_{\mathrm{model}}^2 + \mathrm{SD}_{\mathrm{breach}}^2}$$

$$\mathrm{SD}_{\mathrm{model}} = \sqrt{\mathrm{SD}_{\mathrm{topo}}^2 + \mathrm{SD}_{\mathrm{n-value}}^2}$$

The uncertainty in hydraulic model results is highly correlated to the uncertainty in the topographic data used to represent the geometric characteristics of the river reaches. The SD for topographic uncertainty is estimated to be 0.48 ft. This uncertainty value was based on the description of the topographic survey data provided in the Ayres Final Topographic Survey Report (AYRES, 2003)

The SD associated with roughness was estimated at two locations throughout the model. The values were estimated by computing water surface profiles with roughness values increased and decreased by 20 percent. The standard deviation was found to be 0.3 feet based on the average change in water surface elevation within the upper and lower inundation limits.

The SD associated with breach width was computed by simulating breach widths by +/-33%. The standard deviation was found to be 1.0 feet based on the average change in water surface elevation between the upper and lower inundation limits.

3.4 Hydraulic Model Results.

The hydraulic models described above were utilized to compute water surface profiles for two levee overtopping scenarios. Models were also utilized to simulate inundation depths within the study area from levee breach scenarios at 14 locations.

a. Levee Infinite Height Scenario (Scenario A).   For this scenario, water surface profiles were simulated assuming all levees were infinitely high and would contain all flow within the infinite channel without overtopping.   This scenario was used to evaluate the sensitivity of water surface elevations to levee overtopping assumptions. Infinite levee water surface profiles were developed for Sutter Bypass (Plate 12), Feather River (Plate 13), Wadsworth Canal (Plate 14), and Cherokee Canal (plates 15 and 16). Peak stage and flow frequency estimates at index points throughout the study area are presented in Tables 14 through 18. Peak stage frequency and flow frequency curves for the index points are provided in Plates 17 to 30.

b. Levee Overtopping Scenario (Scenario B).   For this scenario, water surface profiles were based on the assumption that all Flood Risk Management levees can be overtopped but they do not fail. Peak stage and flow frequency tables for index points throughout the study area are presented in Tables 14 through 18. Peak stage frequency and flow frequency curves for the index points are provided in Plates 17 to 30.

Table 14
Feather River Hydraulic Characteristics, Alternative SB-1
Oroville Dam to Yuba River

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	**50%**	**10%**	**4%**	**2%**	**1%**	**0.5%**	**0.2%**
Feather River at RM 57.95 (Geotechnical Index MA 7 – 0.51) 1957 Design Top of Levee = 132.32 FT-NAVD88 2008 NLDB Top of Levee = 136.00 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC/SHY	SAC	SHY	SAC/SHY	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS) 1/	0	60,000	100,000	150,000	150,000	150,000	174,000	320,400
Stage (FT-NAVD88)	96.13	118.95	123.97	127.58	127.58	127.58	128.84	131.27
Velocity (FPS)	0	5.43	7.28	8.10	8.22	8.22	8.50	9.00
Overtopping Levee Model (Scenario B)								
Flow (CFS) 1/	0	60,000	100,000	150,000	150,000	150,000	174,000	320,400
Stage (FT-NAVD88)	96.13	118.95	123.97	127.58	127.58	127.58	128.84	131.18
Velocity (FPS)	-	5.94	7.28	8.22	8.22	8.22	8.50	9.09
Feather River at RM 44.50 (Geotechnical Index MA 16 – 2.9) 1957 Design Top of Levee = 93.59 FT-NAVD88 2008 NLDB Top of Levee = 93.73 FT-NAVD88								
Controlling Storm Centering	-	SAC	SHY	SAC	SHY	SAC	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	50,300	107,100	157,100	159,600	164,600	182,400	294,600
Stage (FT-NAVD88)	48.65	79.49	83.78	86.61	86.85	86.97	88.16	94.59
Velocity (FPS)	-	1.91	2.23	2.51	2.50	2.55	2.58	2.77
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	50,300	107,100	157,100	159,600	164,600	182,400	309,800
Stage (FT-NAVD88)	48.65	79.49	83.78	86.61	86.85	86.97	88.16	93.90
Velocity (FPS)	-	1.91	2.23	2.51	2.50	2.55	2.58	3.02
Feather River at RM 41.20 (Geotechnical Index MA 16 – 0.9) 1957 Design Top of Levee = 90.48 FT-NAVD88 2008 NLDB Top of Levee = 91.02 FT-NAVD88								
Controlling Storm Centering	-	SAC	SHY	SAC	SHY	SAC	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	49,400	106,800	157,100	159,600	162,700	182,300	293,600
Stage (FT-NAVD88)	43.04	74.93	80.12	83.49	83.89	83.90	85.48	92.96
Velocity (FPS)	-	2.15	1.91	1.99	1.96	1.99	1.97	2.03
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	49,400	106,800	157,100	159,600	162,700	182,300	294,200
Stage (FT-NAVD88)	43.04	74.93	80.12	83.49	83.89	83.90	85.47	91.87
Velocity (FPS)	-	2.15	1.91	1.99	1.96	1.99	1.97	2.15
Feather River at RM 30.25 (Geotechnical Index LD9 – 0.52) 1957 Design Top of Levee = 84.17 FT-NAVD88 2008 NLDB Top of Levee = 86.52 FT-NAVD88								
Controlling Storm Centering	-	SHY	SHY	SAC	SHY	SHY	SHY	2/
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	48,100	106,500	156,700	157,600	156,300	165,400	292,800
Stage (FT-NAVD88)	31.86	63.00	72.01	75.58	76.52	76.50	79.31	87.04
Velocity (FPS)	-	1.88	1.88	2.30	2.17	2.16	2.01	2.67
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	48,100	106,500	156,700	157,600	156,300	165,400	267,700
Stage (FT-NAVD88)	31.86	63.00	72.01	75.58	76.52	76.50	79.31	85.79
Velocity (FPS)	-	1.88	1.88	2.30	2.17	2.16	2.01	2.56

Notes:
1/ Flow at index point MA 7–0.51 is split into two parallel model reaches. Estimated flow is from cross section 60.81 upstream of split.
2/ Controlling Storm Centering for 0.2% ACE is SHY for Scenario A and SAC for Scenario B.

Table 15
Feather River Hydraulic Characteristics, Alternative SB-1
Yuba River to Sutter Bypass

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	**50%**	**10%**	**4%**	**2%**	**1%**	**0.5%**	**0.2%**
Feather River at RM 23.25 (Geotechnical Index LD1 – 9.31) 1957 Design Top of Levee = 76.87 FT-NAVD88 2008 NLDB Top of Levee = 78.50 FT-NAVD88								
Controlling Storm Centering	-	SHY	SHY	SHY	SHY	SAC	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	71,100	192,800	257,000	281,800	283,700	361,900	535,900
Stage (FT-NAVD88)	19.36	53.30	63.06	66.50	67.74	67.96	71.36	77.80
Velocity (FPS)	-	3.72	3.08	3.22	3.27	3.25	3.46	3.90
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	71,100	192,800	257,000	281,800	283,800	361,900	522,700
Stage (FT-NAVD88)	19.36	53.30	63.06	66.50	67.73	67.94	71.35	76.56
Velocity (FPS)	-	3.72	3.08	3.22	3.27	3.25	3.46	3.99
Feather River at RM 16.75 (Geotechnical Index LD1 – 3.99) 1957 Design Top of Levee = 67.90 FT-NAVD88 2008 NLDB Top of Levee = 68.40 FT-NAVD88								
Controlling Storm Centering	-	SHY	SHY	SHY	SHY	SHY	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	70,500	191,500	255,800	280,500	283,000	360,200	533,900
Stage (FT-NAVD88)	12.53	47.11	56.47	60.02	61.31	61.73	64.97	71.05
Velocity (FPS)	-	3.96	3.06	3.19	3.24	3.22	3.44	3.96
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	70,500	191,600	255,700	280,400	282,900	360,200	491,800
Stage (FT-NAVD88)	12.53	47.11	56.46	60.00	61.28	61.68	64.92	69.20
Velocity (FPS)	-	3.96	3.06	3.20	3.25	3.21	3.45	3.91
Feather River at RM 12.50 (Geotechnical Index MA 3 – 4.92) 1957 Design Top of Levee = 59.88 FT-NAVD88 NLDB Top of Levee = 64.59 FT-NAVD88								
Controlling Storm Centering	-	SHY	SHY	SHY	SHY	SAC	SHY	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	53,900	151,800	209,700	233,300	240,800	305,000	449,800
Stage (FT-NAVD88)	16.77	43.87	50.88	53.95	55.19	55.98	58.44	63.14
Velocity (FPS)	-	1.44	2.29	2.64	2.75	2.73	3.09	3.78
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	53,900	151,500	209,000	232,300	239,600	304,000	403,600
Stage (FT-NAVD88)	16.77	43.83	50.83	53.90	55.14	55.90	58.34	61.63
Velocity (FPS)	-	1.44	2.29	2.63	2.74	2.73	3.09	3.59

Table 16
Sutter Bypass Hydraulic Charachteristics, Alternative SB-1

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	50%	10%	4%	2%	1%	0.5%	0.2%
Sutter Bypass at RM 84.31 (Geotechnical Index Sutter – 4) 1957 Design Top of Levee = 59.57 FT-NAVD88 2008 NLDB Top of Levee = 60.60 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	57,400	102,000	126,200	155,100	184,200	228,200	326,900
Stage (FT-NAVD88)	33.97	46.87	50.64	52.75	54.42	56.19	58.53	63.21
Velocity (FPS)	-	1.78	2.16	2.27	2.49	2.66	2.9	3.35
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	57,400	102,000	126,200	155,100	184,200	228,200	265,200
Stage (FT-NAVD88)	33.97	46.86	50.64	52.75	54.43	56.18	58.45	59.82
Velocity (FPS)	-	1.78	2.16	2.27	2.49	2.66	2.91	3.16
Sutter Bypass at RM 82.45 (Geotechnical IndexSutter – 6.2) 1957 Design Top of Levee = 58.73 FT-NAVD88 2008 NLDB Top of Levee = 58.30 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	57,700	102,800	126,800	156,000	185,000	229,000	327,200
Stage (FT-NAVD88)	29.28	44.95	49.08	51.41	53.03	54.82	57.15	61.83
Velocity (FPS)	-	1.69	2.04	2.13	2.36	2.53	2.78	3.23
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	57,700	102,800	126,800	156,000	185,100	227,900	247,800
Stage (FT-NAVD88)	29.28	44.92	49.08	51.42	53.04	54.81	57.06	58.51
Velocity (FPS)	-	1.69	2.04	2.13	2.36	2.53	2.78	2.82
Sutter Bypass at RM 72.17 (Geotechnical Index Sutter – 17.3) 1957 Design Top of Levee = 54.20 FT-NAVD88 2008 NLDB Top of Levee = 54.10 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	71,000	117,300	141,100	162,900	197,000	236,500	328,900
Stage (FT-NAVD88)	25.50	41.00	45.16	47.97	49.15	50.70	52.75	57.13
Velocity (FPS)	-	1.40	1.75	1.80	1.96	2.21	2.43	2.86
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	69,100	117,400	141,300	163,800	197,600	236,500	257,800
Stage (FT-NAVD88)	25.50	40.94	45.17	47.98	49.15	50.68	52.62	54.41
Velocity (FPS)	-	1.37	1.75	1.80	1.98	2.22	2.44	2.48

Table 17
Wadsworth Canal Hydraulic Characteristics, Alternative SB-1

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	50%	10%	4%	2%	1%	0.5%	0.2%
Wadsworth Canal at RM 4.54 1957 Design Top of Levee = 61.65 FT-NAVD88 2008 NLDB Top of Levee = 62.10 FT-NAVD88								
Controlling Storm Centering	-	WAD	WAD	WAD	WAD	WAD	WAD	WAD
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	820	2250	3200	4000	4830	5750	7070
Stage (FT-NAVD88)	40.50	50.18	55.75	58.20	59.75	61.21	62.61	64.75
Velocity (FPS)	-	4.24	4.30	4.42	4.50	4.58	4.61	4.44
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stage (FT-NAVD88)		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Velocity (FPS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wadsworth Canal at RM 0.81 (Geotechnical Index Wadsworth – 0.84 1957 Design Top of Levee = 59.35 FT-NAVD88 2008 NLDB Top of Levee = 58.80 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	820	2,250	3,200	4,000	4,830	5,750	7,070
Stage (FT-NAVD88)	36.35	46.88	50.67	52.79	54.46	56.23	58.57	63.24
Velocity (FPS)	-	0.54	1	1.18	1.3	1.39	1.41	1.32
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stage (FT-NAVD88)		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Velocity (FPS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wadsworth Canal at RM 0.25 (Geotechnical Index Wadsworth– 0.5) (XS 0.19) 1957 Design Top of Levee = 59.35 FT-NAVD88 2008 NLDB Top of Levee = 60.30 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	820	2,250	3,200	4,000	4,830	5,750	7,070
Stage (FT-NAVD88)	37.06	46.87	50.65	52.76	54.43	56.20	58.54	63.21
Velocity (FPS)	-	0.47	0.86	1.03	1.13	1.2	1.23	1.16
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stage (FT-NAVD88)		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Velocity (FPS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: N/A - Scenario not modeled.
Velocities based on coincident peak Sutter Bypass stage and peak Wadsworth canal inflow. Velocities would be greater for a low Sutter bypass stage and peak Wadsworth canal inflow.

Table 18
Cherokee Canal Hydraulic Characteristics, Alternative SB-1

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	50%	10%	4%	2%	1%	0.5%	0.2%
Cherokee Canal Cherokee at RM 12.529 Geotech index Cherokee Canal– 9.5 1959 Design Top of Levee = 112.10 FT-NAVD88 2008 NLDB Top of Levee = 112.00 FT-NAVD88								
Controlling Storm Centering	-	CHK	CHK	CHK	CHK	CHK	CHK	CHK
Stage Uncertainty (Ft- 1 S.D.)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	5,500	9,700	11,300	12,400	13,300	14,200	15,300
Stage (FT-NAVD88)	98.89	108.34	110.84	111.80	112.40	112.95	113.45	114.00
Velocity (FPS)	-	2.26	2.83	2.99	3.07	3.13	3.18	3.26
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	5,600	9,500	10,000	10,200	10,200	10,300	10,400
Stage (FT-NAVD88)	98.89	108.36	110.74	111.07	111.14	111.19	111.22	111.25
Velocity (FPS)	-	2.27	2.81	2.86	2.88	2.88	2.89	2.89

c. Levee Breach Scenarios. Inundation maps were developed for fifteen levee breach locations within the study area. These breach locations were spatially distributed throughout the study area to reflect the floodplain characteristics. All breach scenarios assume levees were overtopped without failure at all locations other than the breach location. Breaches 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) ACE events. The resulting inundation maps are hypothetical simulations of levee failures and do not represent the probability of occurrence. A summary of the breach simulation locations is provided in Table 19.

Levee breaches are used to define the inundation if a breach were to occur. The probability of the breach is computed by the FDA model using the discharge-frequency, stage-discharge, failure probability (fragility curve), and their associated uncertainties.

The FLO-2D breach simulation models generate velocities and depths. However these were not post processed as velocity x depth. Only depth is used in the FDA model. For life safety evaluation a simple depth metric was used for alternative evaluations.

Table 19
Simulated Levee Breaches

Breach ID	River Mile	Horizontal Coordinates (FT- NAD83 CCS Zone II)		Breach Width (Feet)	Breach Elevation at Toe (FT-NAVD88)
		Northing	Easting		
Feather River					
FR 9.0 R	57.17	2283867	6661785	1500	115.00
FR 8.0 R	50.20	2258021	6662669	1500	95.74
FR 7.0 R	41.55	2225167	6665302	1500	41.59
FR 6.0 R	34.07	2201918	6666623	1500	69.54
FR 5.0 R	28.25	2178130	6672485	1500	55.82
FR 4.5 R	26.00	2167420	6673291	1500	52.20
FR 4.0 R	17.00	2128205	6675848	1500	45.38
FR 3.0 R	10.50	2095813	6680073	1500	36.45
Sutter Bypass					
SB 5.0 L	88.04	2168107	6626586	1000	39.90
SB 4.0 L	82.45	2158851	6631970	1000	37.36
SB 3.0 L	77.05	2131434	6640141	1000	28.96
Wadsworth Canal					
W2.0R	2.42	2178179	6634678	1000	39.90
W2.0L	2.42	2178079	6634839	1000	43.80
Cherokee Canal					
CC2.0L	13.34	2305152	6638905	50	103.00
CC1.0L	11.4	2296019	6634326	50	103.00

Eight breaches were simulated on the Feather River from the Thermalito Afterbay to the Sutter Bypass. Each breach was simulated using the HEC-RAS model and the breach outflow hydrograph was translated to the FLO-2D model to simulate the inundation area of the breach. A 1,500 foot wide breach width was used for the simulations. The breach width was based on sensitivity analysis presented in the F3 Sutter Basin Feasibility Study report. The size is based on historical breaches within the central valley and achieving a headwater depth to tailwater depth ratio of 0.90.

The breach was initiated at the beginning of the flood simulation and assumed to take 1-hour to develop to the full width. This was done to reflect the hydrologic floodwave assumptions. The comp study hydrographs assume a series of six 5-day floodwaves make up the 30-day hydrograph. They put the largest 5-day wave in the middle of the series. However, the sequence of these 5-day events is uncertain and the largest could be the first. A breach at the initiation of the 30-day wave would reflect the true 30-day flow duration. Breach inundation maps are shown on Plates 31 to 38.

Three breaches were simulated on the Sutter Bypass between Wadsworth Canal and Feather River. Each breach was simulated using the HEC-RAS model and the breach outflow hydrograph was translated to the FLO-2D model to simulate the inundation area of the breach. A 1,000 foot wide breach width was used for the simulations. The breach width was based on sensitivity analysis presented in the F3 Sutter Basin Feasibility Study report. The size is based on historical breaches within the central valley and achieving a headwater depth to tailwater depth ratio of 0.90. Similar to the Feather River breach simulations, the breach was initiated at the beginning of the flood simulation and assumed to take 1-hour to develop to the full width. Breach inundation maps are shown on Plates 39 to 41.

One breach was simulated on the left bank of Wadsworth Canal. The breach was simulated using the HEC-RAS model and the breach outflow hydrograph was translated to the FLO-2D model to simulate the inundation area of the breach. The characteristics of this breach were assumed to be very similar as a breach on the Sutter Bypass because the volume of flow through the breach would originate from the Sutter Bypass. Therefore a 1,000 foot wide breach width was used for the simulations. The breach was initiated at the beginning of the flood simulation and assumed to take 1-hour to develop to the full width. Breach inundation maps are shown on Plate 42.

One breach was simulated on the right bank of Wadsworth Canal. A breach on the right bank levee of the Wadsworth Canal would flood a triangular area between Wadsworth Canal, the Sutter Bypass, and the natural ground elevation south of the Town of Sutter. It was assumed the volume of the Sutter Bypass flood hydrograph would be sufficient to fill this volume to the stage of the channel at the breach location. The breach inundation was simulated by projecting the channel stage on the FLO-2D grid elevations and computing the resulting depths. The breach inundation maps are shown on Plate 43.

Two breaches were simulated on Cherokee Canal upstream and downstream of the Union Pacific Railroad. Each breach was simulated using the HEC-RAS model and the breach outflow hydrograph was translated to the FLO-2D model to simulate the inundation area of the breach. A 50 foot wide breach width was used for the simulations. The breach width was based on historical breach occurrences along the Cherokee Canal. For Cherokee Canal, the PDT was considering the use of FIA modeling where inundation time and velocities plays a role in the calculations. The breach was initiated 1-hour before the peak flood stage and assumed to take 1-hour to develop to the full width. Breach inundation maps are shown on Plates 44 and 45.

d. Natural (Non-Breach) Inundation. Flood depth inundation maps were developed for two natural (non-breach) flood sources within the study area. These sources of flooding are from interior drainage and flood storage within the Butte Basin.

Flood depths from interior drainage were obtained from analysis performed by Peterson-Brustad Incorporated (PBI) a consultant to 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. These maps indicated flooding was limited to non-urban areas and flooding from levee breach sources were far greater sources of damage. Therefore, maps were limited to these three events. Inundation maps from interior flooding are shown on Plate 46.

Flood depths within the Butte Basin were obtained from the Sacramento San Joaquin Comprehensive Study model results. The model is described above. Inundation within the Butte Basin was simulated by projecting the model stage on the FLO-2D grid elevations and computing the resulting depths. Inundation was 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) ACE events. The breach inundation maps are shown on Plate 47.

3.5 Hydraulic Design.

Alternative SB1 is the without project condition and does not include any features requiring hydraulic design.

3.6 Wind Wave Analysis.

An analysis of wind wave runup and wind setup was conducted for the east levee of the Sutter Bypass and west levee of the Feather River. The analysis did not include Cherokee Canal or Wadsworth Canal because wind waves were not considered to be a significant factor in these reaches because their fetch lengths are less than 400 feet. The complete analysis is described in the report “Sutter Basin wave runup analysis”, 15 July 2011. The analysis was performed for three representative sites on the Sutter Bypass and seven representative sites along the Feather River. Results for wind wave run up and setup up for a hypothetical water level at the levee crest are summarized in Tables 20 and 21.

The wind wave run-up calculations were made assuming they could be incorporated into the HEC-FDA model used to compute economic flood damages. However it was later determined that this module in FDA does not work and the results could not be utilized. However, the information is useful to assess the probability of wind wave overtopping. The information was also used to evaluate the performance relative the California State Urban Levee Design Criteria (ULDC).

Wind wave runup and setup were evaluated for three wind speed scenarios over a range of four flood stages. These results could then be interpolated depending on the needs of the study. An analysis of wind speed and flood stage found very low correlation. This indicated that wind wave run-up could be assessed independently of flood frequency. In addition, it was found that wind wave runup and setup were largely independent of water surface elevation in the top 2/3 of the levee height. At these depths the fetch lengths are similar and the waves are not depth limited.

The minimum probable wind scenario was based on the minimum of the annual maximum wind speeds. The most likely wind scenario was based on the average of the annual maximum wind speeds. The maximum probable wind scenario was based on the annual maximum wind speeds. The wind analyses were based on 80 years of record at the Sacramento Executive Airport wind gage.

For each of the wind scenarios, wind wave runup was calculated for four water levels corresponding to the levee toe, 1/3 height, 2/3 height, and top of levee. As described above, it was found that wind wave runup and setup were largely independent of water surface in the top 2/3 of the levee height. Therefore, only the wind wave runup and setup result for the top of levee stage are provided in the Table.

Table 20
Estimated Wind Wave Runup and Setup at Top of Levee
Feather River West Levee, Alternative SB-1

Reach River Mile	Reach Name	Comp Study River Mile	Wind Wave Analysis Index Point	Wind Scenario	Wind Stress	Wave Runup Ru2% (Feet)	Wind Setup (Feet)
58.75							
	Feather River North Upper	48.85	WW-FR7	Probable High Most Likely Probable Low	82.5 mph 40.7 mph 23.1 mph	7.06 4.52 2.43	0.46 0.15 0.04
48.85							
	Feather River North Middle	43.28	WW-FR6	Probable High Most Likely Probable Low	66.5 mph 40.7 mph 23.1 mph	5.01 2.90 2.43	0.15 0.03 0.01
38.71							
	Feather River North Lower	35.78	WW-FR5	Probable High Most Likely Probable Low	72.3 mph 40.7 mph 23.1 mph	4.67 2.90 1.81	0.10 0.03 0.01
30.25							
	Feather River South Shanghai	27.50	WW-FR4	Probable High Most Likely Probable Low	66.5 mph 37.2 mph 27.3 mph	3.74 1.60 1.24	0.07 0.01 0.00
20							
	Feather River South Abbot	19.25	WW-FR3	Probable High Most Likely Probable Low	72.3 mph 40.7 mph 23.1 mph	5.26 3.26 2.03	0.12 0.04 0.01
15.5							
	Feather River South Bear	11.75	WW-FR2	Probable High Most Likely Probable Low	66.5 mph 40.7 mph 23.1 mph	5.41 3.06 1.91	0.15 0.04 0.01
7.5							

Table 21
Estimated Wind Wave Runup and Setup at Top of Levee
Sutter Bypass East Levee, Alternative SB-1

Reach River Mile	Reach Name	Comp Study River Mile	Wind Wave Analysis Index Point	Wind Scenario	Wind Stress	Wave Runup Ru2% (Feet)	Wind Setup (Feet)
87.86							
	Sutter Bypass above Wadsworth	86.18	WW-SB1	Probable High Most Likely Probable Low	82.5 mph 39.9 mph 24.4 mph	3.67 2.00 1.33	0.12 0.03 0.01
83.62							
	Sutter Bypass Upper	80.96	WW-SB2	Probable High Most Likely Probable Low	105.8 mph 36.0 mph 18.5 mph	4.39 1.84 1.33	0.15 0.02 0.01
75.3							
	Sutter Bypass Lower	70.12	WW-SB3	Probable High Most Likely Probable Low	82.5 mph 39.9 mph 24.4 mph	3.67 2.00 1.33	0.11 0.03 0.01
66.3							

3.7 Sedimentation and Channel Stability. An evaluation of sedimentation and channel stability was based on existing studies. The following gives a brief description of the Sutter Bypass, Feather River, and Cherokee Canal.

a. Sutter Bypass. The Sutter Bypass follows the low point of the historic Sutter Basin. Prior to construction of the Sacramento River Flood Protection project the Sutter Basin was a natural overflow area adjacent to natural levees of the Sacramento and Feather Rivers.

The Sutter Bypass is a depositional feature. The rate of sediment deposition along the Sutter Bypass from Long Bridge to Tisdale Weir has been estimated to be 135,000 tons/yr. The deposition rate from Tisdale Weir to Highway 113 (upstream of the Feather River confluence) has been estimated to be 683,000 tons per year. These rates were estimated as part of the 1970 Sacramento River and Tributaries Bank Protection and Erosion Control Investigation. The results were based on an evaluation of sediment transport capacities and are presented in a 4 September, 1986 USACE information pamphlet for Field Reconnaissance Visit of U.S.- Japan Cooperative Science Project on River Meandering (NSF). Deposition rates from the Feather River to the Sacramento River are estimated at 400,000 tons per year based on a comparison of 1939 and 1979 topographic profiles across the bypass. The USACE report concluded that "a significant" portion of the sediment deposited in the lower bypass was derived from the Feather River System.

The Sutter Bypass is inspected as part of the Sacramento River Bank Protection Project. The last complete inspection of the Sutter Bypass east levee occurred in 2011. One active site was identified at RM 77.2 and was 160 feet long. The site was reported to be a slump caused by wind wave erosion.

b. Upper Feather River (River Mile 61-28). The upper Feather River reach extends from Oroville to the mouth of the Yuba River. Within this reach the levee embankment system on the upper Feather River is set back, and the river occupies a wide meander belt similar to the Sacramento River upstream of Colusa. The Lower Feather River is estimated to be degrading. This reach is inspected for erosion sites as part of the Sacramento River Bank Protection Project. The last complete inspection of the Feather River occurred in 2011. One active site was identified at RM 47.6 and was 850 feet long. The site was reported to be scour along the waterside levee toe.

The upper Feather River is significantly different from the lower Feather River in that it did not receive the tremendous sediment influx from hydraulic mining from the Yuba River. Although hydraulic mining took place on the upper Feather River, the amount of material introduced to the river was significantly less. As with all other locations disturbed by the hydraulic mining debris, the upper Feather River aggraded during the late 19th century due to the influx of sediment. Subsequently, the river has degraded into the debris. In addition to hydraulic mining sediments, the river itself was dredged and the tailings were deposited in mounds which essentially block the hydraulic conveyance of the overbank. Construction of the Oroville Dam has altered the hydrology significantly and has reduced the sediment load.

From Oroville Dam to River mile 56, Gold mining dredge spoils border the river. As high flows bypass the majority of dredge spoils via the Thermalito Afterbay, coarse sediment within the spoils is rarely transported. In this reach the sinuosity is low, split flow around mid channel bars is common, and sediment is dominated by coarse gravel to cobble-sized materials. From River Mile 56 to River Mile 44.2 (Honcut Creek) the Feather River is a sand to fine gravel-dominated, high sinuosity stream.

From River Mile 44.2 to River Mile 27 (Yuba River) the Feather River is a sinuous, meandering river whose bed material is dominated by sand to fine gravel-size sediment. The river is highly dynamic and contains large point bars and chute channels. Bank erosion is extensive; however, wide levee setback precludes direct levee threat. Where the channel flows close to the levee, Modesto outcrops compose the channel banks, resisting erosion. Sand channels are commonly preserved in the bank stratigraphy, suggesting that during hydraulic mining, large quantities of sand were stored within this reach. Vegetation displaying distinct adventitious root zones also records a period of rapid aggradation. Point bars generally consist of sand-sized sediment. Active point bar growth, chute cutoffs and bendway migration are evidenced active bank erosion and active chutes across the bars.

Sediments that make up the active channel and floodplain deposits of the upper Feather River can be divided into Holocene (recent) and Pleistocene ages. The Pleistocene deposits affecting the river include the Riverbank and Modesto Formations. Pleistocene sedimentary rocks of the Riverbank and Modesto Formations bound the active meanderbelt of the upper Feather River. .The Modesto Formation is the most common bounding unit, bordering the Feather River meanderbelt along the line of the project levees. Consequently, as the river approaches the levee, in many cases lateral migration is effectively arrested as it encounters resistant sediments of the Modesto Formation, similar to the Sacramento River upstream of Colusa. The Modesto Formation consists of fluvial sediments that include channel fill, point bar, and lateral and vertical accretion deposits. It is generally cohesive and resistant to erosion.

Modes of bank failure that occur on the Feather River study reach are highly dependent on bank lithology and stratigraphy. There is a great deal of erosion happening from RM 45-28. Here the channel is sinuous and actively meandering.

Migration rates are highly variable along the Feather River study reach, reflecting the heterogeneity of materials present, and the range of stages of bend development. Although bankline migration rates are commonly high, levee setback is sufficient so that very little direct levee threat can be demonstrated on the Feather River. From RM 45-28 the channel bed has degraded over time.

b. Lower Feather River (River Mile 28 to 0). The Lower Feather River extends from the Yuba River to the Sacramento River opposite the Fremont Weir. The Lower Feather River estimated to be degrading. This reach is inspected for erosion sites as part of the Sacramento River Bank Protection Project. The last complete inspection of the Feather River occurred in 2011. No active erosion sites were identified.

The lower Feather River reach is presently a wide, low sinuosity, sand-dominated system that is presently sediment-laden. The bed of the Feather River in this reach contains large sand waves, which were observed to be slowly migrating downstream under relatively low flow conditions of mid-summer. These sand waves are generally several hundred feet long and several hundred feet wide, occupying the majority of the channel width. Generally the sinuosity decreases in the downstream direction.

The river planform of this reach prior to 1850 was much like the present-day Sacramento River. Hydraulic mining has had a severe effect on the lower Feather River. The initial surge of hydraulic mining debris in the Feather River consisted of silts and clays known as "slickens". Later on, floods brought down coarser sediment that overlaid the slickens. The average fill thickness in the Feather River from the mouth of the Yuba River to Nicolaus was 20 feet. The original sinuous channel was completely in filled. The high sediment loads caused the rate of bendway cutoffs to increase and the channel sinuosity decreased (slope increased) as a result. Alternate bars formed in response to the generally increased sediment load. The channel was a wide, shallow, sand-dominated system that had low, ill-defined banks, which were commonly overtopped. Levees were later put in place to prevent flooding.

After hydraulic mining was discontinued, the subsequent reduction in sediment load caused the river to incise into the hydraulic mining debris. Degradation of the hydraulic mining has since mostly come to an end. The channel maintained its low sinuosity as it incised, preserving bars as perched geomorphic features. The stratigraphy into which the channel incised consists of clean mining derived sands underlain by fine-grained, thinly bedded silts and clays of the slickens. The slickens add stability to the Feather River system, as the fine-grained sediments commonly form a cohesive toe. Recent data indicate, however, that the Feather River has locally eroded through the slickens such that the lowermost parts of the banks below the water may be composed of pre-hydraulic mining deposits. If the channel has eroded into the sands, then it is important to consider potential ramifications of the changing erodibility of the channel perimeter. Though the Feather River is sand-dominated there is also evidence of coarser materials being deposited from the Yuba River.

The slickens are laterally continuous and very homogeneous, and therefore display little variability in terms of erosion resistance for a given stratigraphic horizon. The slickens are underlain by pre-hydraulic mining Feather River meanderbelt deposits. These older deposits are likely to be much more heterogeneous than those exposed along the river today, in that they were deposited in a coarse grained meanderbelt, much like the Sacramento River above Colusa. Such material diversity will likely result in variable erosion rates, causing planform adjustment to the differences in resistance of materials encountered following degradation. Any rapid lateral adjustment of the river could in turn create a threat to bordering flood control levees.

The erosion-resistant nature of the Modesto Formation has resulted in the formation of a steep knick zone that contains over 5 feet of drop in bed elevation in a few hundred feet of channel. The report indicates the location as river mile 24.8. This headcut has migrated upstream as a horseshoe-shaped feature. Migration of the headcut upstream has serious implications with respect to upstream continuation of the degradation.

Bank failure mechanisms on the Feather River are highly correlated to bank stratigraphy. Sand-sized sediment is derived from Feather River bank erosion as well as from tributaries. Upper bank sediments on this reach of the Feather River commonly consist of clean sands underlain by a fine-grained cohesive toe. Both of these units represent hydraulic mining debris deposited during the aggradational period of the hydraulic mining era. The upper bank unit is prone to erosion and contributes sand size sediment to the system. Bed sediments consist primarily of sand. Where the bank stratigraphy is not the coarsening upward hydraulic mining sequence, it is generally Pleistocene-age Modesto Formation. The Modesto Formation consists of tan and light gray gravely sand, silt, and clay. Both types of bank materials are relatively erosion resistant at the bank toe and are responsible for the low bank erosion rates in the study reach. In general the Modesto Formation forms a high bank that is highly resistant to erosion and is therefore capable of significant bendway distortion and planform control.

As mentioned previously, the sinuosity generally increases in the upstream direction in this reach of the Feather River. An increase in sinuosity in the upstream direction reflects the increasing amount of Modesto outcrop exposed in the channel banks, which has helped to maintain channel planform. The channel has incised into the cohesive slickens, which has also helped to maintain the channel planform. Flow control in the watershed has also contributed to the maintenance of channel planform. Though the river is largely stable, if the river degrades through the slickens and high shear stresses are imparted on less cohesive underlying bank strata, channel migration rates and sinuosity may increase due to the significant bank erosion and development of channel asymmetry. As the supply of sand to the study reach appears relatively constant and incision rates have slowed significantly since the early part of this century, incision into underlying strata may not be imminent.

d. Wadsworth Canal. The Wadsworth Canal is a leveed channel which conveys interior drainage into the Sutter Bypass. A search of past studies and reports found no information about sedimentation rates in the canal. This reach is inspected for erosion sites as part of the Sacramento River Bank Protection Project. The last complete inspection of the Wadsworth Canal occurred in 2011. Two erosion sites were identified. Site WAD_2-1_L is located on the left bank and extends from River Mile 2.25 to River Mile 1.8. The site was identified as a bank failure with leaning trees and exposed roots. Site WAD_2-4L is also located on the left bank and extends from River Mile 3.15 to River Mile 2.2. The site was identified as a bank failure.

e. Cherokee Canal. Cherokee Canal is a leveed channel that conveys runoff from the Clear Creek, Dry Creek, Gold Run Creek, and Cottonwood Creek watersheds to Butte Slough. DWR has completed several sediment removal projects along the canal to maintain the design capacity. A sediment yield and transport study was completed by URS Corporation for the Sacramento District in January 2003. The study indicated the channel is depositional. Cherokee Canal is not inspected for bank erosion by the Sacramento Bank Protection Project.

3.8 Flood Risk.

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 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.

The risk assessment approach included an evaluation of potential flood sources with respect to geotechnical fragility, channel hydrology, channel hydraulics, and potential inundation patterns of a levee breach or natural overbank (non-levee). Thirteen geotechnical reaches were identified. Within each of the geotechnical reaches a representative geotechnical fragility curve was developed and a stage-discharge relationship was developed using a system based hydraulic model. Selection of the geotechnical reaches is described in detail in the geotechnical analysis report. Fifteen breach sources and one non-leveed flood sources were identified. All breach source locations identified within a geotechnical reach were assigned to the same geotechnical fragility curve location.

a. Levee Assurance. The reliability of Flood Risk Management (FRM) features within the study area is expressed as an assurance level (conditional non-exceedance probability) for a given median ACE hydrologic event. The assurance varies over levee reaches due to variations in geotechnical fragility, hydrology, and hydraulic characteristics and their uncertainties.

Levee assurance was computed for the 13 geotechnical reaches within the study area using the HEC-FDA computer program. The reaches are shown on Plate 48 and described in Tables 22 through 26. Assurance was calculated at the geotechnical fragility curve location within each reach and assumed to represent the assurance throughout the entire reach. Assurance was calculated with the HEC-FDA program using an unregulated flow-frequency curve, unregulated to regulated transform, stage-discharge relationships, geotechnical fragility curves, and Hydraulic Top of Levee Elevation (HTOL). Uncertainty in each relationship was incorporated using the FDA Monte Carlo simulation. Wind wave runup and setup were not included in the assurance calculations. FDA input assumptions are described in Tables 22 through 26.

Flow-frequency curves were based on the analytical statistics computed for unregulated conditions. Uncertainty in the flow-frequency curve is based on the period of record described in the hydrology section above. For the Sutter Bypass and Feather Rivers, the nearest upstream analytical curve statistics were utilized in combination with an unregulated-regulated transform. The unregulated flow in the transform is computed directly from the flow frequency statistics. The regulated flow used in the transform was obtained from the hydraulic model at the index location (Tables 14 -18). The transforms are used to translate the uncertainty in flow frequency estimates to the regulated condition.

The geotechnical fragility curves were based on geotechnical analysis and are presented in the geotechnical appendix and provided as Attachment B to this report. The curves are assumed to have a 100% probability of failure at the levee crest. The crest elevation was modified in the

FDA model to reflect the Hydraulic Top of Levee (HTOL). The hydraulic top of levee is defined as the elevation at the index point corresponding to the first point of overtopping within the reach. The HTOL is lower than the actual top of levee at index points with high localized crest elevations.

Stage discharge curves used in the analysis are described in Tables 14 through 18. For index points that represent the first levee segment downstream of high ground, stages and flows are based on Scenario A (infinite levee height). This was done to prevent overestimating the assurance within these reaches. The overestimate would occur if upstream overtopping reduces the flow and stage at the index point but the overtopping failure is not accounted for in the performance evaluation.

Table 22
FDA Input for Feather River West Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
58.75							
	Feather River North Upper	57.95	129.62	MA7- Ham Bend	A	at Oroville with Regulated Transform	- Represents Breaches F9.0R, F8.0R - HTOL based on overtopping at RM 58.25 - NLDB TOL 136.00 FT-88
48.85							
	Feather River North Middle	41.20	91.02 (NLDB)	MA16-0.9	B	at Oroville with Regulated Transform	- Represents Breaches F7.0R
38.71							
	Feather River North Lower	30.25	85.01	LD9-0.52	B	at Oroville with Regulated Transform	-Represents Breaches F6.0R, F5.0R - HTOL based on overtopping at RM 32.35 - NLDB TOL 86.52 FT-88
30.25							
	Feather River South Shanghai	23.25	75.79	LD1-9.31	B	at Shanghai with Regulated Transform	- Assumes gate closure at Railroad. - Represents Breaches F4.5R, F4.4R - HTOL based on overtopping at RM 27.19 - NLDB TOL 78.50 FT-88
20							
	Feather River South Abbot	16.75	67.53	LD1-3.99	B	at Shanghai with Regulated Transform	- Represents Breaches F4.1R, F4.0R - HTOL based on overtopping at RM 19.28 - NLDB TOL 68.50 FT-88
15.5							
	Feather River South Bear	12.50	60.75	MA3-4.92	B	at Shanghai with Regulated Transform	- Represents Breaches F3.0R - HTOL based on overtopping at RM 9.18 - NLDB TOL 64.60 FT-88
7.5							
NLDB - Top of Levee in 2008 National Levee Database							

Table 23
FDA Input for Sutter Bypass East Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
87.86							
	Sutter Bypass above Wadsworth	83.70	59.21	Sutter-4	B	at Ord Ferry with Regulated Transform	- Model XSEC 84.31 - Represents Breach S5.0L - HTOL based on overtopping at RM 85.19 - NLDB TOL 60.60 FT-88
83.62							
	Sutter Bypass Upper	81.92	57.72	Sutter - 6.2	B	at Ord Ferry with Regulated Transform	- Model XSEC 82.45 - Represents Breach S4.0L - HTOL based on overtopping at RM 83.53 - NLDB TOL 58.20 FT-88
75.3							
	Sutter Bypass Lower	71.65	52.93	Sutter - 17.3	B	at Ord Ferry with Regulated Transform	Model XSEC 72.17 -Represents Breach S3.0L - HTOL based on overtopping at RM 66.3 - NLDB TOL 54.10 FT-88
66.3							
NLDB - Top of Levee in National Levee Database							

Table 24
FDA Input for Wadsworth Canal South Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
4.54							
	Wadsworth Canal at Interceptor Canals	4.54	62.10 (NLDB)	None	A	Wadsworth Canal nr Sutter	- No breach represented
4.50							
	Wadsworth Canal Left Levee	0.81	58.80 (NLDB)	Wadsworth LB- 0.83	A	None	- Based on Stage Frequency Curve - Represents Breach WC 2.0L
0							
NLDB - Top of Levee in National Levee Database							

Table 25
FDA Input for Wadsworth Canal North Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
4.54							
	Wadsworth Canal at Interceptor Canals	4.54	62.10 (NLDB)	None	A	Wadsworth Canal nr Sutter	- No breach represented
4.50							
	Wadsworth Canal Right Levee	0.25	60.30 (NLDB)	Wadsworth RB- 0.83	A	None	- Based on Stage Frequency Curve - Represents Breach WC 2.0R
0							
NLDB - Top of Levee in National Levee Database							

Table 26
FDA Input for Cherokee Canal South Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
15.7							
	Cotton Wood Creek to Hwy 162	12.53	110.6 (NLDB)	Cherokee 9.50	A	Cherokee Canal nr Richvale	- Represents Breaches CC1.0L and CC 2.0 L - HTOL based on overtopping at RM 13.42 - NLDB TOL 112.00 FT NAVD88
10.8							
NLDB - Top of Levee in National Levee Database							

b. Composite Flood Depths. Maps showing composite floodplains were developed to demonstrate FRM 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 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
- 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 provided in Plates 49 through 56. All maps include the natural (non-leveed) flood inundation depths. Table27 provides performance values at simulated breach locations. These maps demonstrate the variation of flood risk management assurance throughout the study area.

Table 27
Project Performance at Simulated Levee Breach Locations, Alternative SB-1

Simulated Breach		Annual Exceedance Probability		Long Term Risk			Flood Risk Management Assurance by Event Flood Frequency (Breach included in floodplain map if shaded)						
Label	River Mile	Median	Exp.	10 Years	30 Years	50 Years	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Feather River													
F9.0R	57.17	0.0696	0.0769	0.5506	0.9092	0.9817	0.9909	0.8187	0.6499	0.6087	0.5777	0.4781	0.331
F8.0R	50.20	0.0686	0.0768	0.5504	0.9091	0.9816	0.9909	0.8187	0.6499	0.6087	0.5777	0.4781	0.331
F7.0R	41.55	0.0203	0.0238	0.2138	0.5140	0.6996	0.9999	0.9299	0.7965	0.7586	0.7209	0.5657	0.298
F6.0R	34.07	0.0353	0.0391	0.3286	0.6973	0.8635	0.9999	0.848	0.744	0.6685	0.5995	0.4486	0.2193
F5.0R	28.25	0.0353	0.0391	0.3286	0.6973	0.8635	0.9999	0.848	0.744	0.6685	0.5995	0.4486	0.2193
F4.5R	26.00	0.0909	0.1071	0.6778	0.9666	0.9965	0.9838	0.8025	0.6253	0.581	0.5626	0.4788	0.2988
F4.4R	25.99	0.0909	0.1071	0.6778	0.9666	0.9965	0.9838	0.8025	0.6253	0.581	0.5626	0.4788	0.2988
F4.1R	17.00	0.0622	0.0676	0.5036	0.8777	0.9699	0.9999	0.7722	0.6232	0.5759	0.5396	0.3996	0.175
F4.0R	16.99	0.0622	0.0676	0.5036	0.8777	0.9699	0.9999	0.7722	0.6232	0.5759	0.5396	0.3996	0.175
F3.0R	10.50	0.0167	0.0192	0.1766	0.4418	0.6216	0.9999	0.9443	0.9171	0.889	0.8447	0.6847	0.4057
Sutter Bypass													
S5.0L	88.04	0.2184	0.2331	0.9297	0.9997	0.9999	0.8232	0.5684	0.4267	0.3803	0.2991	0.1896	0.0827
S4.0L	82.45	0.4468	0.5156	0.9993	0.9999	0.9999	0.5362	0.3336	0.3257	0.2956	0.2223	0.1391	0.0631
S3.0L	77.05	0.1945	0.2104	0.9058	0.9992	0.9999	0.8101	0.6612	0.635	0.6009	0.5021	0.3426	0.1654
Wadsworth Canal													
W3.0R	4.54	0.0065	0.0086	0.0826	0.2279	0.3501	0.9999	0.9995	0.9951	0.9338	0.705	0.3791	0.0786
W2.0R	2.42	0.3590	0.3577	0.9880	0.9999	0.9999	0.6394	0.3611	0.239	0.2263	0.1884	0.0874	0.0074
W2.0L	2.42	0.1137	0.1157	0.7075	0.9750	0.9979	0.9583	0.7575	0.5626	0.4783	0.3363	0.1392	0.0056
Cherokee Canal													
CC2.0L	13.34	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015
CC1.0L	11.4	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015
Notes: Assurance based on existing top of levee or 1957 design top of levee, whichever is higher within the reach. Assurance accounts for stage uncertainty, hydrologic uncertainty, and geotechnical uncertainty.													

d. Flood Velocities. The average velocity within the floodway is provided in Tables 14 through 18. If a levee breach were to occur, inundation velocities and depths within the study area would vary by proximity to a breach, breach location, and magnitude of flood event. The velocity field for a levee breach can be characterized as highest near the breach due to the rapidly varying flow conditions. The remaining area would have lower velocities associated with the slope of the topography and floodplain roughness. For evaluation of life loss consequence the study area can be divided into a breach zone, zone with rapidly rising water, and a remaining zone (Yonkman, 2008). The simulated levee breach at F9.0R during a 1% (1/100) ACE event is representative of the study area.

(1) Breach zone. The breach zone is characterized by destruction of buildings and the highest life safety consequence. Yonkman describes this area as having velocities greater than 6 feet per second and the product of depth and velocity greater than 22 ft^2 per second. For the Sutter Basin Feasibility study, velocities within 1000 feet of the breach were assumed to be great

enough to destroy buildings. This distance is based on evaluation of the 1955 levee breach which showed structures knocked off their foundations.

(2) Zone with rapidly rising water. This zone is characterized by rapidly changing velocity and depth. Model results indicate velocities of less than 3 feet per second within a few thousand feet from a levee breach.

(3) Remaining zone. This zone is characterized by slower onset of flooding. The majority of the study area is defined as the remaining zone. Models of the F9.0R breach indicate velocities of less than 2fps for the remaining portion of the inundation area. Higher velocities are indicated where flows overtop linear features such as the UPRR railroad embankment. Additional locations with higher velocities may occur. However, they would be localized and uncertain.

e. Evacuation Routes. The composite floodplain maps include the location of potential evacuation routes within the Sutter Basin study area. The Sutter County Evacuation and Mass Shelter/Care Plan identify Highways 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 Highways 99, 162 and the Colusa Highway could be used as conditions allow (SBFCA, 2012).

The maps provide an indication of evacuation reliability associated with potential flood depths within the basin. However, the following limitations should be considered when comparing the floodplain maps to the evacuation routes.

(1) Evacuation routes depicted on the maps may be closed due to localized flooding related to interior drainage. During the 1997 flood event, seven different evacuation zones were established over seven days due to constantly changing conditions (SBFCA, 2012). 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. During the 1955 flood one of the spans of 5th street bridge crossing from Yuba City to Marysville collapsed into the river due to pier scour.

(2) The destination of the evacuation routes are also at risk of flooding.

(3) The FLO-2D model results shown on the maps are based on a grid element size of 1000 feet. Depths shown are an average over the grid element. The model includes the large scale features that impact the general depth and direction of flooding. These large features include levees, railroad embankment and bridges and culverts through the railroad embankment. Small scale topographic features such as drainage ditches, roadway embankments, and roadway culverts are not represented in the model. In addition, small scale topographic variations along roadways (vertical crests and vertical sags) are not represented. As a result, the small scale depressions that can make a roadway impassable are not represented. Whereas the model results may show 0.1 feet of average depth along a roadway alignment, the actual depths could be 3 feet

deep in the smaller topographic depressions. A model depth of 0.1 feet should be used as a likely indicator that a roadway is impassable.

(4) The maps are the composite of multiple breach simulations. The maps depict long term probabilities. However, each flood event would result from different breach locations. The evacuation route during a breach would be highly uncertain. Individual breach inundation maps are provided in Plates 31 though 48.

(5) The maps include representative breach locations and resulting depth fields. Additional levee breach simulations may result in greater depths in some locations.

f. 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/small river and stream flood warnings are issued by the NWS when flooding of main stem rivers is occurring or imminent (CNRFC, 2013). Main stem river flooding refers to flooding of gauged and forecasted rivers (CNRFC, 2013). The product can also be used to issue Small River and Stream Flood Warnings for smaller rivers/streams which 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 (CNRFC, 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 (CNRFC, 2013).

In addition to the advisories described above, the NWS in coordination with the California Department of Water Resources 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 to 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, Boyds 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 five 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-January2006 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 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 five 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-January2006 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 22 December 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).

g. Loss of Life Potential. To evaluate the potential for loss of life, the population density within the study area was compared to the composite floodplain maps. The distribution of population within the study area was based on 2010 census blocks. The population was assigned to single family residences within the census block. The population of the residences within each FLO-2D grid element was then summed. The population within a floodplain was a simple addition of all grid elements with depths greater than a specified depth. A map of the estimated population density throughout the study area is provided in Plate 4.

The population within areas greater than 0 feet, 2 feet, and 15 feet are provided in Tables 28, 29, and 30 respectively.

Table 28.
Population within Alternative SB1 Floodplain
Depths Greater Than 0 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	251
Yuba City Urban	0	67351	67368	67368	67368	67368	67368
Biggs Urban	0	19	1452	1452	1452	1452	1763
Gridley Urban	0	0	6379	6379	6379	6379	6379
Live Oak Urban	0	0	8362	8362	8362	8362	8362
Sutter County Rural	1089	4837	6260	6314	6323	6354	6378
Butte County Rural	0	9	4776	4788	4788	4793	4899
Total	1089	72216	94597	94663	94672	94707	95400

Table 29.
Population within Alternative SB1 Floodplain
Depths Greater Than 2 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	57736	63471	64529	64529	66380	67368
Biggs Urban	0	0	1352	1352	1352	1353	1554
Gridley Urban	0	0	1176	1176	1176	1186	5483
Live Oak Urban	0	0	4156	5882	5882	6498	8362
Sutter County Rural	767	4088	4840	5098	5095	5505	6199
Butte County Rural	0	0	2424	2527	2527	2887	3882
Total	767	61824	77418	80564	80561	83809	92847

Table 30.
Population within Alternative SB1 Floodplain
Depths Greater Than 15 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	137	137	137	303	934
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
Sutter County Rural	0	499	774	944	958	1059	1183
Butte County Rural	0	0	0	0	0	0	0
Total	0	499	911	1080	1095	1362	2117

3.9 Potential Adverse Effects.

a. Induced Flooding. There is no induced flooding associated with the without project condition.

b. Transfer of Flood Risk. There is no transfer of flood risk associated with the without project condition. However, Alternative SB-1 forms the basis for evaluating the transfer of risk for other alternatives. The transfer of flood risk is evaluated by comparing with-project and without-project 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" (USACE, 2008). The performance values associated with hydrologic and hydraulic parameters, and their uncertainties, are provided in Table 31.

Table 31
Project Performance at Simulated Levee Breach Locations
Hydrologic and Hydraulic Parameters Only

Simulated Breach		Annual Exceedance Probability		Long Term Probability of Failure			Flood Risk Management Assurance by Event Flood Frequency						
Label	River Mile	Median	Exp.	10 Years	30 Years	50 Years	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Feather River													
F9.0R	57.17	0.0020	0.0023	0.0233	0.0683	0.1112	0.9999	0.9999	0.9949	0.9915	0.9726	0.8551	0.6390
F8.0R	50.20	0.0001	0.0023	0.0225	0.0659	0.1075	0.9999	0.9999	0.9949	0.9915	0.9726	0.8551	0.6390
F7.0R	41.55	0.0022	0.0022	0.0220	0.0646	0.1054	0.9999	0.9999	0.9999	0.9999	0.9895	0.8576	0.5427
F6.0R	34.07	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5547
F5.0R	28.25	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5548
F4.5R	26.00	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.4R	25.99	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.1R	17.00	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F4.0R	16.99	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F3.0R	10.50	0.0024	0.0027	0.0267	0.0781	0.1267	0.9999	0.9999	0.9999	0.9992	0.9744	0.8030	0.4813
Sutter Bypass													
S5.0L	88.04	0.0027	0.0037	0.0362	0.1048	0.1686	0.9999	0.9999	0.9995	0.9874	0.9087	0.7126	0.4666
S4.0L	82.45	0.0029	0.0040	0.0390	0.1126	0.1805	0.9999	0.9999	0.9994	0.9857	0.8992	0.6903	0.4306
S3.0L	77.05	0.0036	0.0036	0.0520	0.1481	0.2344	0.9999	0.9999	0.9977	0.9713	0.8483	0.6001	0.3058
Wadsworth Canal													
W3.0R	4.54	0.0065	0.0086	0.0826	0.2279	0.3501	0.9999	0.9995	0.9951	0.9338	0.705	0.3791	0.0786
W2.0R	2.42	0.0048	0.0055	0.0394	0.1137	0.1823	0.9999	0.9995	0.9995	0.9995	0.9946	0.7118	0.0904
W2.0L	2.42	0.0036	0.0048	0.0540	0.1534	0.2424	0.9999	0.9995	0.9995	0.9984	0.9521	0.4586	0.0181
Cherokee Canal													
CC2.0L	13.34	0.1205	0.1576	0.8200	0.9942	0.9998	0.9999	0.3986	0.1293	0.0474	0.0177	0.0077	0.0018
CC1.0L	11.4	0.1205	0.1576	0.8200	0.9942	0.9998	0.9999	0.3986	0.1293	0.0474	0.0177	0.0077	0.0018

3.10 California State Urban Levee Design Criteria

A local sponsor objective is to achieve the California State Urban Levee Design Criteria (ULDC). The ULDC criteria are described in the DWR report "Urban Levee Design Criteria, May 2012.   The purpose of the ULDC is to provide engineering criteria and guidance for civil engineers to follow in meeting the requirements of California's Government Code Sections 65865.5, 65962, and 66474.5 with respect to findings that levees and floodwalls in the Sacramento-San Joaquin Valley provide protection against a flood that has a 1-in-200 chance of occurring in any given year, and to offer this same guidance to civil engineers working on levees and floodwalls anywhere in California (DWR, 2012). Two options are offered for determining if a levee meets the urban and urbanizing area levee system design.

The freeboard approach requires 3 feet of freeboard above the mean 0.5% (1/200) ACE flood event. The risk and uncertainty approach allows for a lesser amount of freeboard if a high level of assurance can be demonstrated.   For assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria.

Both ULDC approaches require that water surface profiles do not account for overtopping in urban areas for the 0.5% (1/200) ACE event. An evaluation of the Sutter Basin study area indicated no overtopping occurs for the 0.5% (1/200) ACE event. Therefore, the hydraulic model results were applicable for the ULDC analysis. Both ULDC approaches require that additional freeboard be provided if the wind wave run-up from a 1.3% ACE wind event would exceed the top of levee. Both ULDC approaches also require minimum geotechnical standards.

Based on a review of the ULDC criteria, none of the levee reaches would meet the ULDC criteria without geotechnical remediation.

4.0 Alternative SB-7 (Sunset Weir to Laurel Ave)

4.1 General Design Features

a. Levees. This project would involve fixing the Feather River levees to meet current USACE design standards from Sunset Weir to Laurel Ave. The levee height would be based on the 1957 design profile or the existing profile, whichever is higher. In no cases would the levee be raised above these profiles.

b. Interior Drainage Facilities. The project would involve the replacement of gravity drainage culverts within the reach. All replacement culverts would remain the same capacity as the without project conditions.

c. Operation and Maintenance. The project will be maintained to meet current design standards. The project will rely on one gate type closure structure at the UPRR railroad bridge crossing (RM 29.8).

4.2 Hydrology.

The hydrology associated with Alternative SB-7 is identical to Alternative SB-1 (without project conditions).

4.3 Hydraulic Models

Hydraulic models associated with Alternative SB-7 are identical to Alternative SB-1 (without project conditions). The alternative does not include any features that change the hydraulic conditions or geometry.

4.4 Hydraulic Model Results.

Hydraulic model results associated with Alternative SB-7 are identical to Alternative SB-1 (without project conditions).

4.5 Hydraulic Design.

a. Levee Height. This project would involve fixing the Feather River levees to meet current USACE design standards from Thermalito Afterbay to Laurel Avenue. The levee height would be based on the 1957 design profile or the existing profile, whichever is higher. In no cases would the levee be raised above these profiles.

b. Closure Structures. A gate type closure structure is specified where the UPRR crosses the levee embankment at River Mile 29.8. This location is the lowest point along the levee and the performance of project depends on the closure structure operating correctly. If this structure is not operated correctly the levee could breach due to overtopping. This would result in rapid inundation of Yuba City. This is a highly populated area and a failure would have high life safety consequences. To further increase the robustness of the levee, this location would be made more resistant to overtopping.

c. 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 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. 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 will be covered with anchored High Performance Turf Reinforced Mat (HPTRM). This design will increase the erosion resistance of the levee and allow for more controlled failure of the levee due to overtopping.

d. Erosion Protection. Erosion protection was not specified within the design reach.

e. Interior Drainage Facilities. If replacement is required to meet USACE design standards, the existing drainage features will be replaced with the same hydraulic capacity.

4.6 Wind Wave Analysis

Wind wave runup and setup associated with Alternative SB-7 is identical to Alternative SB-1 (without project conditions).

4.7 Sedimentation and Channel Stability

Sedimentation and Channel Stability associated with Alternative SB-7 is identical to Alternative SB-1 (without project conditions).

4.8 Flood Risk.

Flood risk would be reduced by Alternative SB-7 by reduction of the geotechnical fragility within the project reach.

a. Levee Assurance. Levee assurance values within reaches modified by the project were recomputed assuming no failure until overtopping. Detailed with-project fragility curves were not used to conduct the with-project analysis. An economic sensitivity analysis was conducted to evaluate this simplified with-project fragility assumption and it was determined it would have insignificant impacts on the results. All other inputs to calculate assurance were identical to Alternative SB-1, the without project condition. The assurance values are provided in Table 32.

b. Composite Floodplains. Maps showing composite floodplains were developed to demonstrate FRM reliability for Alternative SB-7. The composite floodplains are provided in Plates 57 to 64. All maps include the natural (non-leveed) flood inundation depths. Table 32 provides the assurance values used to determine if a simulated breach was included in the composite floodplain map.

d. Flood Velocities. Flood velocities for a levee beach would be identical as alternative SB-1.

Table 32
Assurance at Simulated Levee Breach Locations, Alternative SB-7

Simulated Breach		Annual Exceedance Probability		Long Term Risk			Flood Risk Management Assurance by Event Flood Frequency (Breach included in floodplain map if shaded)						
Label	River Mile	Median	Exp.	10 Years	30 Years	50 Years	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Feather River													
F9.0R	57.17	0.0696	0.0769	0.5506	0.9092	0.9817	0.9909	0.8187	0.6499	0.6087	0.5777	0.4781	0.331
F8.0R	50.20	0.0686	0.0768	0.5504	0.9091	0.9816	0.9909	0.8187	0.6499	0.6087	0.5777	0.4781	0.331
F7.0R	41.55	0.0203	0.0238	0.2138	0.5140	0.6996	0.9999	0.9299	0.7965	0.7586	0.7209	0.5657	0.298
F6.0R	34.07	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5547
F5.0R	28.25	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5548
F4.5R	26.00	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.4R	25.99	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.1R	17.00	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F4.0R	16.99	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F3.0R	10.50	0.0167	0.0192	0.1766	0.4418	0.6216	0.9999	0.9443	0.9171	0.889	0.8447	0.6847	0.4057
Sutter Bypass													
S5.0L	88.04	0.2184	0.2331	0.9297	0.9997	0.9999	0.8232	0.5684	0.4267	0.3803	0.2991	0.1896	0.0827
S4.0L	82.45	0.4468	0.5156	0.9993	0.9999	0.9999	0.5362	0.3336	0.3257	0.2956	0.2223	0.1391	0.0631
S3.0L	77.05	0.1945	0.2104	0.9058	0.9992	0.9999	0.8101	0.6612	0.635	0.6009	0.5021	0.3426	0.1654
Wadsworth Canal													
W3.0R	4.54	0.0065	0.0086	0.0826	0.2279	0.3501	0.9999	0.9995	0.9951	0.9338	0.705	0.3791	0.0786
W2.0R	2.42	0.3590	0.3577	0.9880	0.9999	0.9999	0.6394	0.3611	0.239	0.2263	0.1884	0.0874	0.0074
W2.0L	2.42	0.1137	0.1157	0.7075	0.9750	0.9979	0.9583	0.7575	0.5626	0.4783	0.3363	0.1392	0.0056
Cherokee Canal													
CC2.0L	13.34	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015
CC1.0L	11.4	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015

Notes: Assurance based on existing top of levee or 1957 design top of levee, whichever is higher within the reach. Assurance accounts for stage uncertainty, hydrologic uncertainty, and geotechnical uncertainty.
Index points within the Alternative SB-7 project reach shown in Bold Italics

d. Evacuation Routes. Evacuation routes for alternative SB-7 are shown on the composite floodplain maps. Relative to Alternative SB-1, the project increases the reliability of the evacuation route to Marysville.

e. Flood Warning Time. A description of flood warning time is provided in Alternative SB-1. Alternative SB-7 will result in a significant increase in warning time to the population within Yuba City because the probability of flooding from a geotechnical type failure (1-hour warning time) would be reduced and the warning time for overtopping type failures are significantly longer (24 to 36 hours).

f. Loss of Life Potential. To evaluate the potential for loss of life, the population density within the study area was compared to the composite floodplain maps of alternative SB-7. The distribution of population within the study area was based on 2010 census blocks. A map of the estimated population density throughout the study area is provided in Plate 4. The population within areas greater than 0 feet, 2 feet, and 15 feet are provided in Tables 33, 34, and 35 respectively.

Table 33.
Population within Alternative SB-7 Floodplain
Depths Greater Than 0 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	251
Yuba City Urban	0	43	6194	12519	14429	67368	67368
Biggs Urban	0	19	1452	1452	1452	1452	1763
Gridley Urban	0	0	6379	6379	6379	6379	6379
Live Oak Urban	0	0	8362	8362	8362	8362	8362
Sutter County Rural	1089	1718	4788	5742	5867	6354	6378
Butte County Rural	0	9	4776	4788	4788	4793	4899
Total	1089	1789	31951	39242	41276	94707	95400

Table 34.
Population within Alternative SB-7 Floodplain
Depths Greater Than 2 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	16	699	976	66380	67368
Biggs Urban	0	0	1352	1352	1352	1353	1554
Gridley Urban	0	0	1176	1176	1176	1186	5483
Live Oak Urban	0	0	4156	5882	5882	6498	8362
Sutter County Rural	767	1478	2073	2930	3267	5505	6199
Butte County Rural	0	0	2424	2527	2527	2887	3882
Total	767	1478	11196	14567	15180	83809	92847

Table 35.
Population within Alternative SB-7 Floodplain
Depths Greater Than 15 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	0	0	0	303	934
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
Sutter County Rural	0	0	4	231	303	1059	1183
Butte County Rural	0	0	0	0	0	0	0
Total	0	0	4	231	303	1362	2117

4.9 Potential Adverse Effects.

a. Induced Flooding. The hydraulic features associated with Alternative SB-7 are identical to Alternative SB-1. Therefore, there is no induced flooding associated with Alternative SB-7.

b. Transfer of Flood Risk. The hydraulic features associated with Alternative SB-7 are identical to Alternative SB-1. Therefore, there is no induced flooding associated with Alternative SB-7.

4.10 California State Urban Levee Design Criteria

Based on a review of the ULDC criteria, none of the levee reaches only the reaches associated with breaches F4.0R, F4.1R, F4.4R, F4.5R, F5.0R would meet the DWR ULDC criteria. As a result only the Yuba City Urban area would meet the ULDC requirements.

5.0 Alternative SB-8 (Thermalito to Laurel Avenue)

5.1 General Design Features

a. Levees. This project would involve fixing the Feather River levees to meet current USACE design standards from Thermalito Afterbay to Laurel Avenue. The levee height would be based on the 1957 design profile or the existing profile, whichever is higher. In no cases would the levee be raised above these profiles. Within three reaches, the levee will be shifted 20 feet towards the river. This was required to provide an access road on the landward side of the levee toe. Additional details are discussed in the hydraulic design section below.

b. Interior Drainage Facilities. The project would involve the replacement of gravity drainage culverts within the reach. Five of the gravity drainage culverts will be removed because they are no longer used for drainage and one culvert will be downsized. Additional details are discussed in the hydraulic design section below.

c. Operation and Maintenance. The project will be maintained to meet current design standards. The project will rely on one flood gate closure structure at the UPRR railroad bridge crossing.

5.2 Hydrology.

The hydrology associated with Alternative SB-8 is identical to Alternative SB-1 (without project conditions).

5.3 Hydraulic Models

Hydraulic models were revised to incorporate the 20 foot riverward shift in the levee along three reaches. The shift in the levee alignment was necessary to provide an access road adjacent to an existing canal located along the landward toe. The upstream reach is 2.3 miles long and extends from RM 45.5 (FRWL station 1675+00) to RM 47.55 (FRWL station 1753+00). The middle reach is 0.25 miles long and extends from RM 44.6 (FRWL Station 1610+00) to RM 44.8 (FRWL Station 1623+00). The lower reach is 0.28 miles long and extends from RM 38.8 (FRWL Station 1434+00) to RM 39.1 (FRWL Station 1449+00). All other model features are the same as the SB-1 alternative.

5.4 Hydraulic Model Results.

The hydraulic model created for Alternative SB-8 computed the same water surface profiles as Alternative SB-1. Within the three reaches where the levee will be shifted 20 feet riverward, the channel cross section width is over 5000 feet and this was found to have no measureable impact on the water surface throughout the model domain. Therefore, the hydraulic model results provided for Alternative SB-1 are applicable to SB-8.

5.5 Hydraulic Design.

a. Levee Height. This project would involve fixing the Feather River levees to meet current USACE design standards from Thermalito Afterbay to Laurel Avenue. The levee height would be based on the 1957 design profile or the existing profile, whichever is higher. In no cases would the levee be raised above these profiles.

b. Closure Structures. A gate type closure structure is specified where the UPRR crosses the levee embankment at River Mile 29.8. This location is the lowest point along the levee and the performance of project depends on the closure structure operating correctly. If this structure is not operated correctly the levee could breach due to overtopping. This would result in rapid inundation of Yuba City. This is a highly populated area and a failure would have high life safety consequences. To further increase the robustness of the levee, this location would be made more resistant to overtopping.

c. 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 alternative SB-8 is based on an existing levee profile, the design top of levee was reviewed relative to the modeled mean water surface profiles to determine likely initial overtopping locations. 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% (1/200) 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% (1/200) ACE events. This is identical to the reach identified for the SB7 alternative.

Within both 1-mile reaches, the landward side of the levee will be covered with anchored High Performance Turf Reinforced Mat (HPTRM). This design will increase the erosion resistance of the levee and allow for more controlled failure of the levee due to overtopping.

d. Erosion Protection. Erosion protection was not specified within the design reach.

e. Interior Drainage Facilities. All drainage features would be replaced with the same capacity except at six locations described in Table 36. Five of the facilities appear to provide no interior drainage function and one location appears to be oversized. Each of the six sites was visited by SBFCA's engineering consultant, PBI, and adjacent land owners were reviewed. The results of the analysis are described in a technical memorandum to the Sutter Butte Flood Control Agency titled, Culvert Removal Analysis for the Feather River West Levee Improvement Project, 17 August, 2012.

Table 36
Proposed Culvert Modifications, Alternative SB-8

River Mile	FRWLP Station	Culvert Size	Notes
44.90	1639+00	2-24"	Remove Culvert, Culvert inlet was filled with soil with no obvious signs of a drainage path leading to the culvert
48.00	1785+24	1-24"	Remove Culvert, Culvert did not appear to be used with no signs of a drainage path leading to the culvert
51.20	1961+03	2-60"	Reduce Culvert Size, Culvert appeared to be oversized. Recommend reducing size to 1-36"
57.05	2239+66	1-24"	Remove Culvert, No culvert inlet was found.
57.10	2245+52	1-24"	Remove Culvert, Culvert inlet was filled with soil with no obvious signs of a drainage path leading to the culvert
57.15	2256+94	1-24"	Remove Culvert, Culvert inlet was nearly buried. Culvert is located near another culvert. Nearby culvert should provide adequate capacity.

5.6 Wind Wave Analysis.

Wind wave runup and setup associated with Alternative SB-8 is identical to Alternative SB-1 (without project conditions).

5.7 Sedimentation and Channel Stability

Sedimentation and Channel Stability associated with Alternative SB-8 is identical to Alternative SB-1 (without project conditions).

5.8 Flood Risk.

Flood risk would be reduced by Alternative SB-8 by reduction of the geotechnical fragility within the reach.

a. Levee Assurance. Levee assurance values within reaches modified by the project were recomputed assuming no failure until overtopping. Detailed with-project fragility curves were not used to conduct the with-project analysis. An economic sensitivity analysis was conducted to evaluate this simplified with-project fragility assumption and it was determined it would have insignificant impacts on the results. All other inputs to calculate assurance were identical to Alternative SB-1, the without project condition.

b. Composite Floodplains. Maps showing composite floodplains were developed to demonstrate FRM reliability for Alternative SB-8. The composite floodplains are provided in Plates 65 through 71. All maps include the natural (non-leveed) flood inundation depths. Table 37 provides the assurance values used to determine if a simulated breach was included in the floodplain map.

Table 37
Project Performance at Simulated Levee Breach Locations, Alternative SB-8

Simulated Breach		Annual Exceedance Probability		Long Term Risk			Flood Risk Management Assurance by Event Flood Frequency (Breach included in floodplain map if shaded)						
Label	River Mile	Median	Exp.	10 Years	30 Years	50 Years	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Feather River													
F9.0R	57.17	0.0020	0.0023	0.0233	0.0683	0.1112	0.9999	0.9999	0.9949	0.9915	0.9726	0.8551	0.6390
F8.0R	50.20	0.0001	0.0023	0.0225	0.0659	0.1075	0.9999	0.9999	0.9949	0.9915	0.9726	0.8551	0.6390
F7.0R	41.55	0.0022	0.0022	0.0220	0.0646	0.1054	0.9999	0.9999	0.9999	0.9999	0.9895	0.8576	0.5427
F6.0R	34.07	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5547
F5.0R	28.25	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5548
F4.5R	26.00	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.4R	25.99	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.1R	17.00	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F4.0R	16.99	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F3.0R	10.50	0.0167	0.0192	0.1766	0.4418	0.6216	0.9999	0.9443	0.9171	0.8890	0.8447	0.6847	0.4057
Sutter Bypass													
S5.0L	88.04	0.2184	0.2331	0.9297	0.9997	0.9999	0.8232	0.5684	0.4267	0.3803	0.2991	0.1896	0.0827
S4.0L	82.45	0.4468	0.5156	0.9993	0.9999	0.9999	0.5362	0.3336	0.3257	0.2956	0.2223	0.1391	0.0631
S3.0L	77.05	0.1945	0.2104	0.9058	0.9992	0.9999	0.8101	0.6612	0.635	0.6009	0.5021	0.3426	0.1654
Wadsworth Canal													
W3.0R	4.54	0.0065	0.0086	0.0826	0.2279	0.3501	0.9999	0.9995	0.9951	0.9338	0.705	0.3791	0.0786
W2.0R	2.42	0.3590	0.3577	0.9880	0.9999	0.9999	0.6394	0.3611	0.239	0.2263	0.1884	0.0874	0.0074
W2.0L	2.42	0.1137	0.1157	0.7075	0.9750	0.9979	0.9583	0.7575	0.5626	0.4783	0.3363	0.1392	0.0056
Cherokee Canal													
CC2.0L	13.34	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015
CC1.0L	11.4	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015

Notes: Assurance based on existing top of levee or 1957 design top of levee, whichever is higher within the reach. Assurance accounts for stage uncertainty, hydrologic uncertainty, and geotechnical uncertainty.
Index points within the Alternative SB-8 project reach shown in Bold Italics

c. Flood Velocities. Flood velocities for a levee beach would be identical as alternative SB-1.

d. Evacuation Routes. Evacuation routes for alternative SB-8 are shown on the composite floodplain maps. Relative to Alternative SB-1, the project increases the reliability of the evacuation routes for Marysville, Biggs, Gridley, and Live Oak.

e. Flood Warning Time. A description of flood warning time is provided in Alternative SB-1. Alternative SB-8 will result in a significant increase in warning time to the population within Yuba City, Biggs, Gridley and Live Oak because the probability of flooding from a geotechnical type failure (1-hour warning time) would be reduced and the warning time for overtopping type failures are significantly longer (24 to 36 hours).

f. Loss of Life Potential. To evaluate the potential for loss of life, the population density within the study area was compared to the composite floodplain maps of alternative SB-8. The distribution of population within the study area was based on 2010 census blocks. A map of the estimated population density throughout the study area is provided in Plate 4. The population within areas greater than 0 feet, 2 feet, and 15 feet are provided in Tables 39, 40, and 41 respectively.

Table 38.
Population within Alternative SB8 Floodplain
Depths Greater Than 0 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	251
Yuba City Urban	0	43	255	4923	6480	67368	67368
Biggs Urban	0	19	19	19	19	1452	1763
Gridley Urban	0	0	0	0	0	6379	6379
Live Oak Urban	0	0	0	0	0	8362	8362
Sutter County Rural	1089	1718	2110	3036	3269	6354	6378
Butte County Rural	0	9	9	9	18	4793	4899
Total	1089	1789	2393	7987	9786	94707	95400

Table 39.
Population within Alternative SB8 Floodplain
Depths Greater Than 2 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	16	417	665	66380	67368
Biggs Urban	0	0	0	0	0	1353	1554
Gridley Urban	0	0	0	0	0	1186	5483
Live Oak Urban	0	0	0	0	0	6498	8362
Sutter County Rural	767	1478	1700	2368	2704	5505	6199
Butte County Rural	0	0	0	0	0	2887	3882
Total	767	1478	1716	2785	3369	83809	92847

Table 40.
Population within Alternative SB8 Floodplain
Depths Greater Than 15 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	0	0	0	303	934
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
Sutter County Rural	0	0	4	231	303	1059	1183
Butte County Rural	0	0	0	0	0	0	0
Total	0	0	4	231	303	1362	2117

5.9 Potential Adverse Effects.

a. Induced Flooding. The hydraulic features associated with Alternative SB-8 are nearly identical to Alternative SB-1. The hydraulic model created for Alternative SB-8 computed the same water surface profiles as Alternative SB-1. Therefore, there is no induced flooding.

b. Transfer of Flood Risk. Analysis of the alternative found no transfer of flood risk. The hydraulic model created for Alternative SB-8 computed the same water surface profiles as Alternative SB-1. Within the three reaches where the levee will be shifted 20 feet riverward, the channel cross section width is over 5000 feet and this was found to have no measureable impact on the water surface throughout the model domain.

5.10 California State Urban Levee Design Criteria

Based on a review of the ULDC criteria, none of the levee reaches only the reaches associated with breaches F4.0R, F4.1R, F4.4R, F4.5R, F5.0R, F6.0R, F7.0R, F8.0R, and F9.0R would meet the DWR ULDC criteria. As a result the area north of Yuba City Urban area would meet the ULDC requirements but the southern portion of the basin below yuba city would not meet the ULDC criteria.

6.0 SUMMARY

This report describes hydraulic, sedimentation, and operations and maintenance analyses performed for the final alternatives of the Sutter Basin Feasibility Study. Analyses were performed for without-project and two project alternative conditions. The report provides an update of the previous analysis of the without-project conditions.

The study is focused on Sutter Basin Feasibility Study area. Composite floodplain delineations are provided 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) ACE events for the existing and alternative conditions.

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ATTACHEMENT A

Memorandum for File:

Sutter Basin Pilot Feasibility Study,

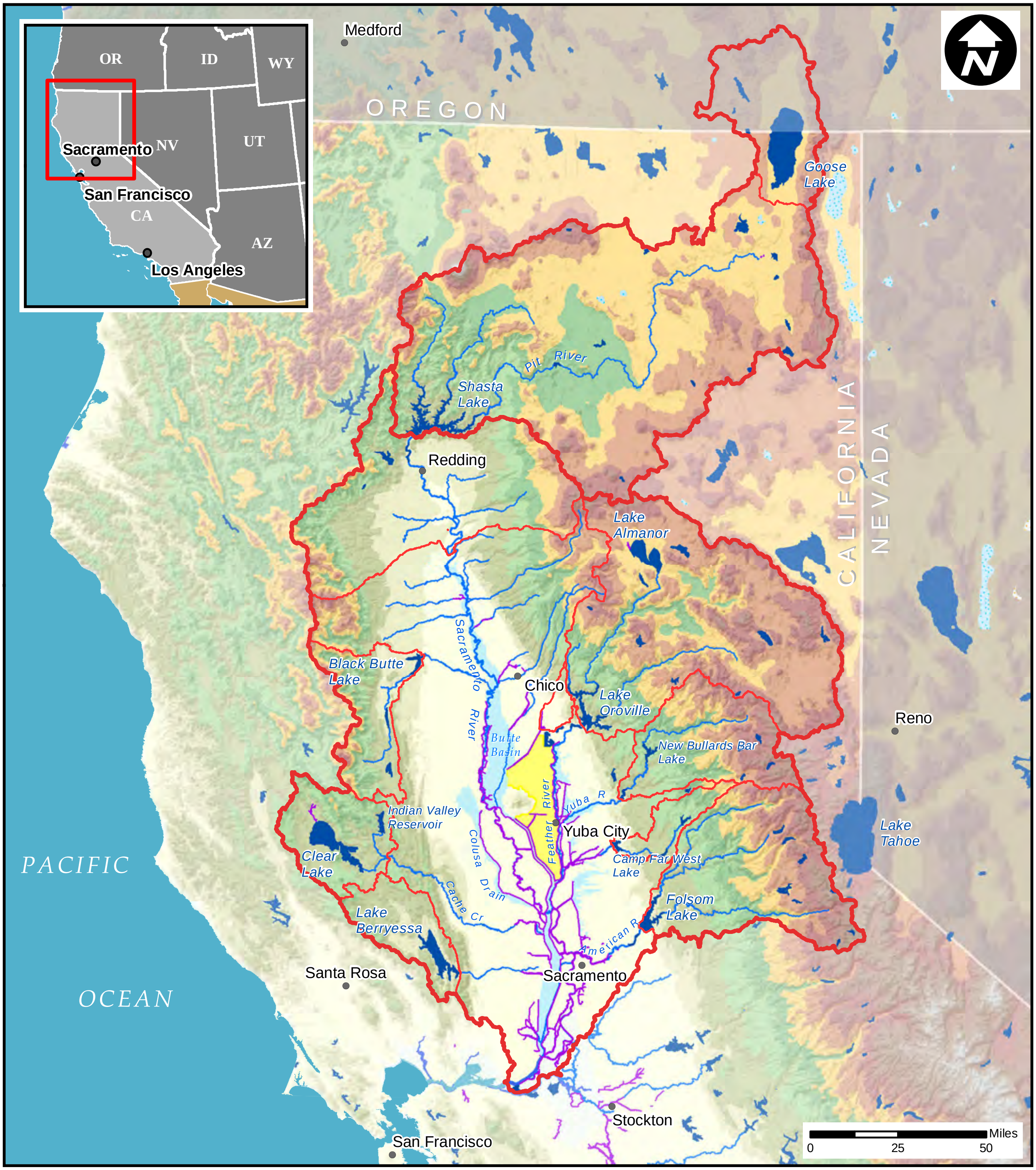
Hydraulic Analysis of Refined Alternatives

8 June 2012

ATTACHMENT B

Final Geotechnical Fragility Curves

February 2013.



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

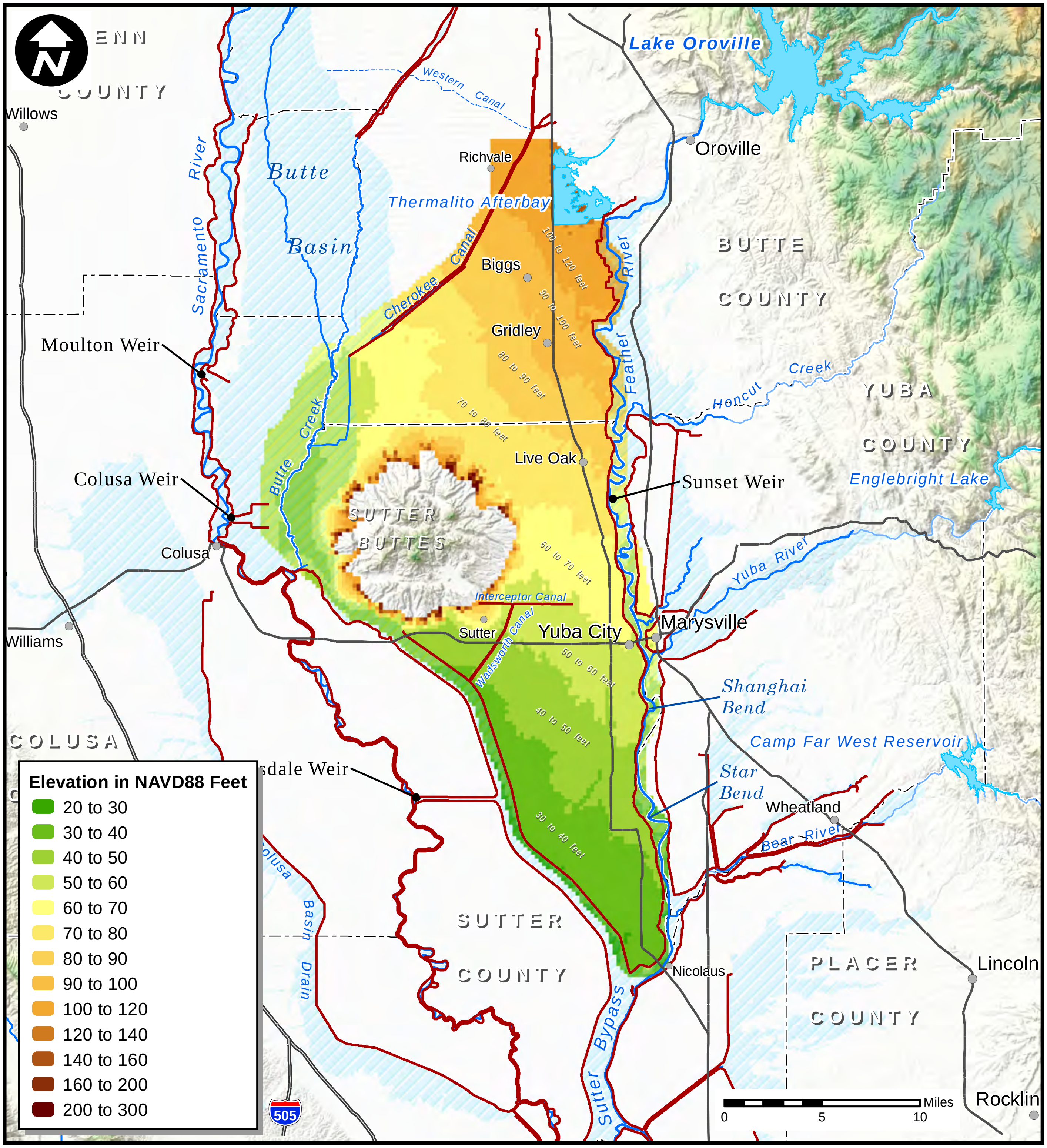
SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 1



Legend

Designated Floodways	Federal Levee
Lake or Reservoir	County Boundary
River or Stream	City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

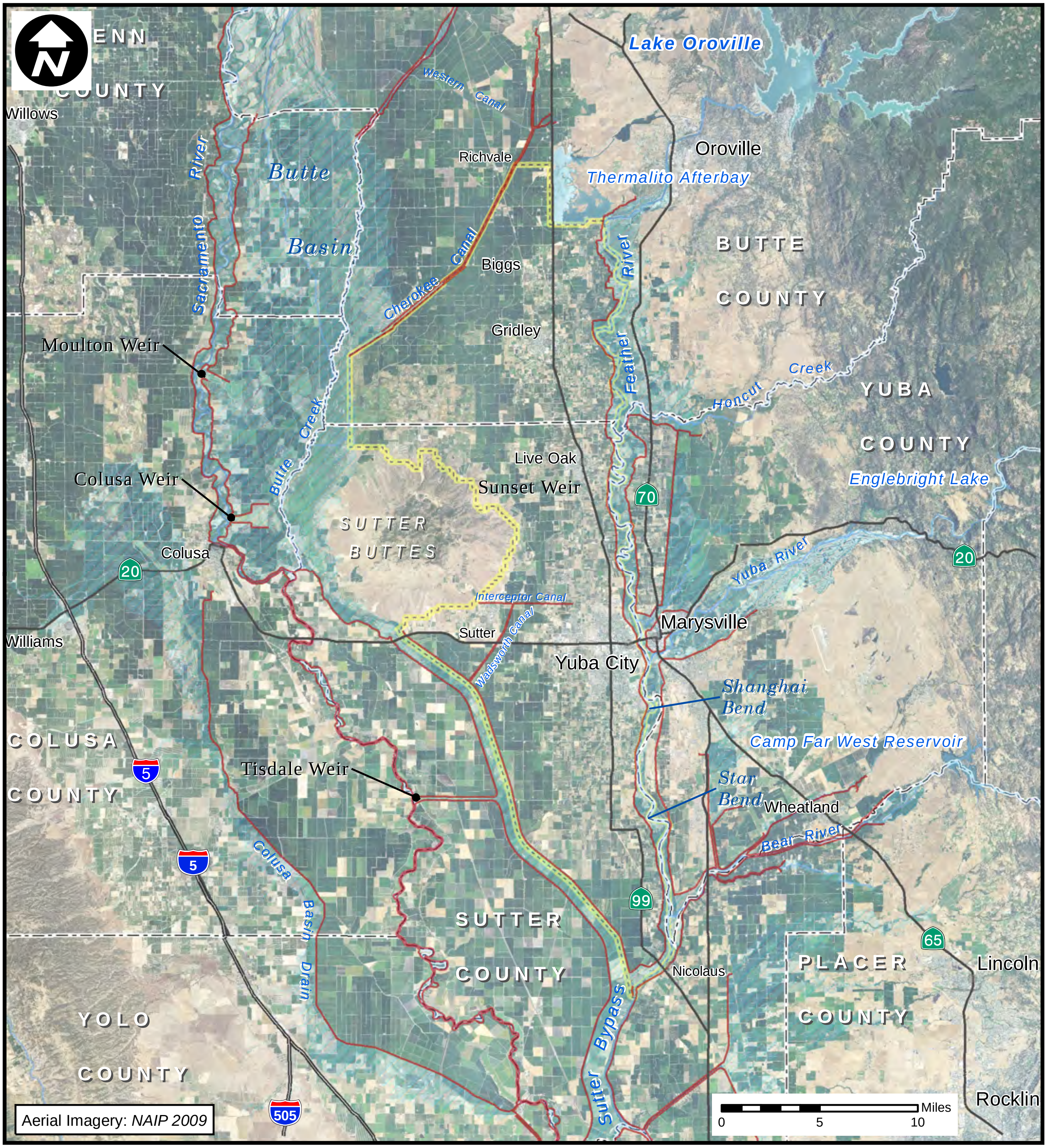
STUDY AREA TOPOGRAPHY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 2



Legend

- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City or Town

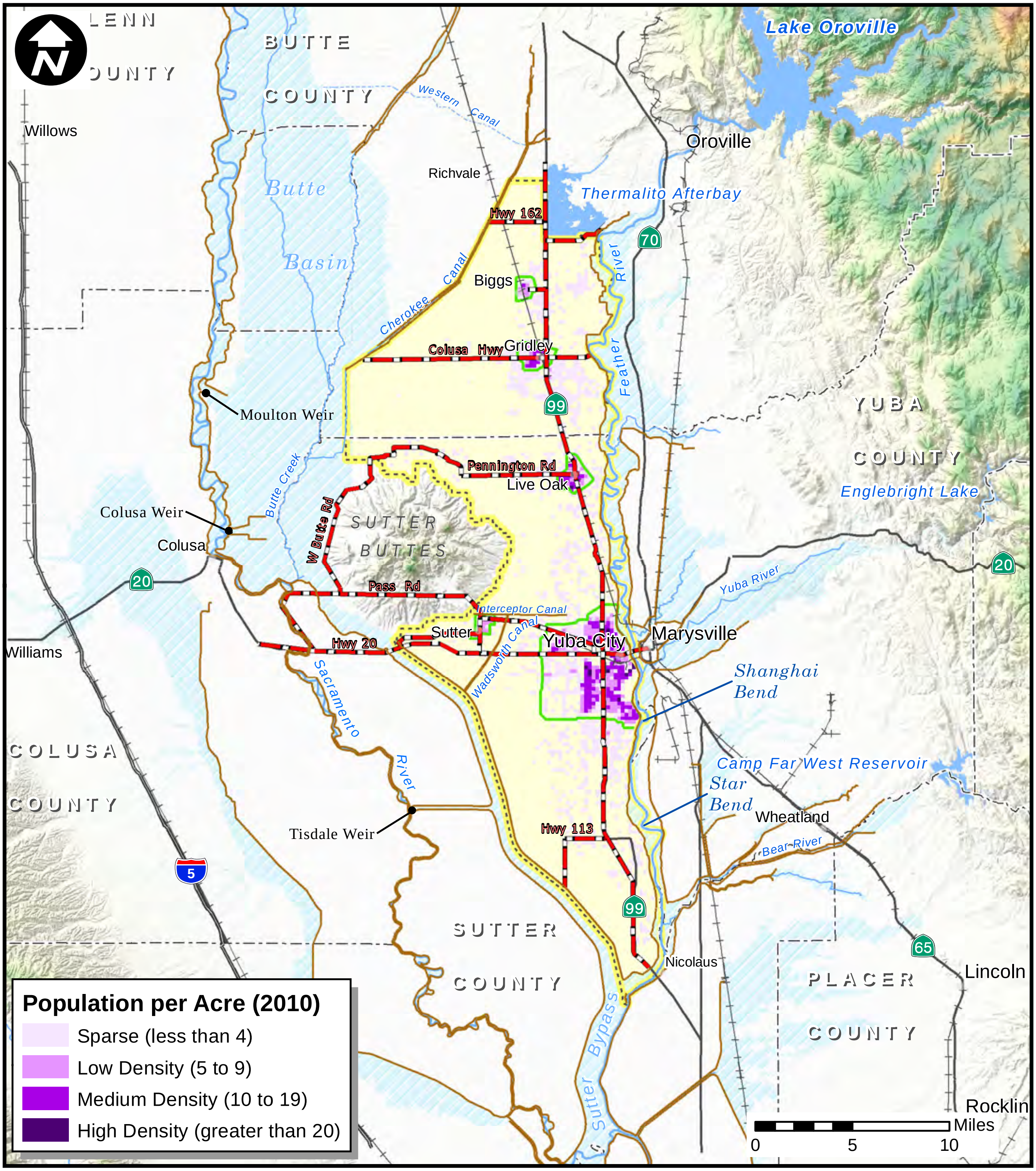
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

STUDY AREA AERIAL IMAGERY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Evacuation Routes
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

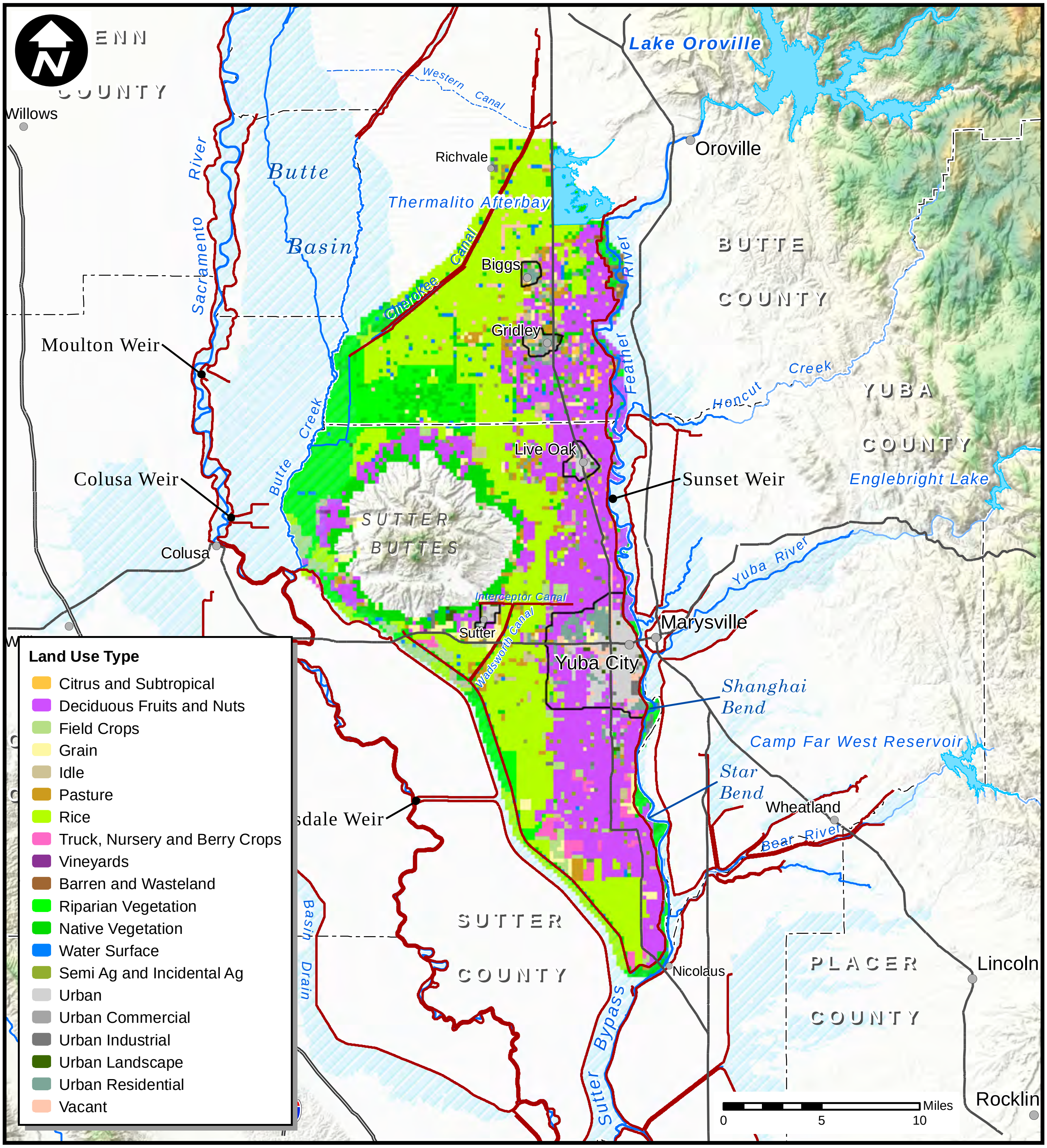
POPULATION DENSITY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 4



Legend

- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

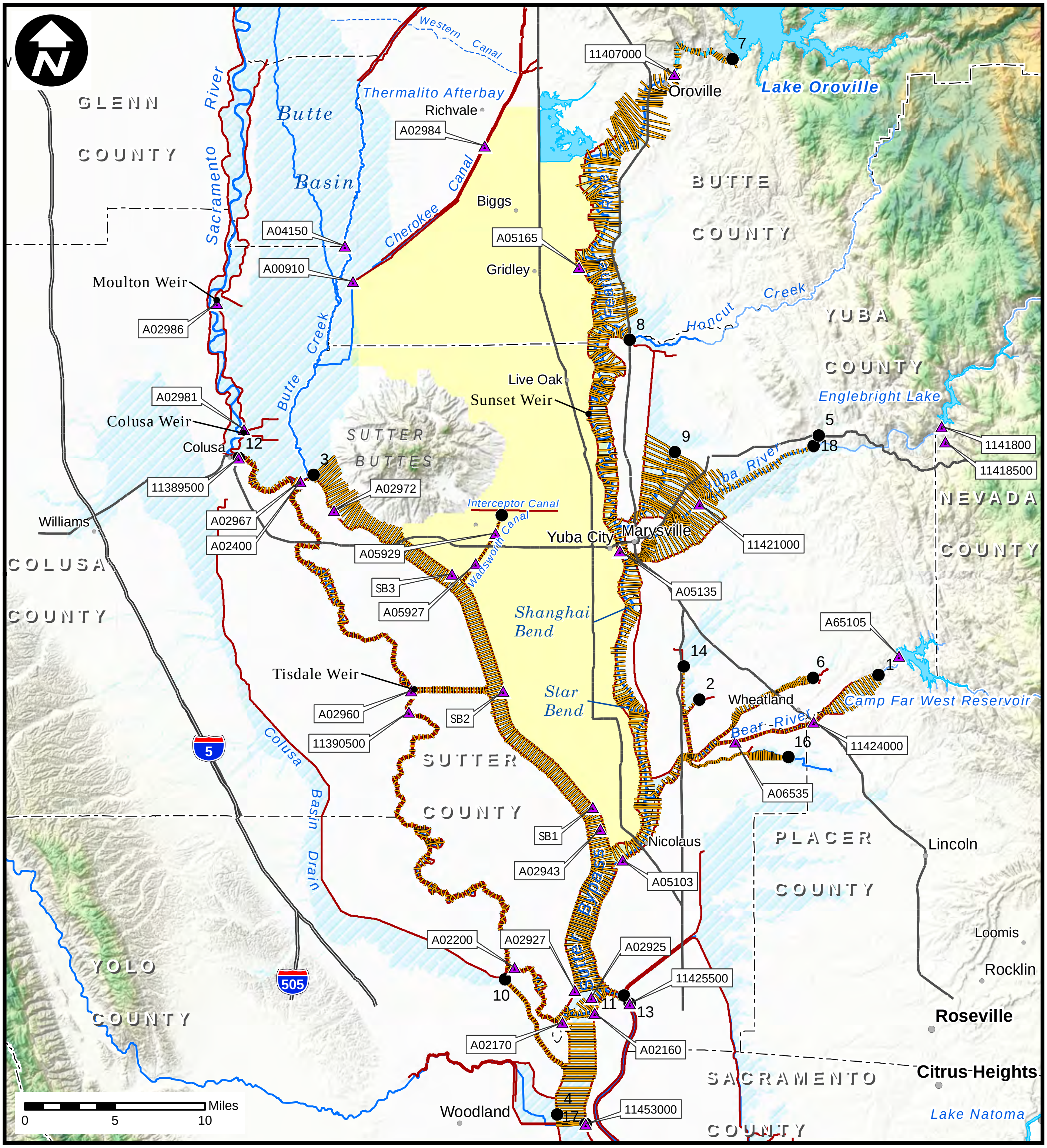
LAND USE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 5



Legend

- Stream Gage
- Model Boundaries
- Model Cross Sectios
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: See Table 1 and 2 for Model Boundary Name

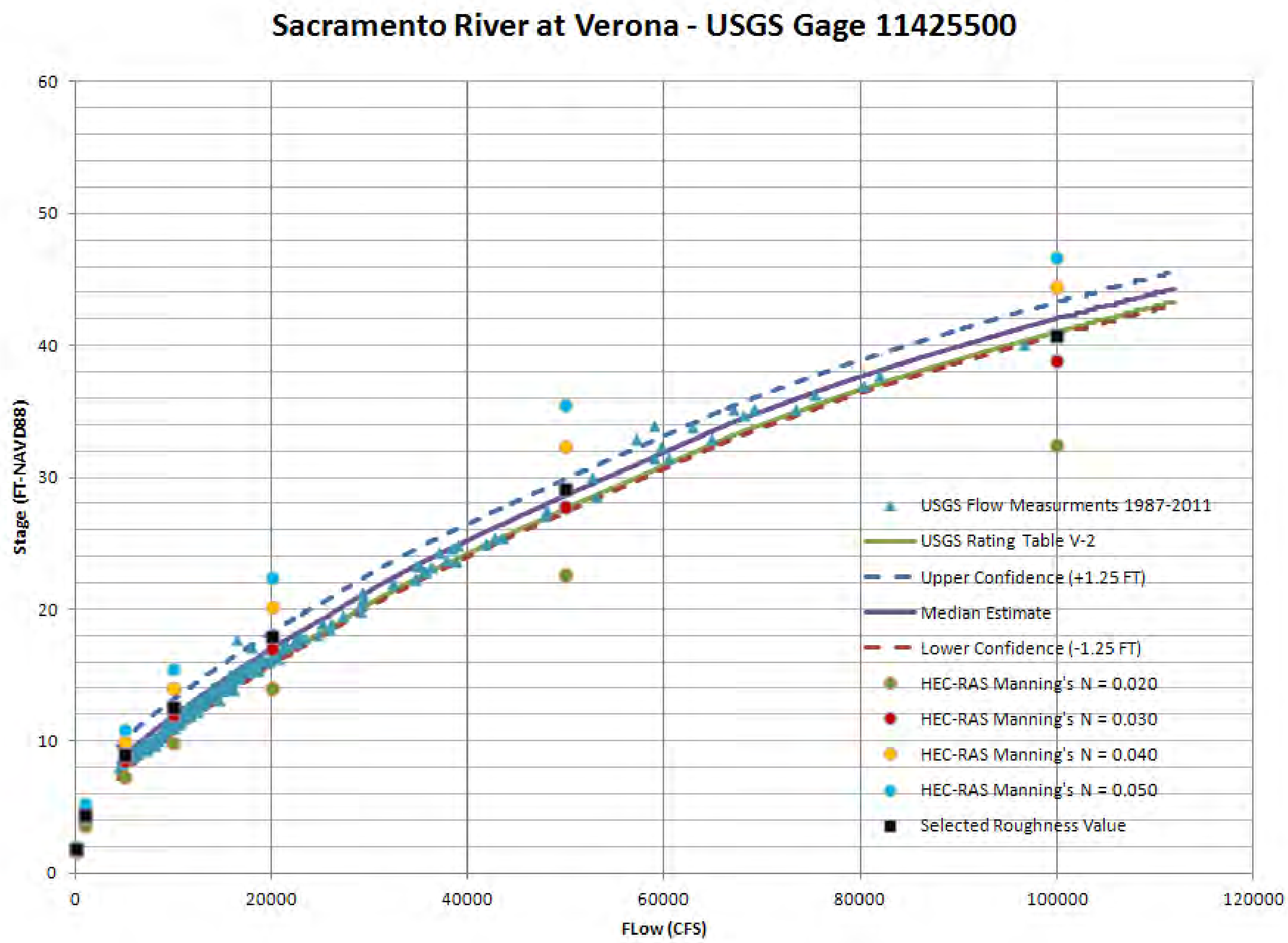
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

HEC-RAS HYDRAULIC MODEL BOUNDARY CONDITIONS AND STREAM GAGES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

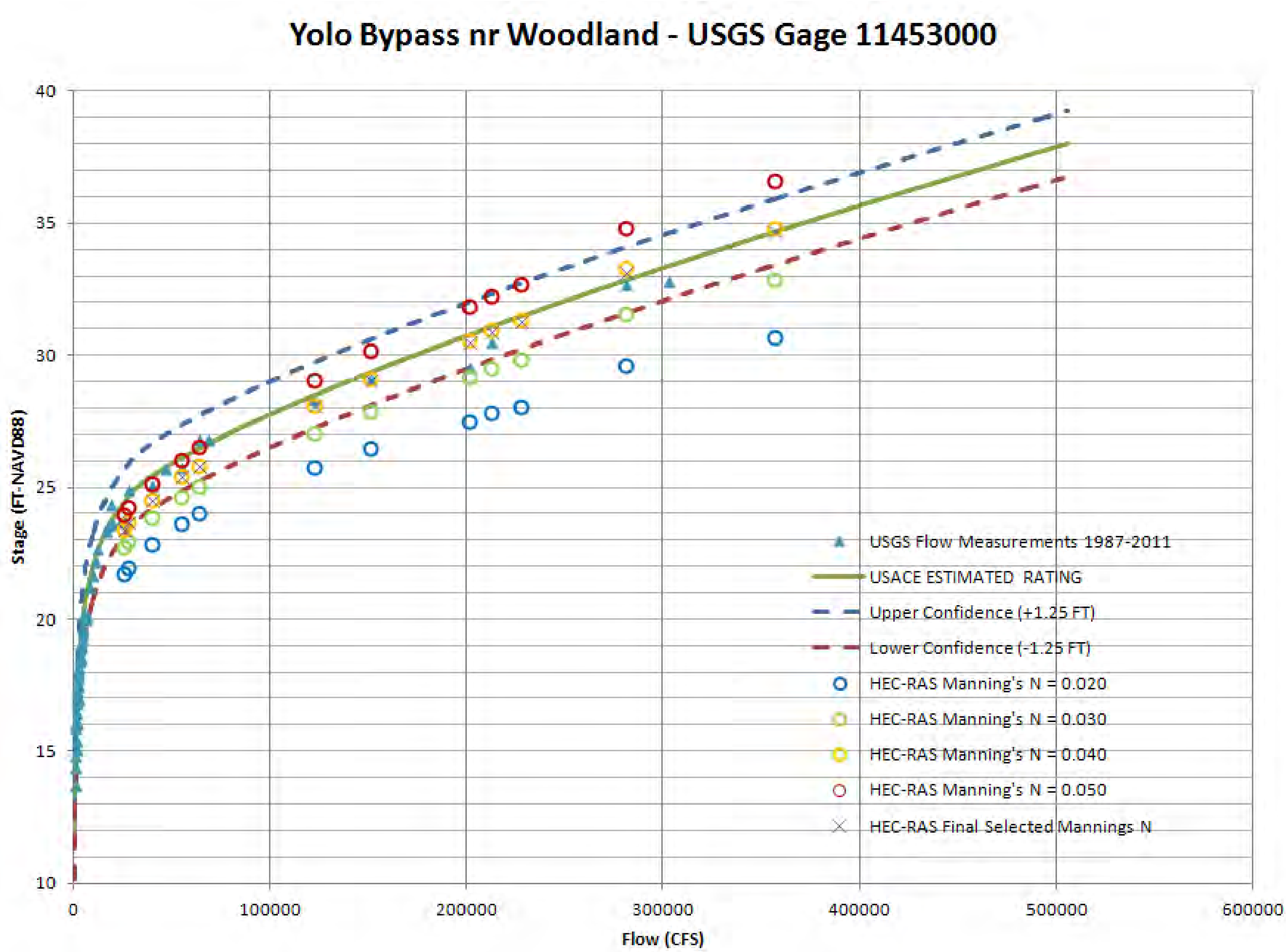


Source:

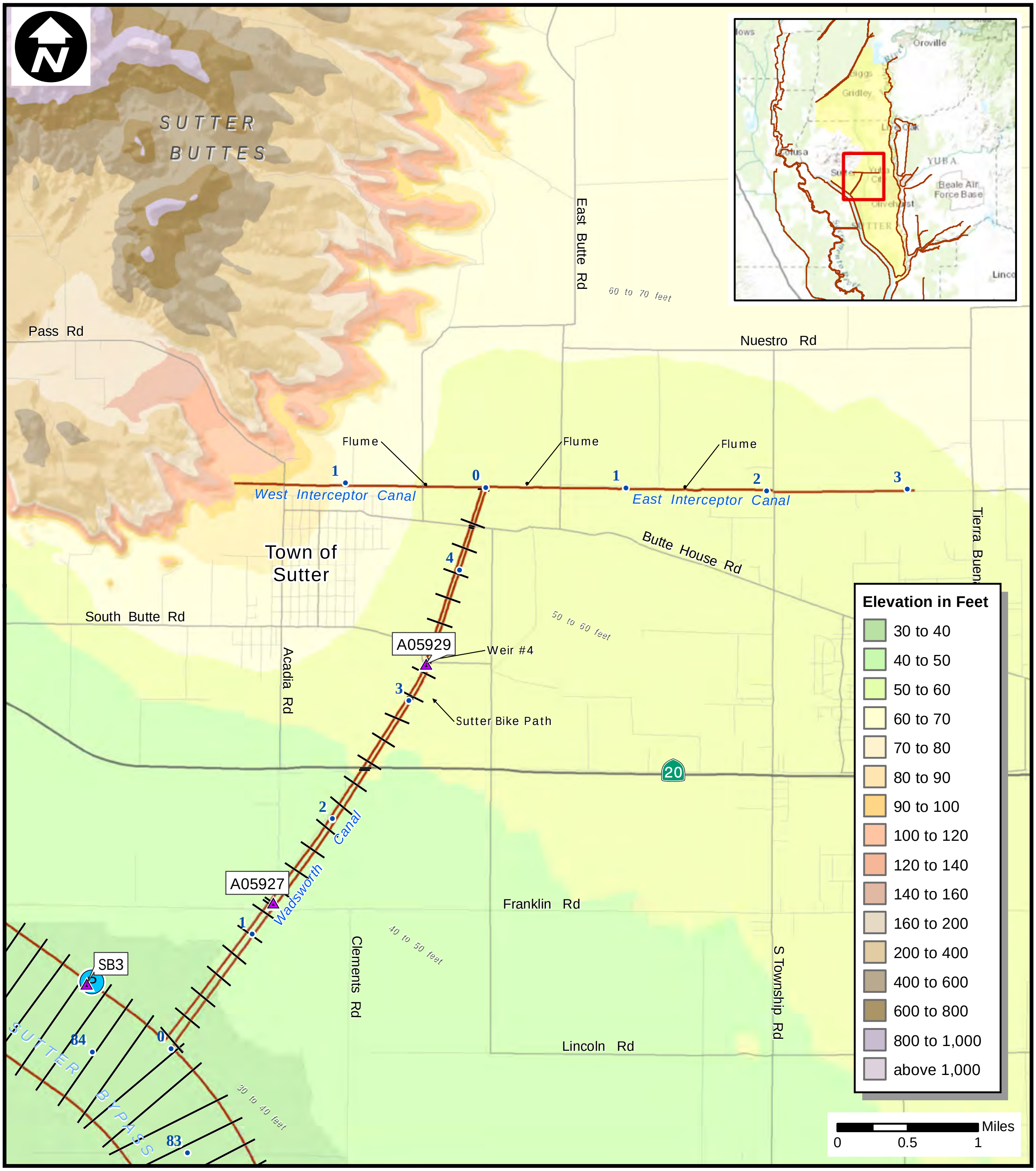
SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE-DISCHARGE CURVE
SACRAMENTO RIVER AT VERONA
WITHOUT PROJECT CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



SUTTER BASIN PILOT FEASBILITY STUDY **SUTTER BASIN, CALIFORNIA**
STAGE-DISCHARGE CURVE **YOLO BYPASS AT WOODLAND** **WITHOUT PROJECT CONDTIONS**
U.S ARMY CORPS OF ENGINEERS **SACRAMENTO DISTRICT**



Legend

- Model Cross Sectios
- Federal Levee
- Pump Station
- Comp Study River Mile

Note: Topography data is from the USGS DEM and is in NAVD88

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

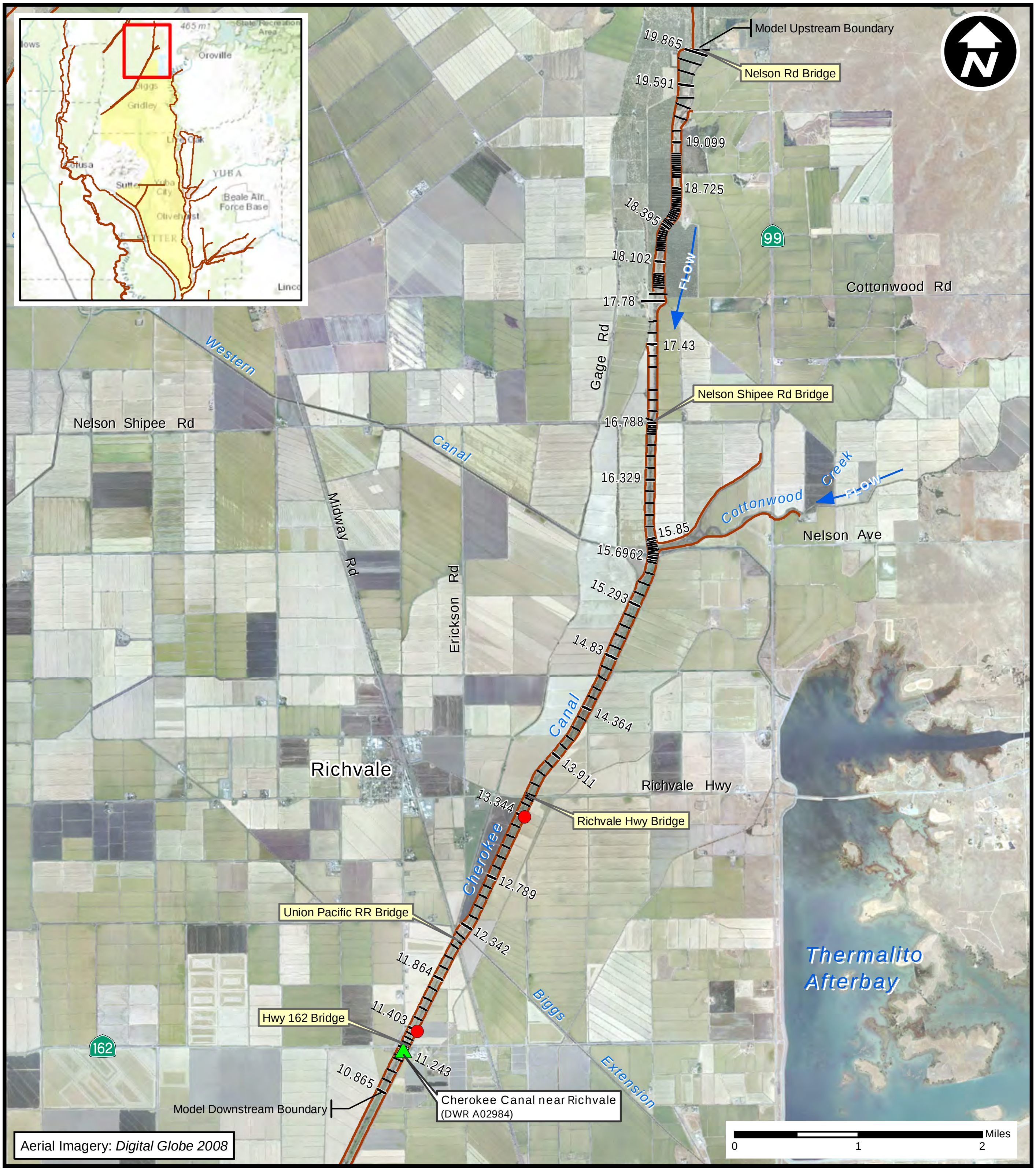
WADSWORTH AND INTERCEPTOR CANALS TOPOGRAPHY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 9



Legend

- ▲ Stream Gage
- ● Breach Simulation Point
- Model Cross Sections
- Federal Levee

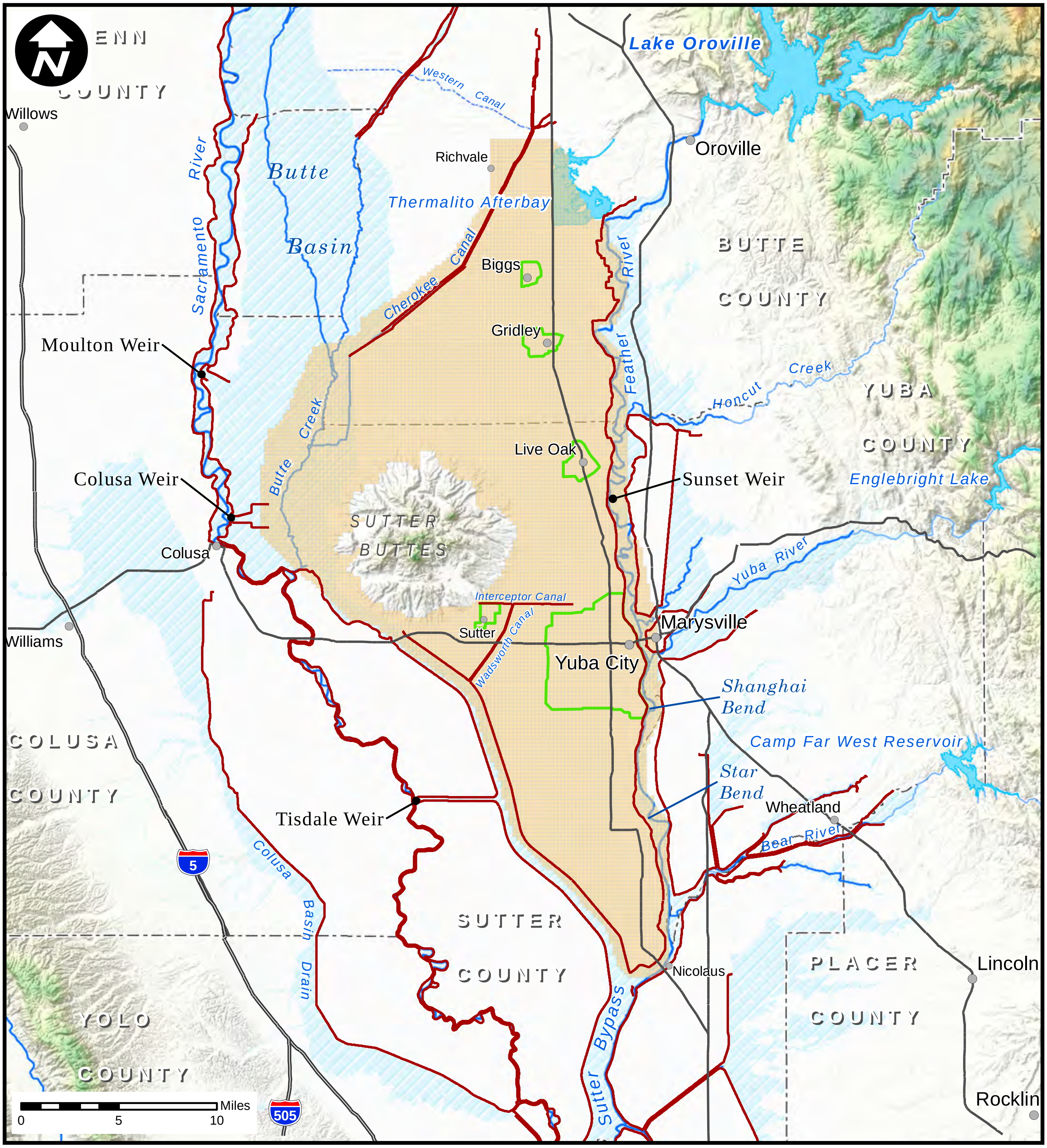
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL HYDRAULIC MODEL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAR 2013



Legend

- FLO2D Grid - 1000 ft
- Designated Floodways
- Lake or Reservoir
- Economic Evaluation Area
- River or Stream
- Federal Levee
- County Boundary
- City or Town

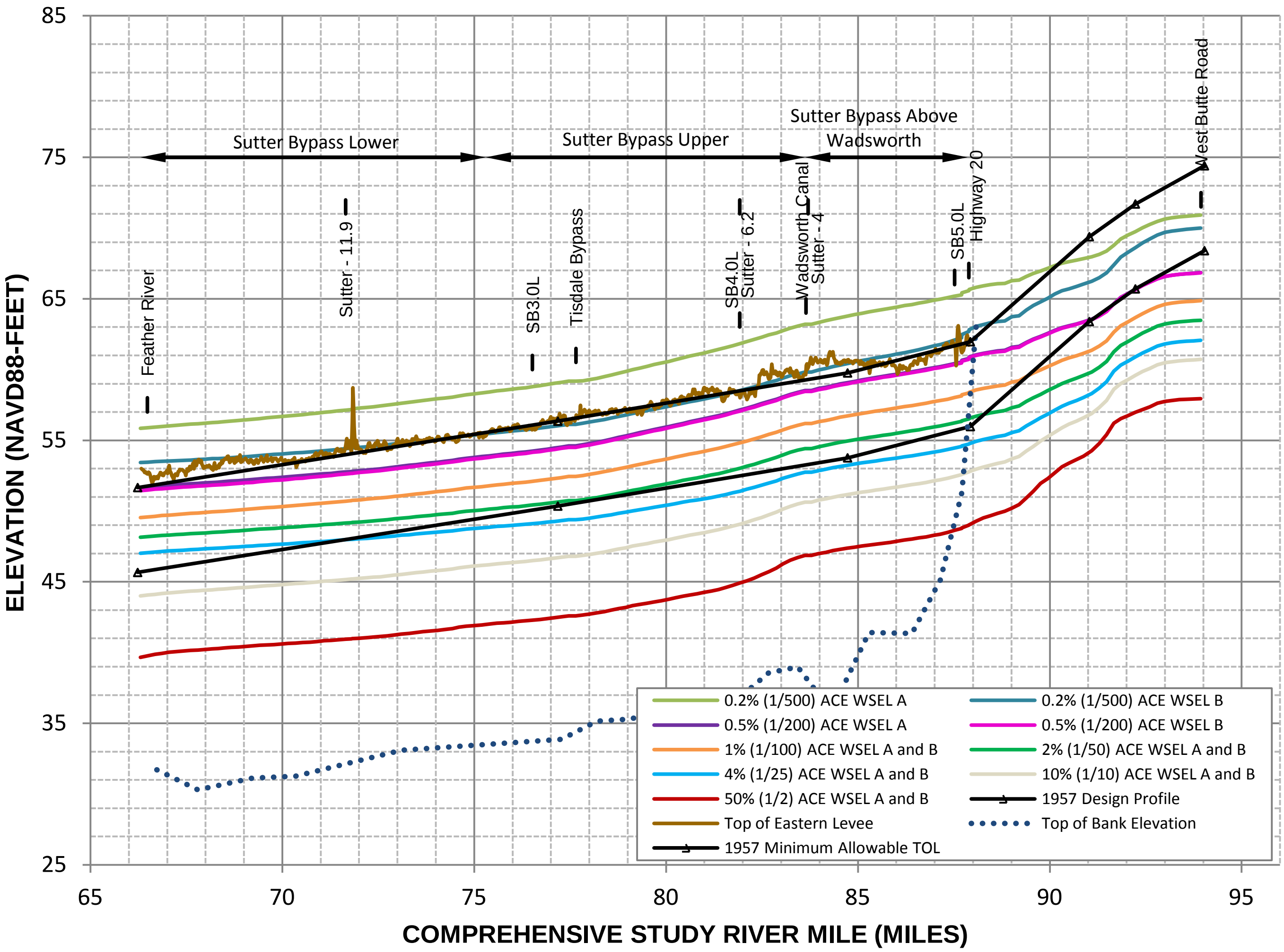
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

FLO2D MODEL GRID

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



Note:

Water Surface Profile A assumes infinite levee height, no overtopping

Water Surface Profile B assumes overtopping only, no failure

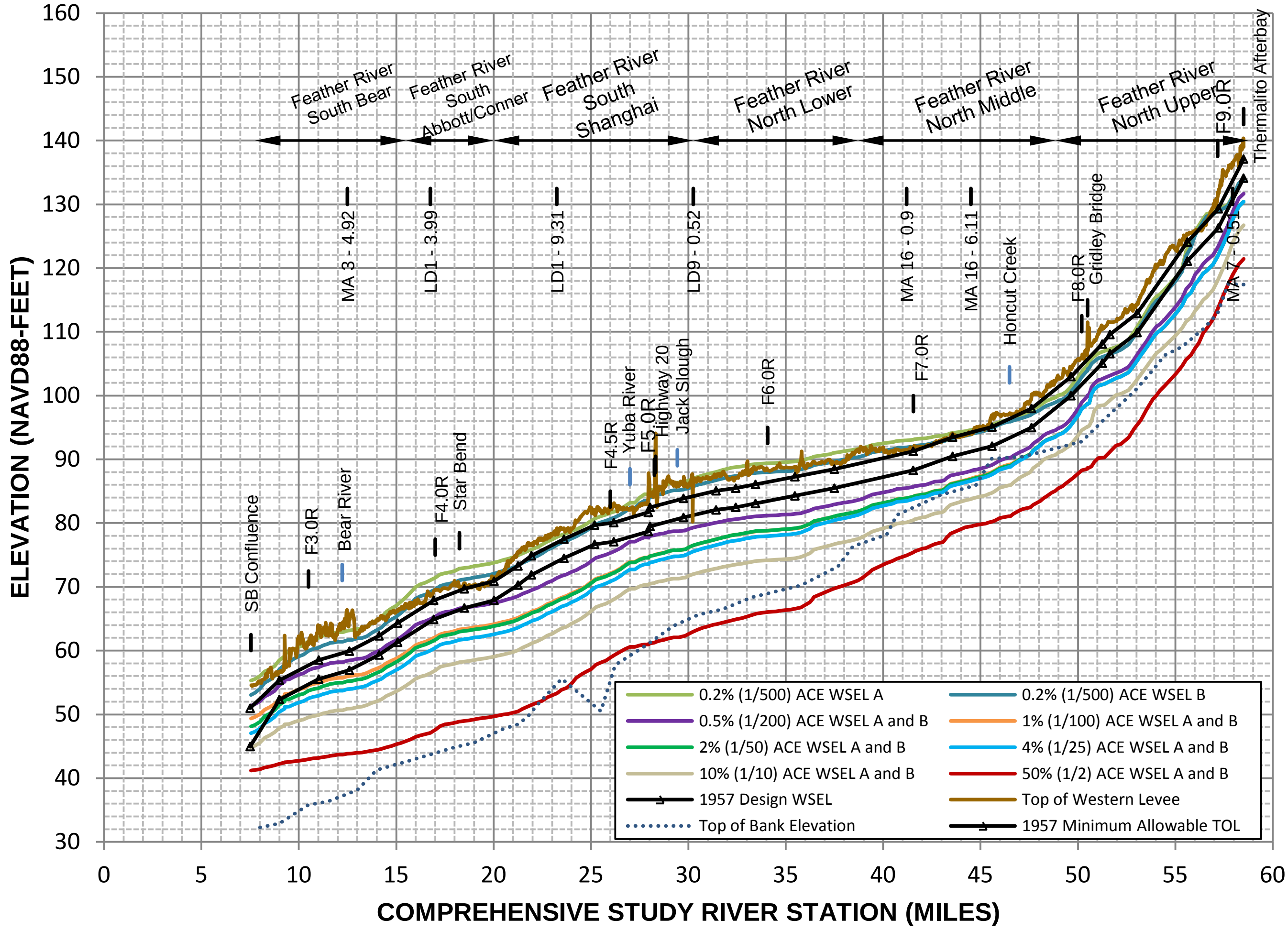
WSEL = Water Surface Elevation

Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

SUTTER BYPASS WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Note:

Water Surface Profile A assumes infinite levee height, no overtopping

Water Surface Profile B assumes overtopping only, no failure

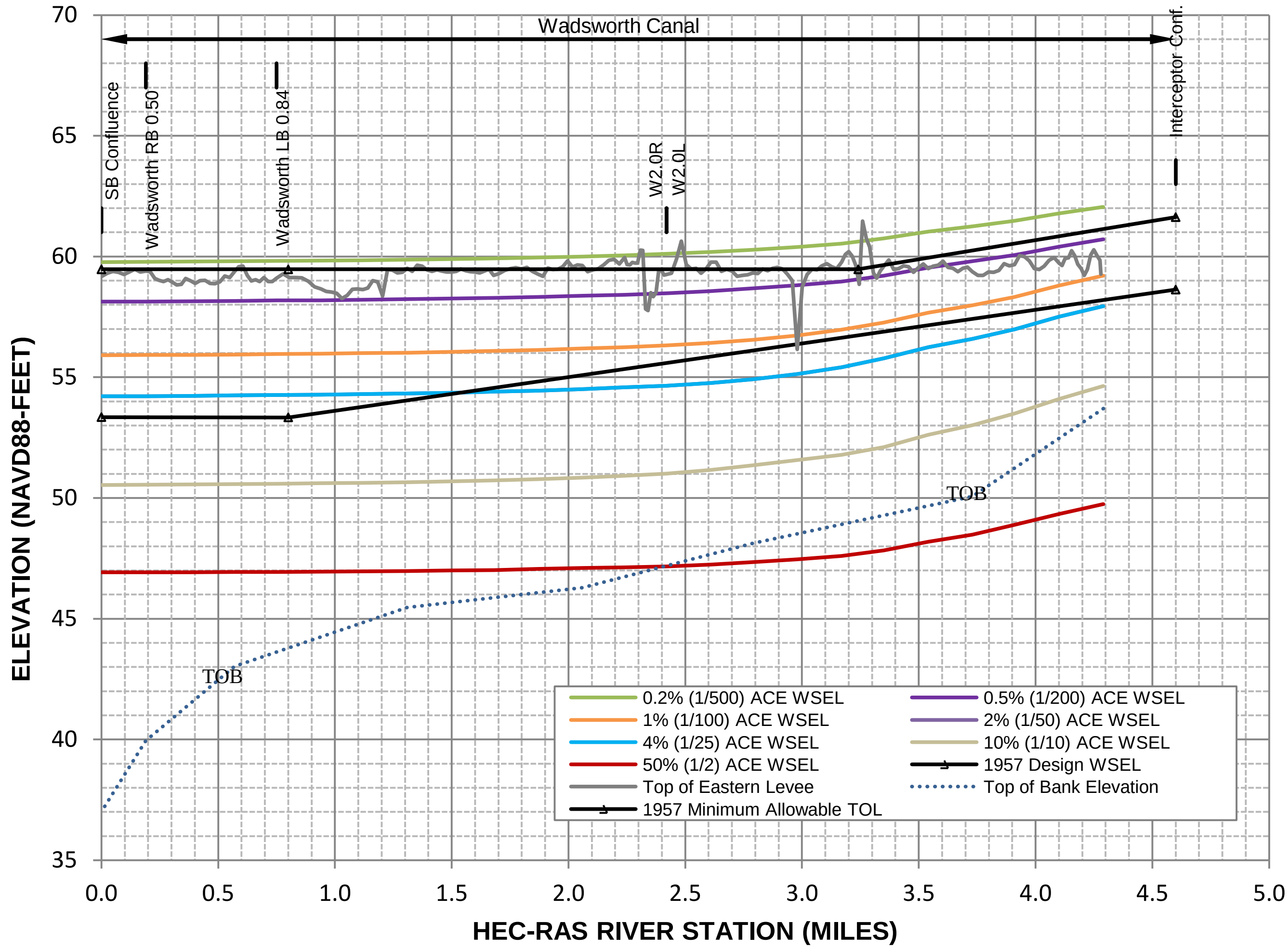
WSEL = Water Surface Elevation

Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

FEATHER RIVER
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Note:

Water Surface Profile A assumes infinite levee height, no overtopping

Overtopping, no failure was not created for Wadsworth Canal

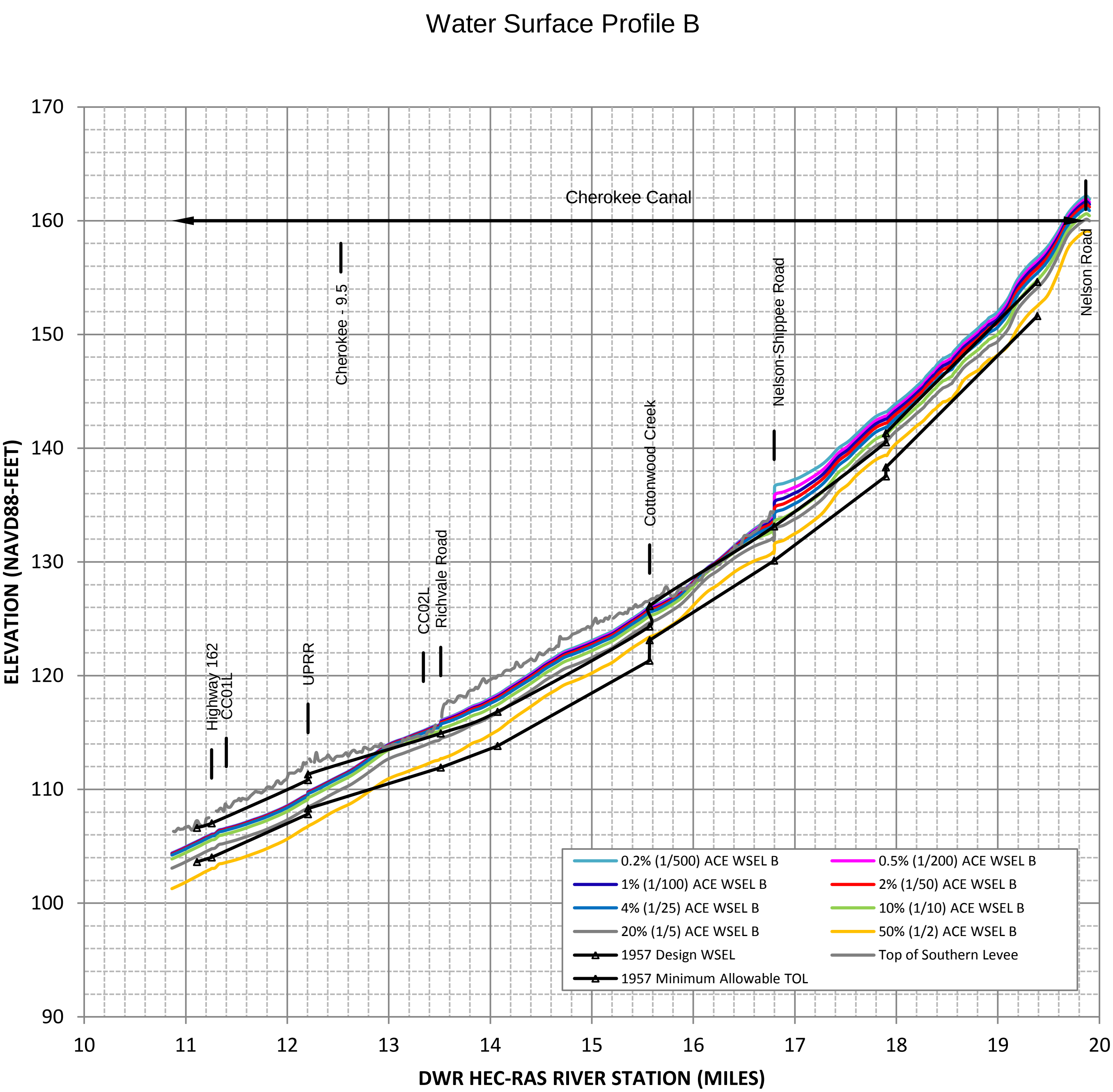
WSEL = Water Surface Elevation

Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

WADSWORTH CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Notes:

Water Surface Profile B assumes overtopping only, no failure.

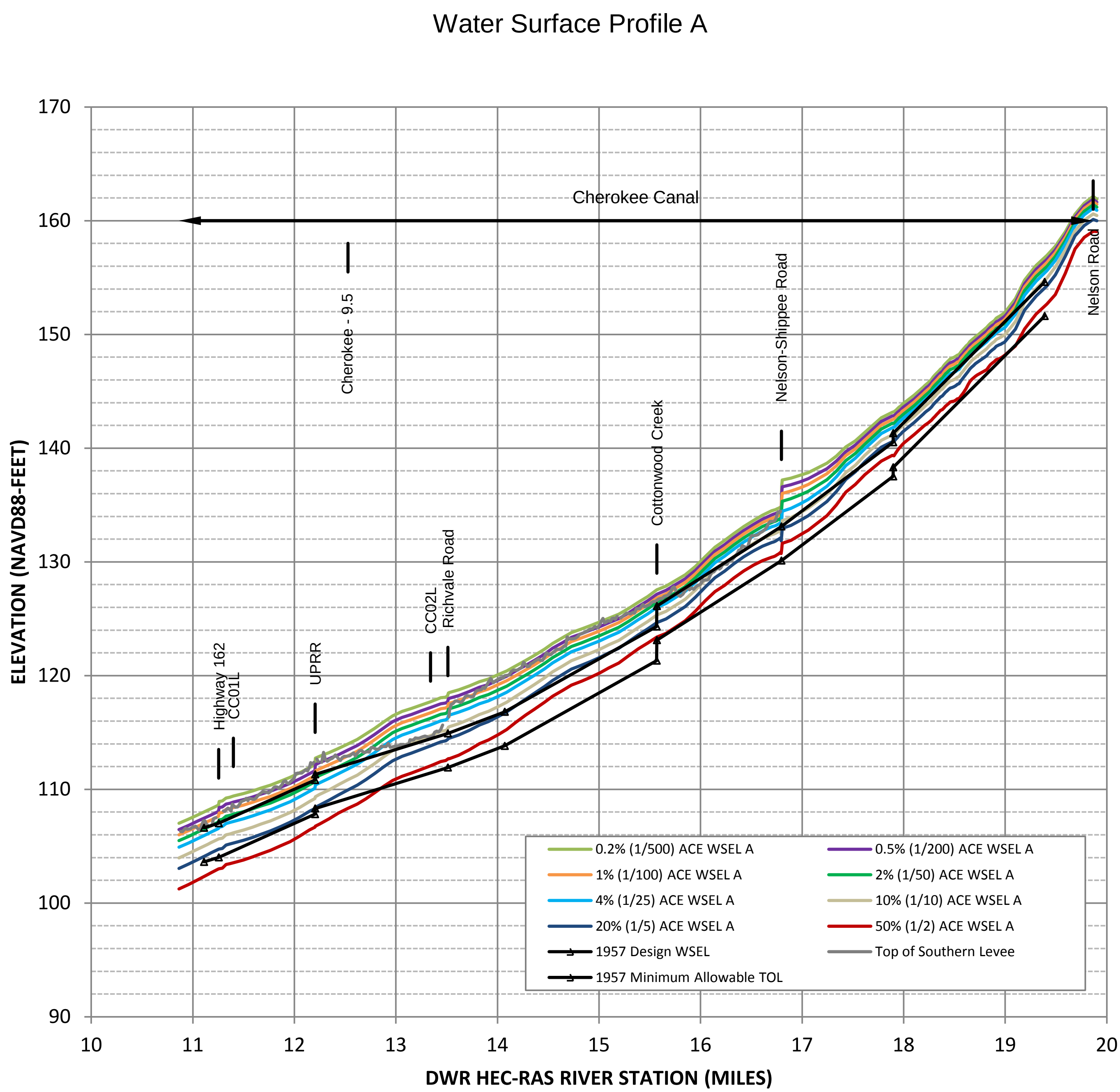
WSEL = Water Surface Elevation

Source:

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Notes:

Water Surface Profile A assumes infinite levee height, no overtopping.

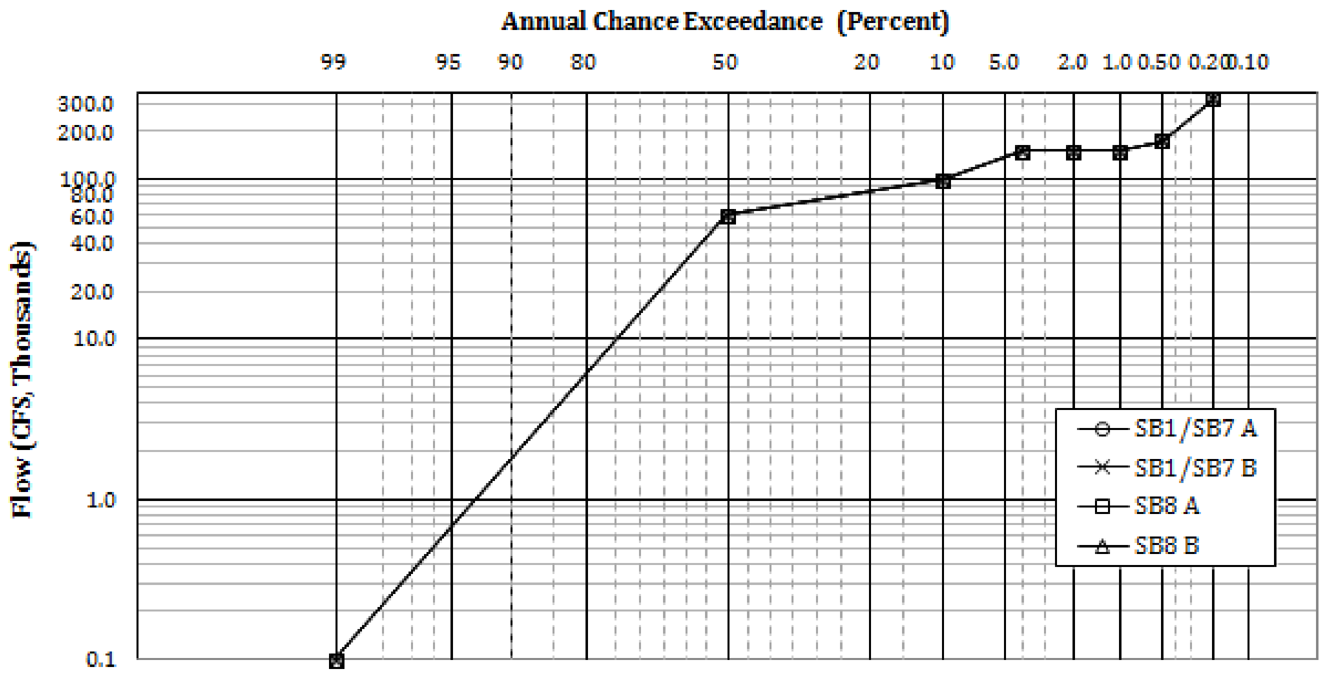
WSEL = Water Surface Elevation

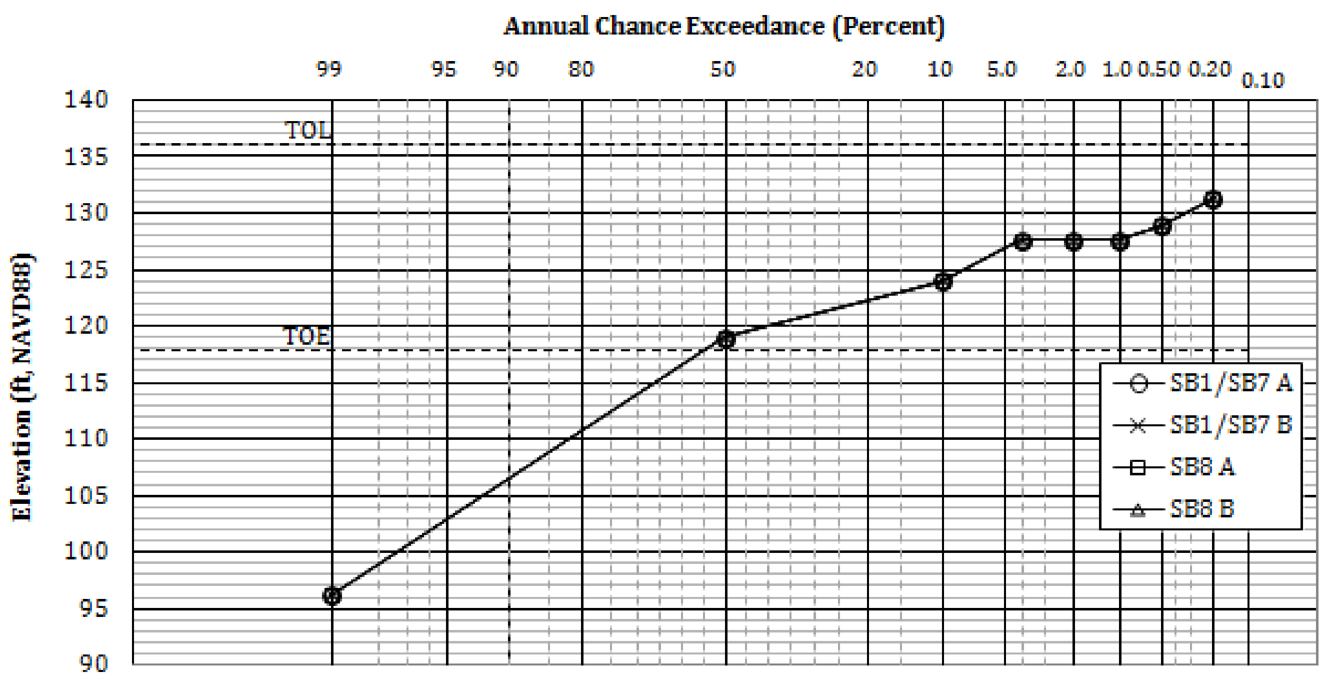
Source:

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





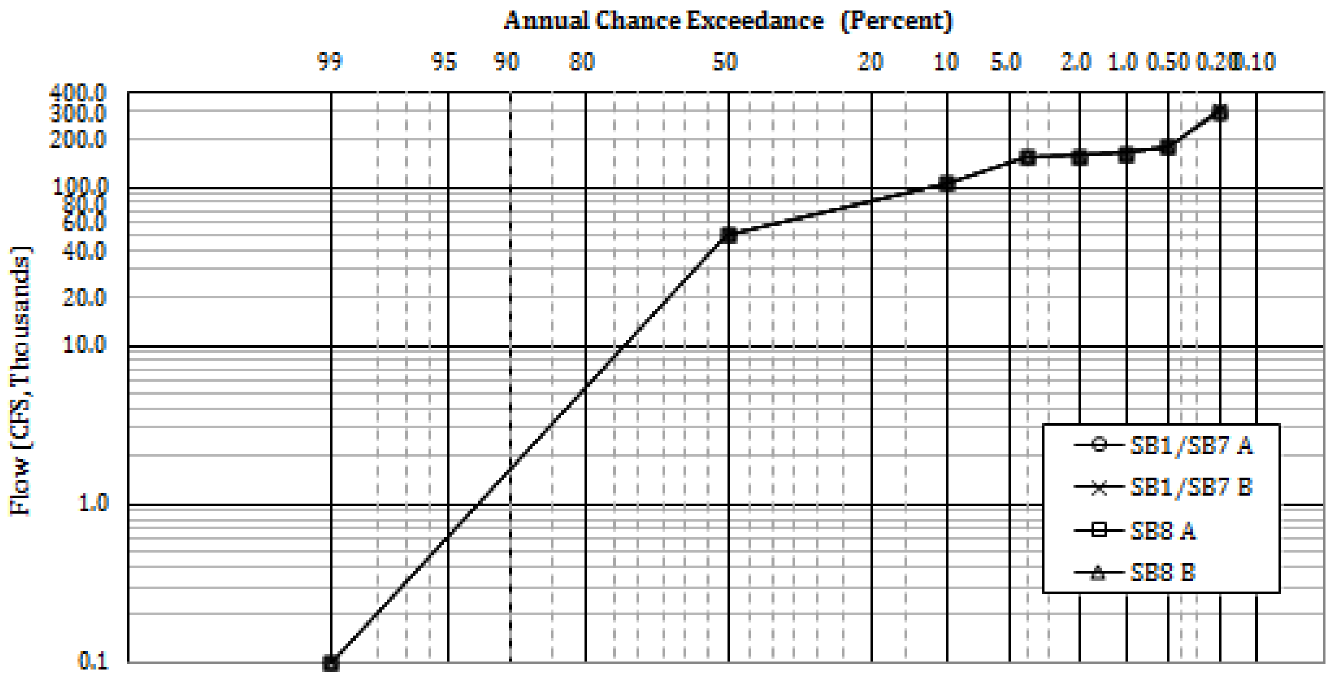
NOTES:
Feather River at Comp Study RM 57.95 refers to Geotechnical index location MA7 – 0.51
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

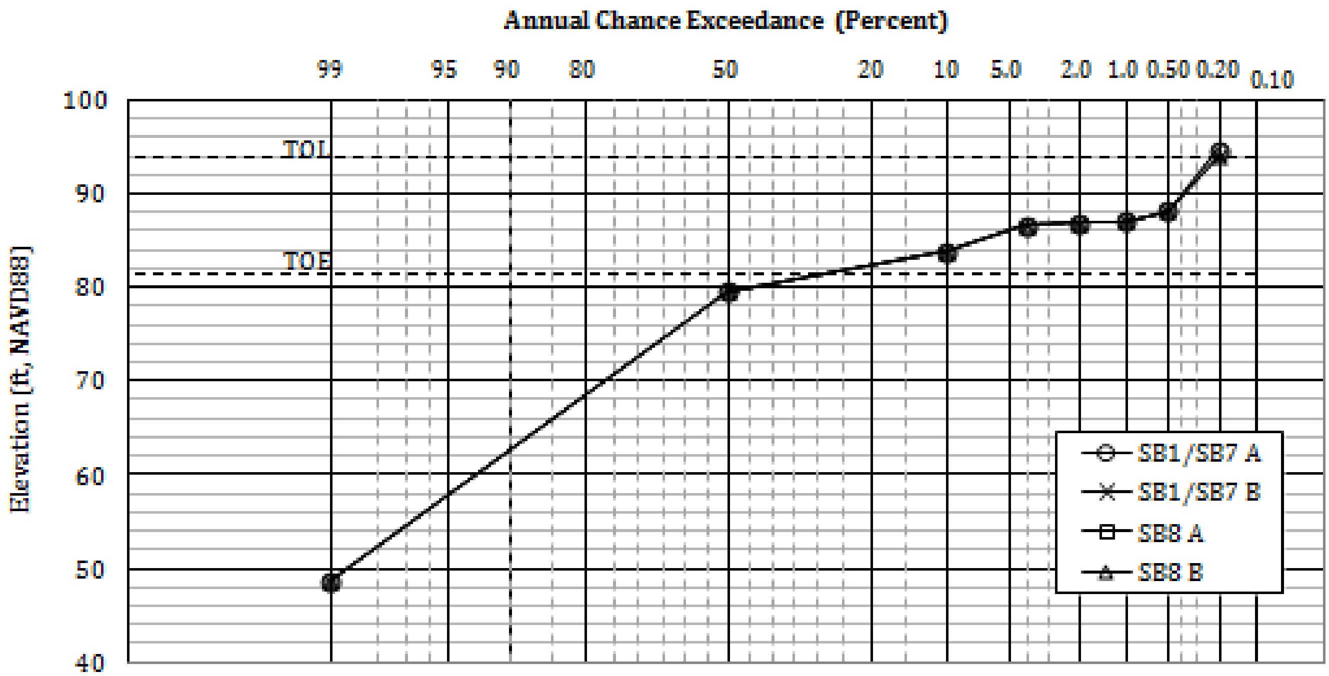
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
FEATHER RIVER AT RM 57.95

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





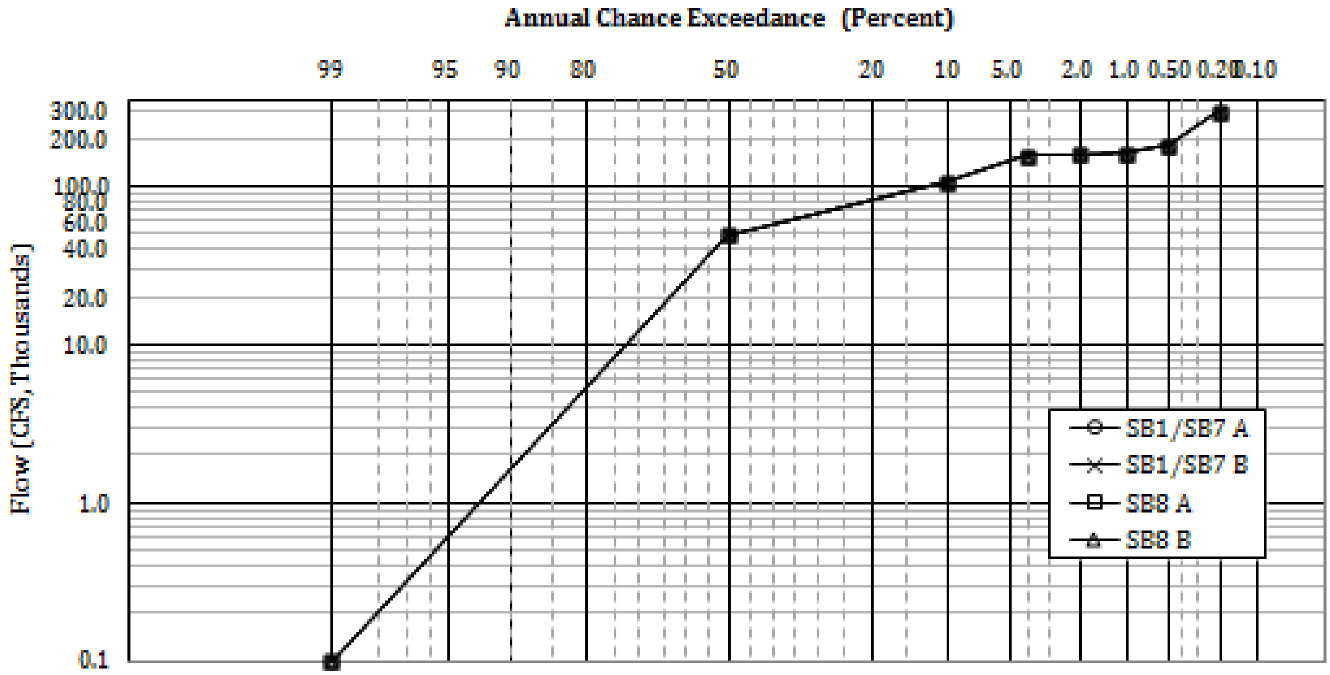
NOTES:
Feather River at Comp Study RM 44.5 refers to Geotechnical index location MA 16 – 2.9
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

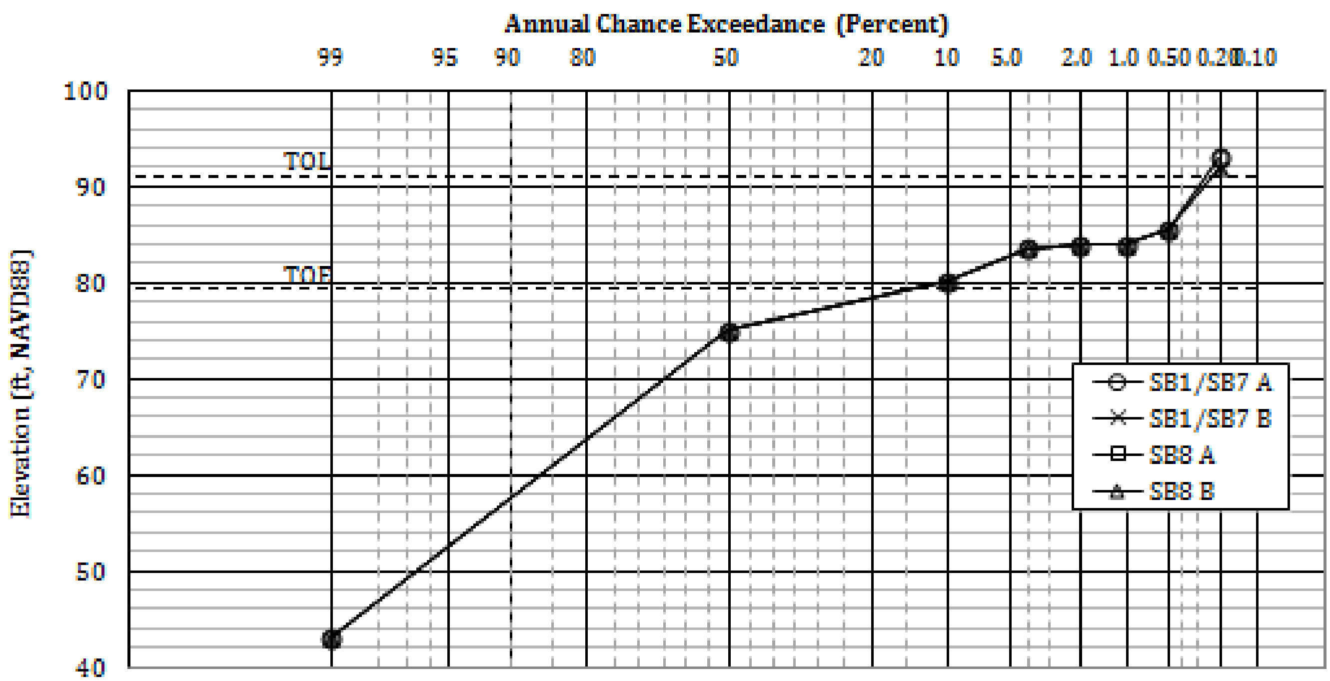
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
FEATHER RIVER AT RM 44.5

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





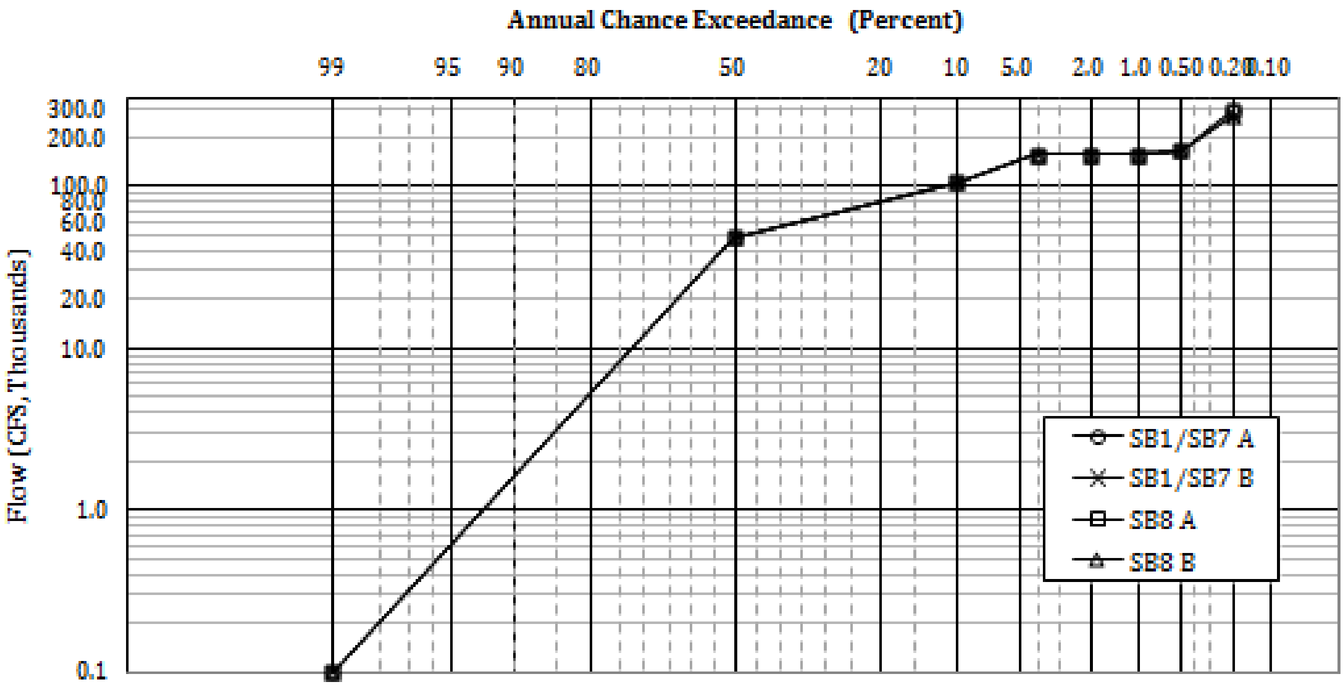
NOTES:
Feather River at Comp Study RM 41.2 refers to Geotechnical index location MA 16 – 0.9
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

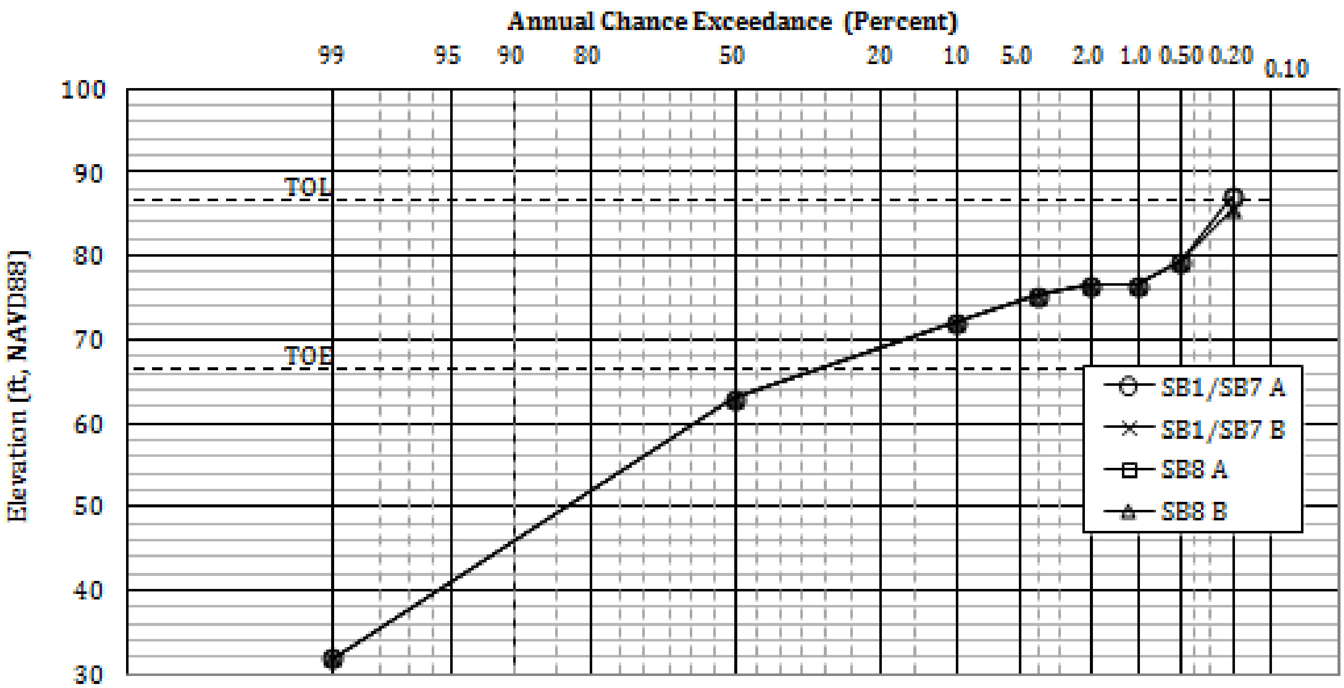
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES FEATHER RIVER AT RM 41.2

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





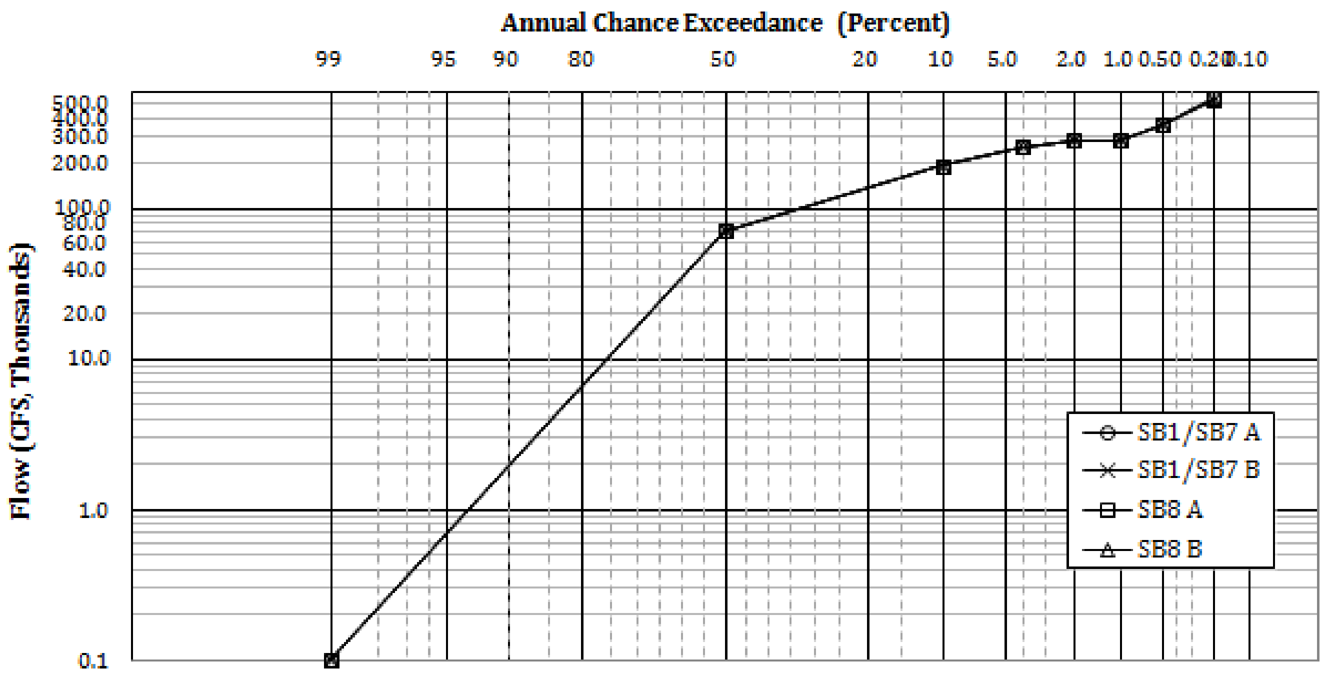
NOTES:
Feather River at Comp Study RM 30.25 refers to Geotechnical index location LD9 – 0.52
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

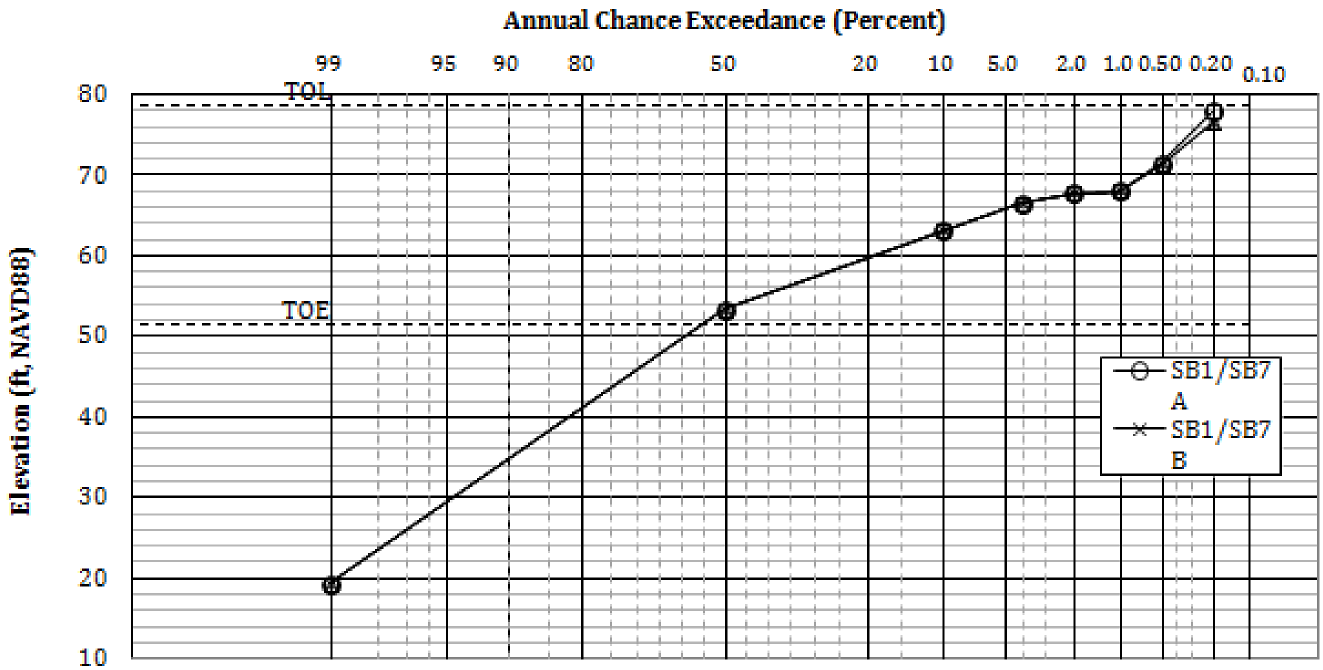
Sou

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES FEATHER RIVER AT RM 30.25

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





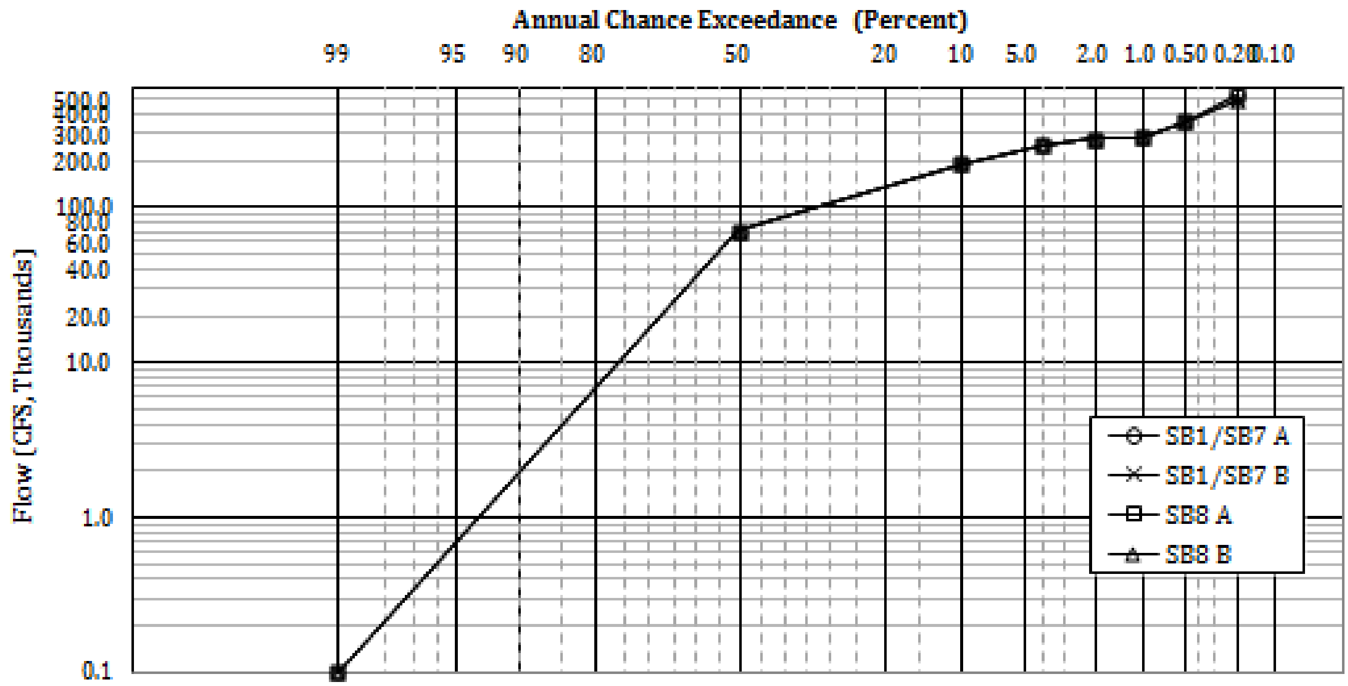
NOTES:
Feather River at Comp Study RM 23.25 refers to Geotechnical index location LD1 – 9.31
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

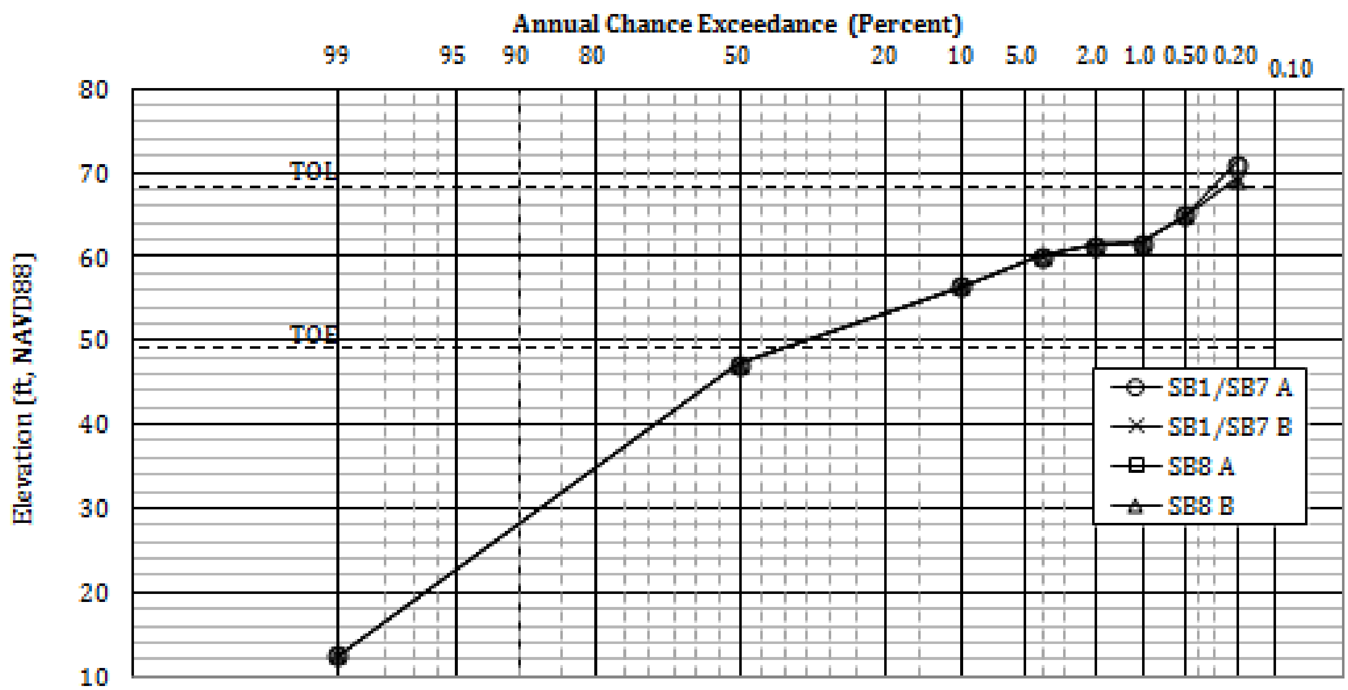
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
FEATHER RIVER AT RM 23.25

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





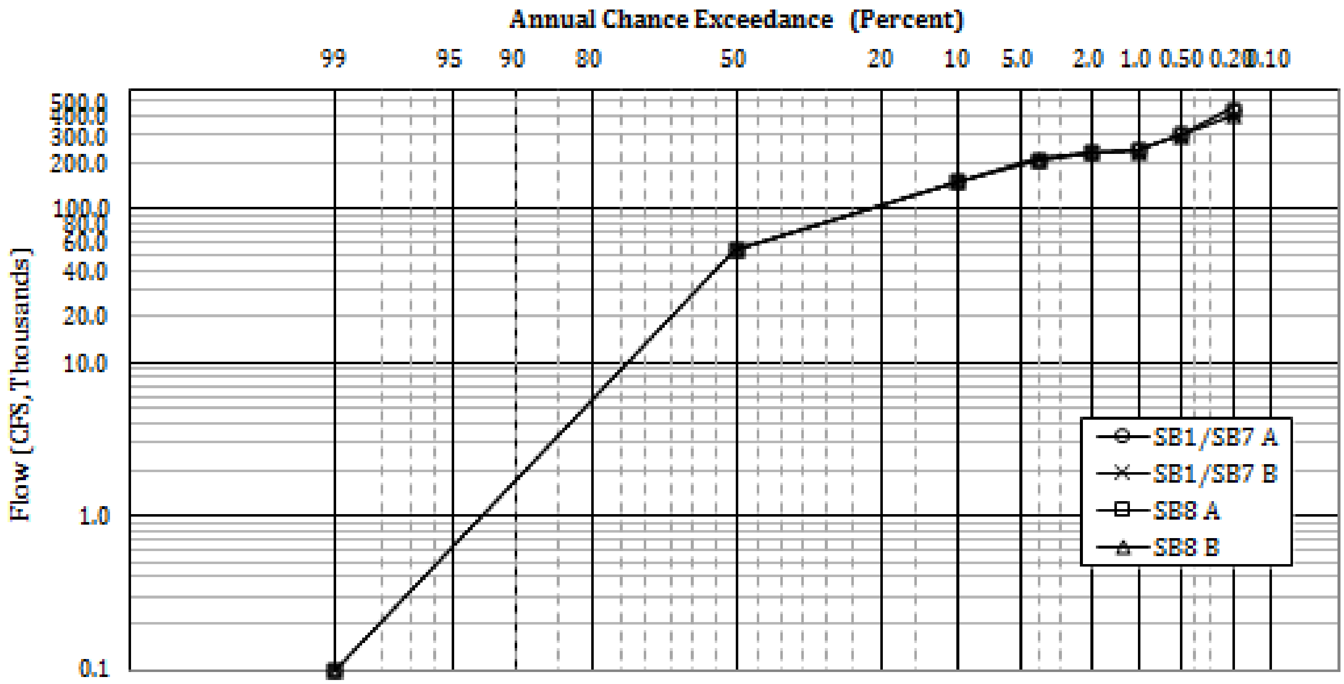
NOTES:
Feather River at Comp Study RM 16.75 refers to Geotechnical index location LD1 – 3.99
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

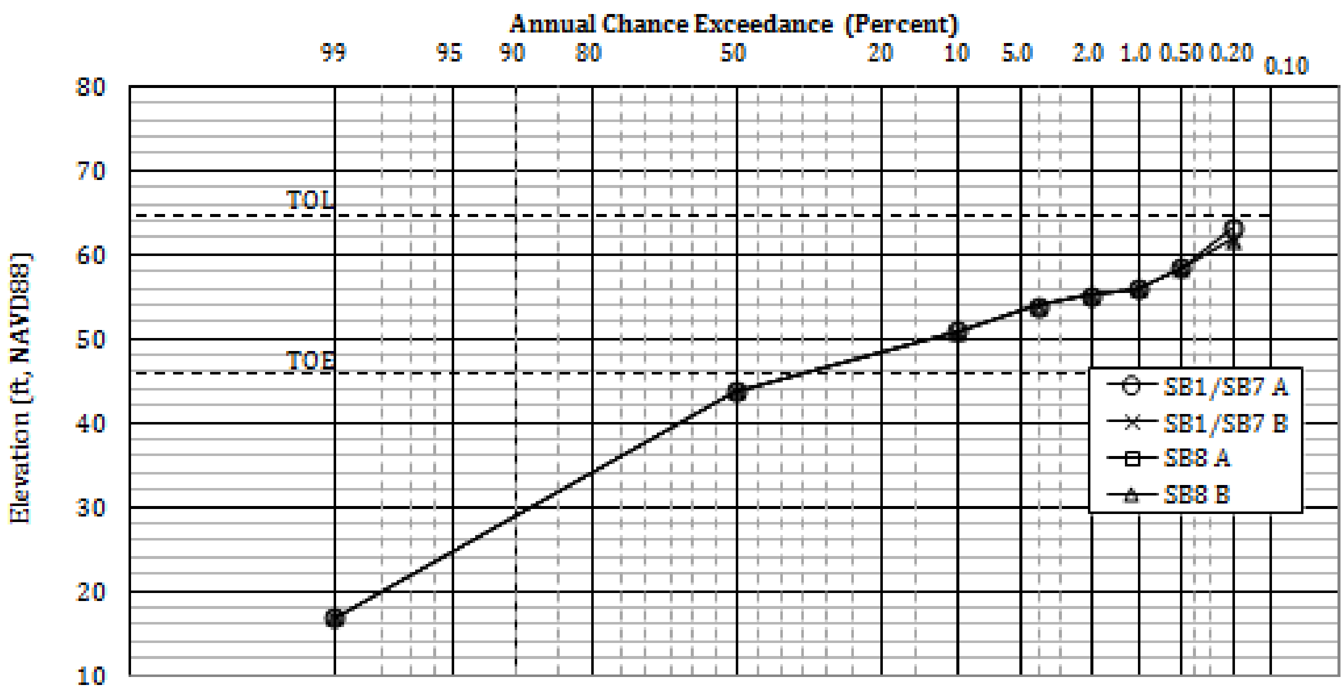
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
FEATHER RIVER AT RM 16.75

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





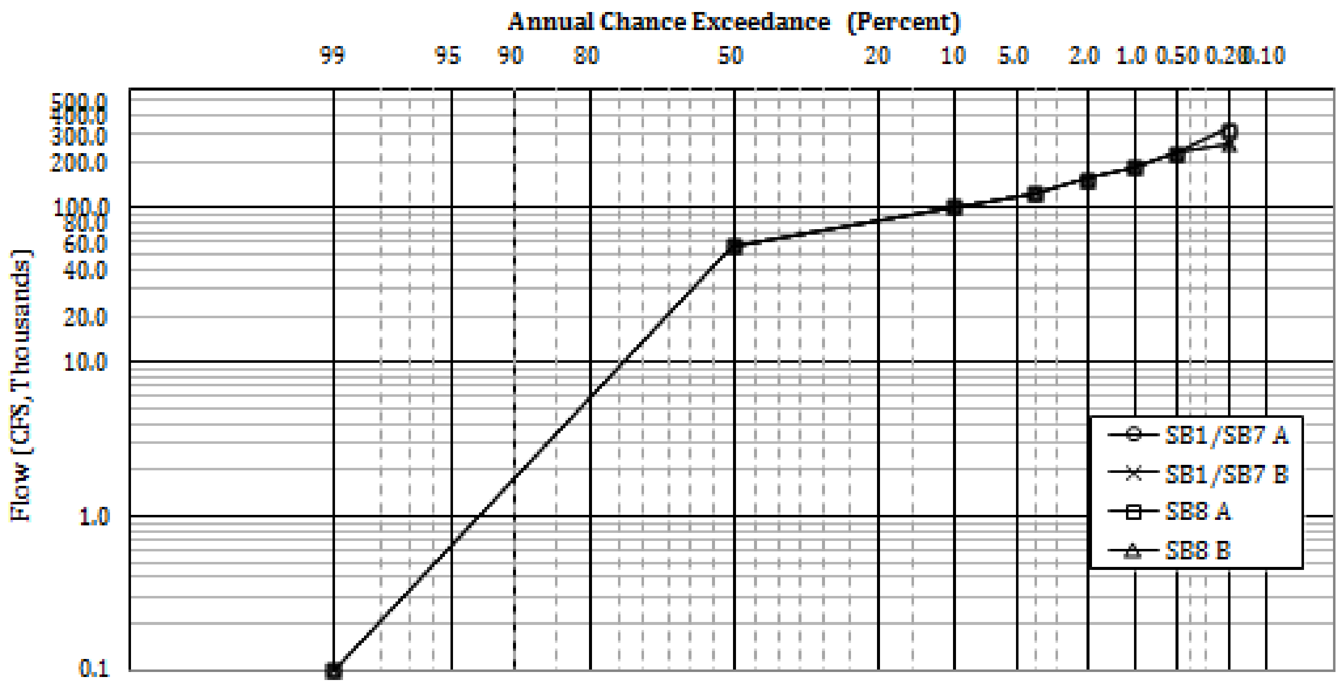
NOTES:
Feather River at Comp Study RM 12.5 refers to Geotechnical index location MA3 – 4.92
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

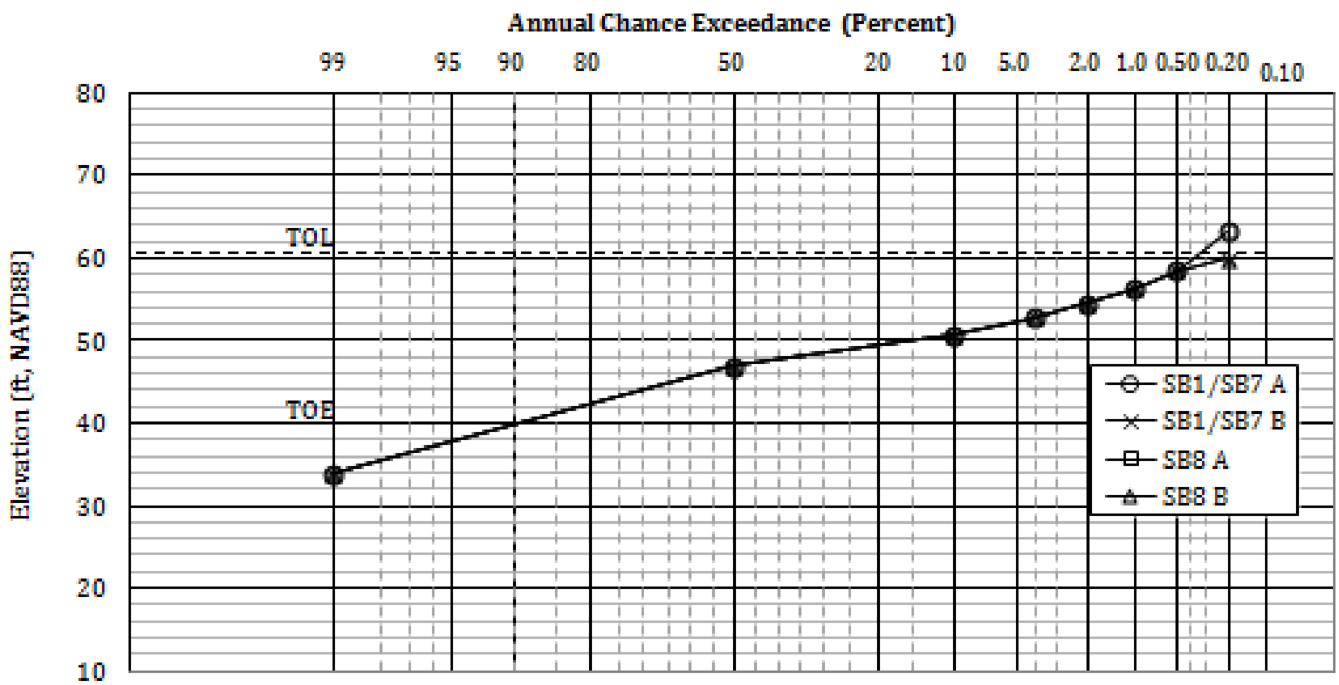
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
FEATHER RIVER AT RM 12.5

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





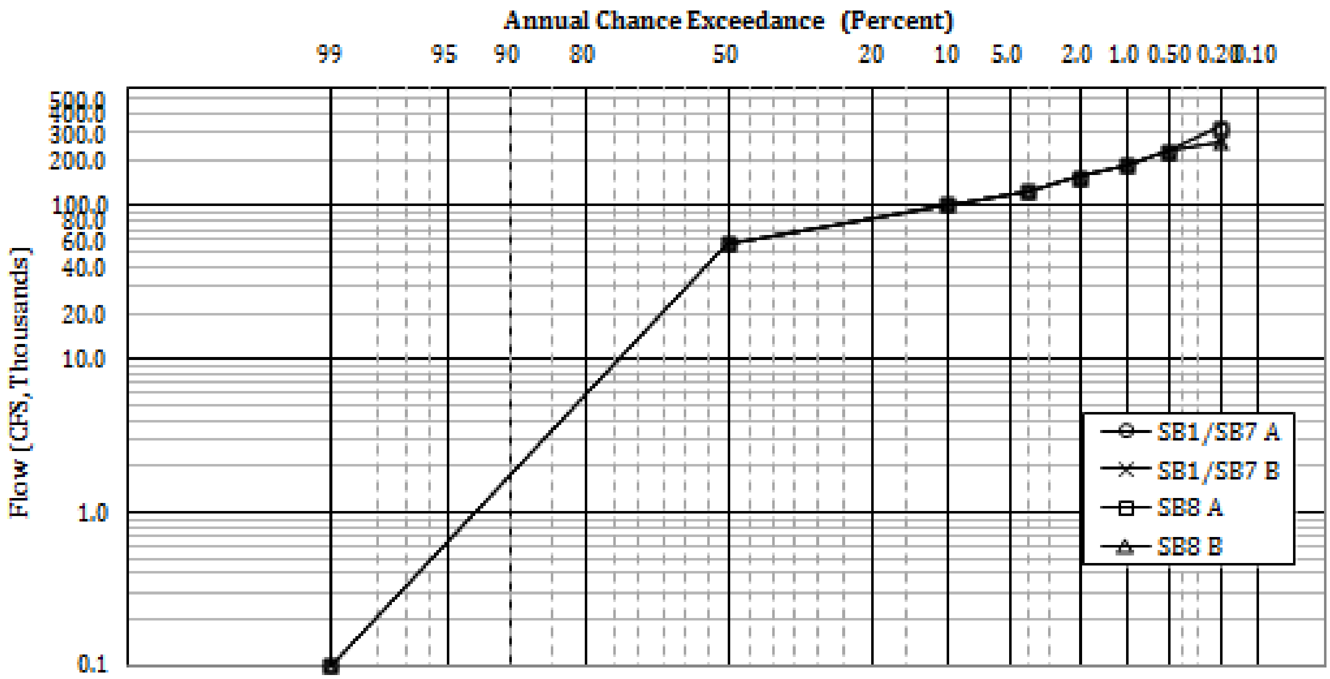
NOTES:
Sutter Bypass at Comp Study RM 83.79 refers to Geotechnical index location SUTTER – 4
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

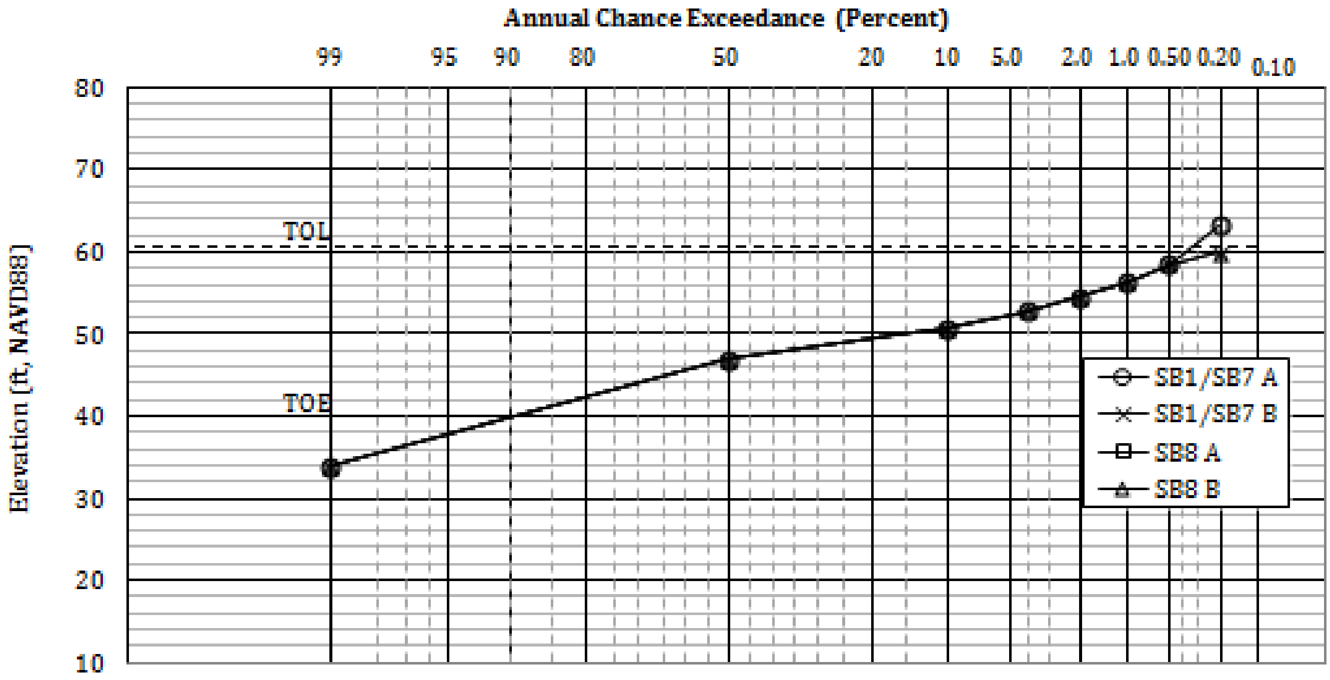
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
SUTTER BYPASS AT RM 83.79

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





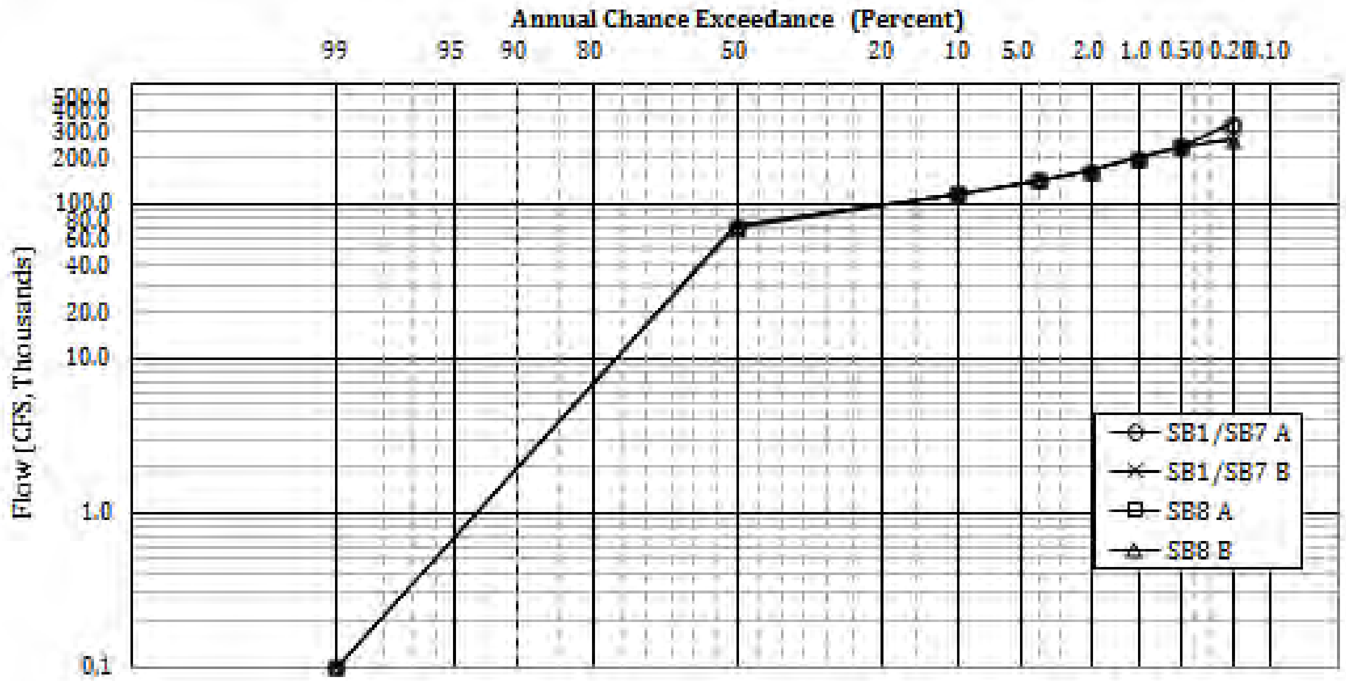
NOTES:
Sutter Bypass at Comp Study RM 81.93 refers to Geotechnical index location SUTTER – 6.2
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

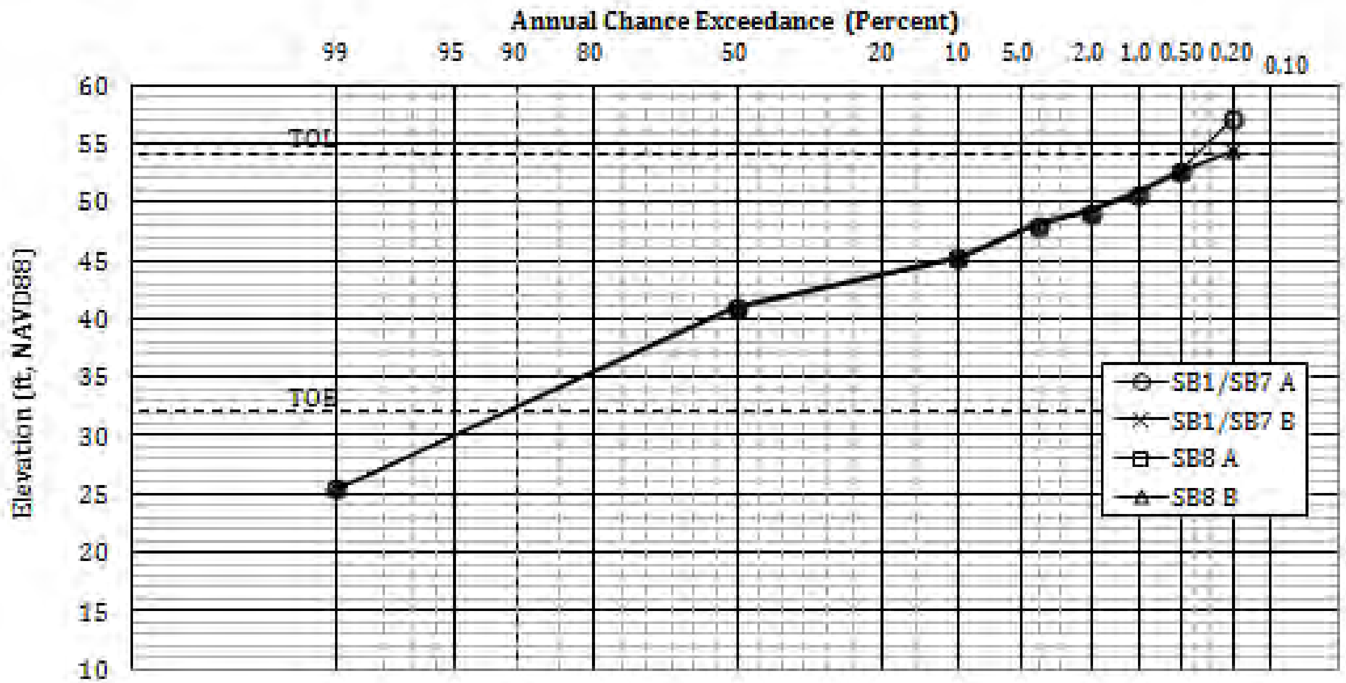
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES SUTTER BYPASS AT RM 81.93

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





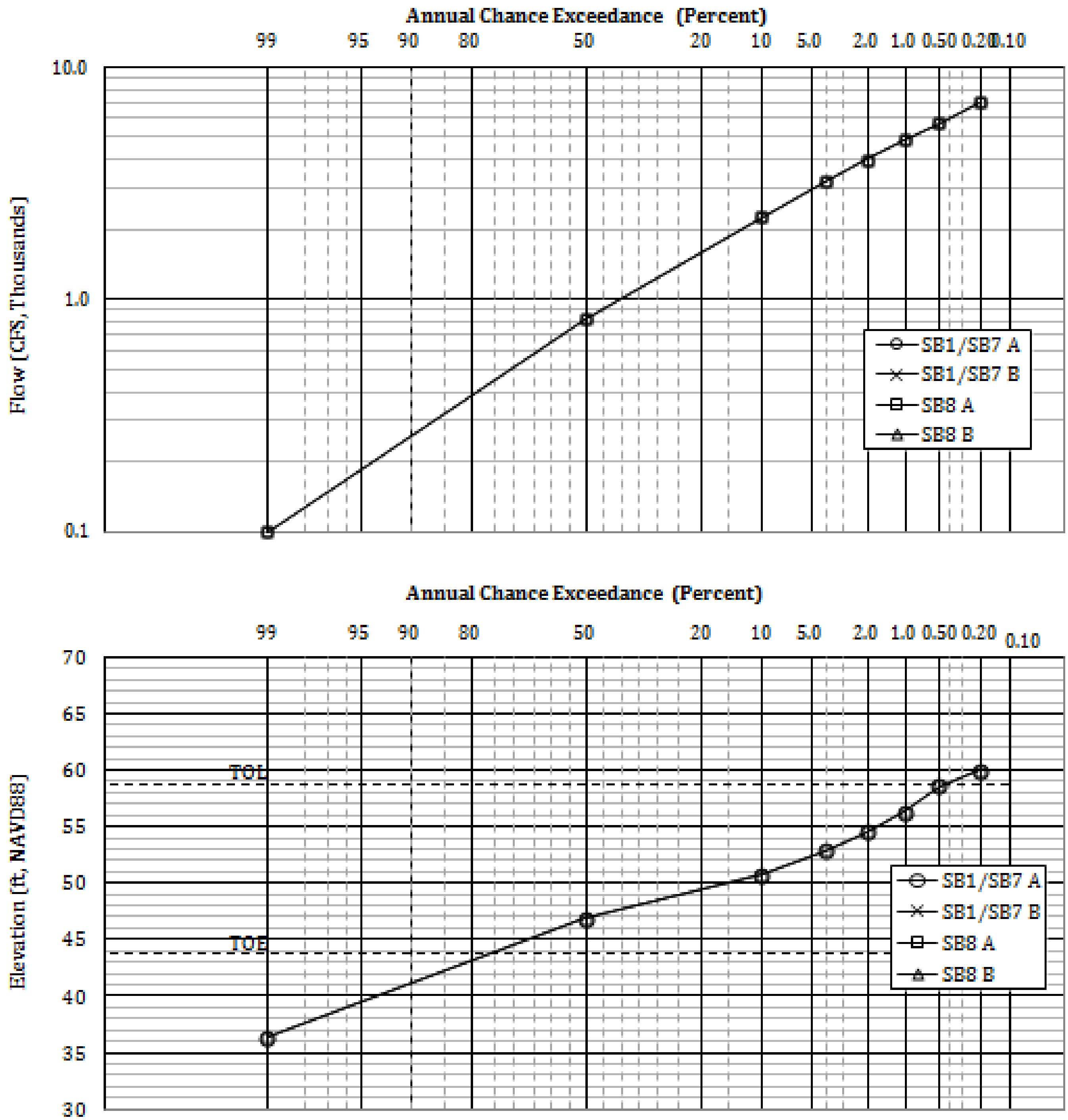
NOTES:
Sutter Bypass at Comp Study RM 71.65 refers to Geotechnical index location SUTTER – 17.3
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
SUTTER BYPASS AT RM 71.65

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



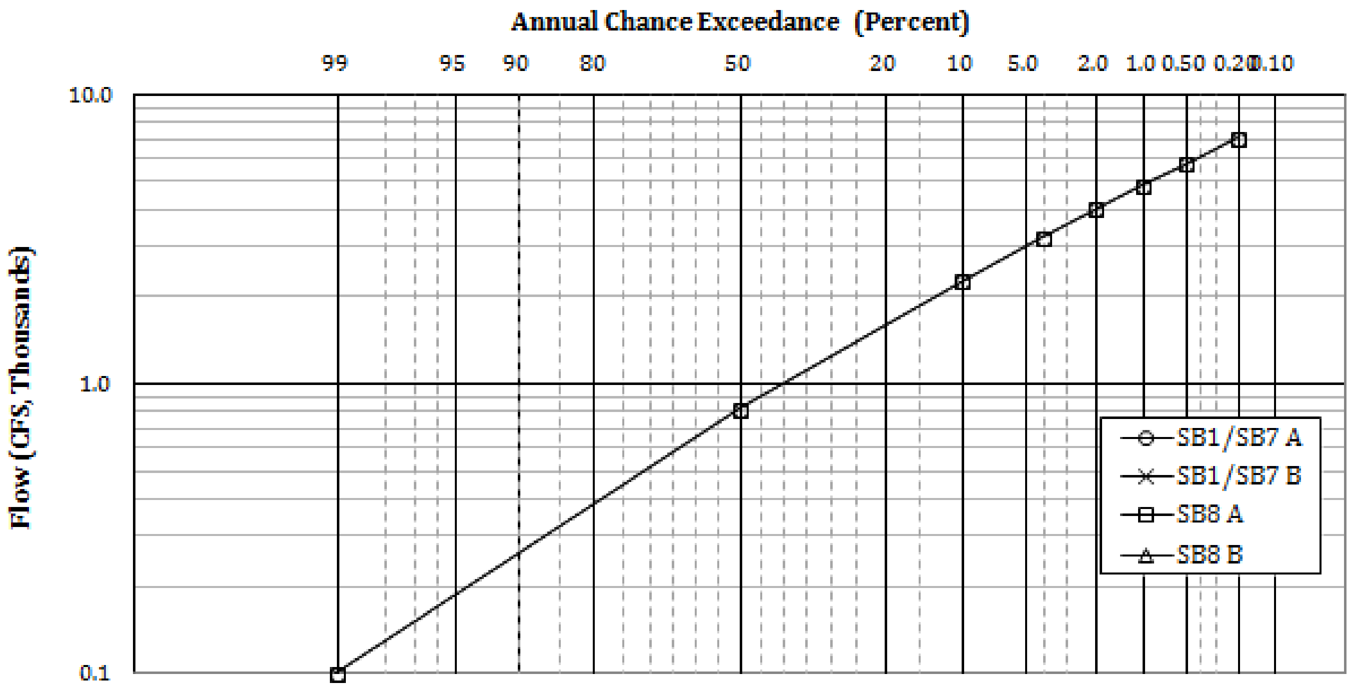
NOTES:
Wadsworth Canal at RM 0.81 refers to Geotechnical index location
WADSWORTH – 0.84
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

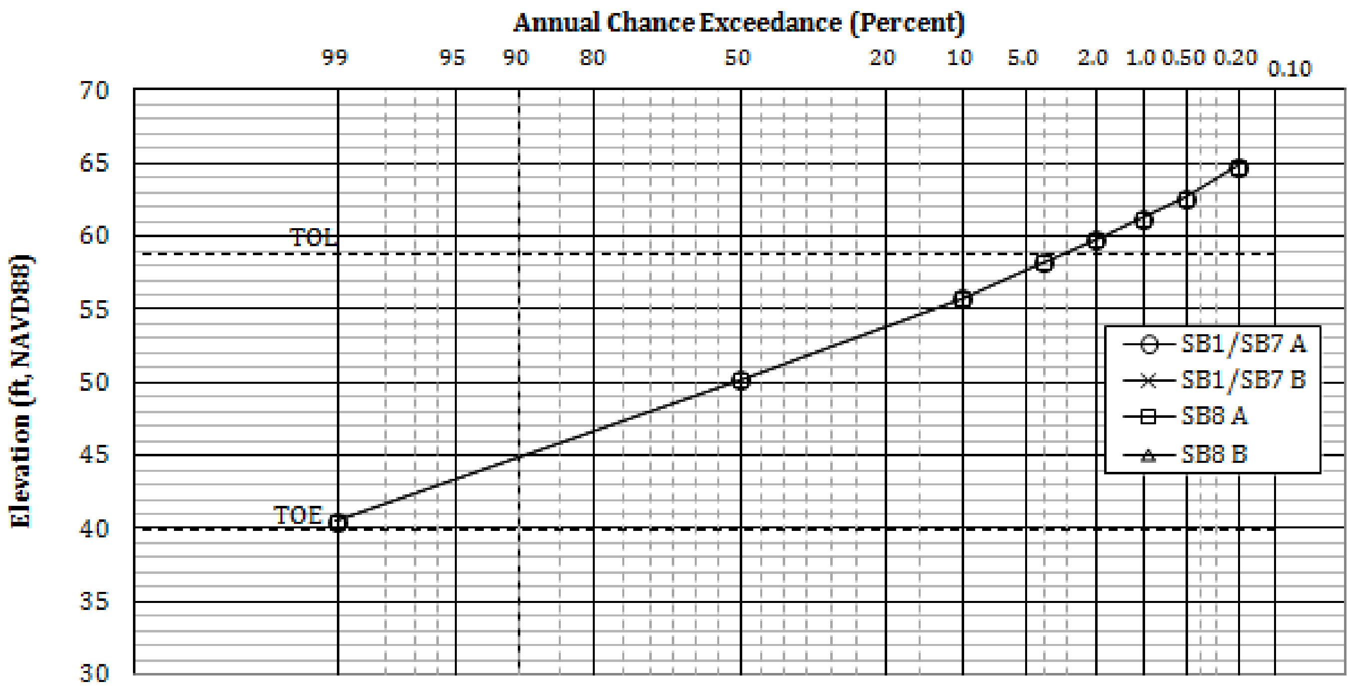
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
WADSWORTH CANAL AT RM 0.81

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





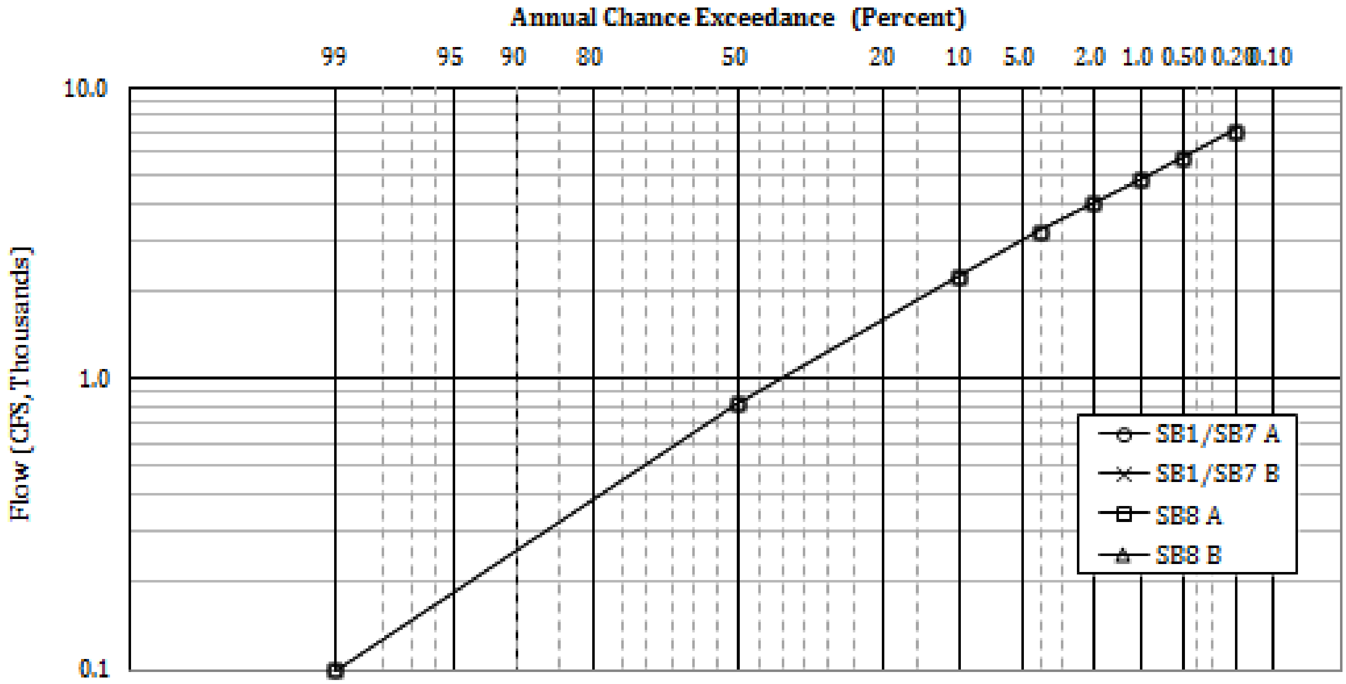
NOTES:
Wadsworth Canal at RM 4.54 defines the upstream capacity prior to overtopping
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

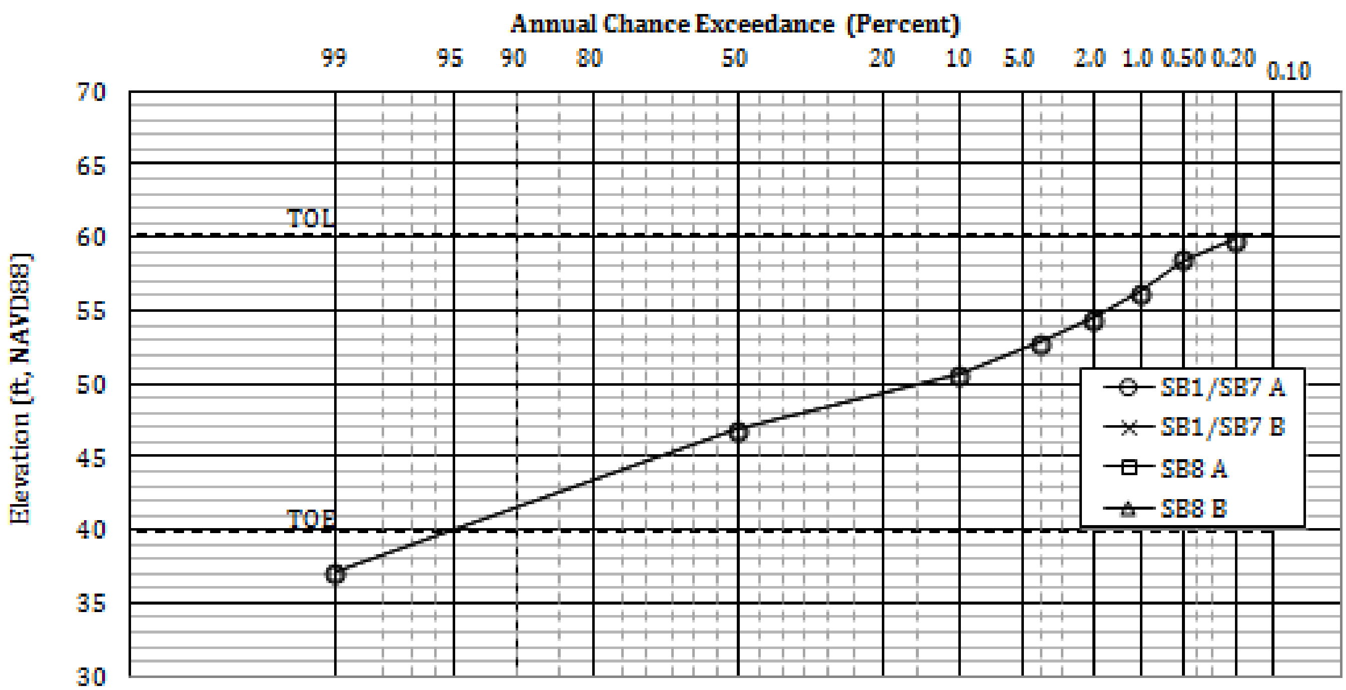
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
WADSWORTH CANAL AT RM 4.54

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





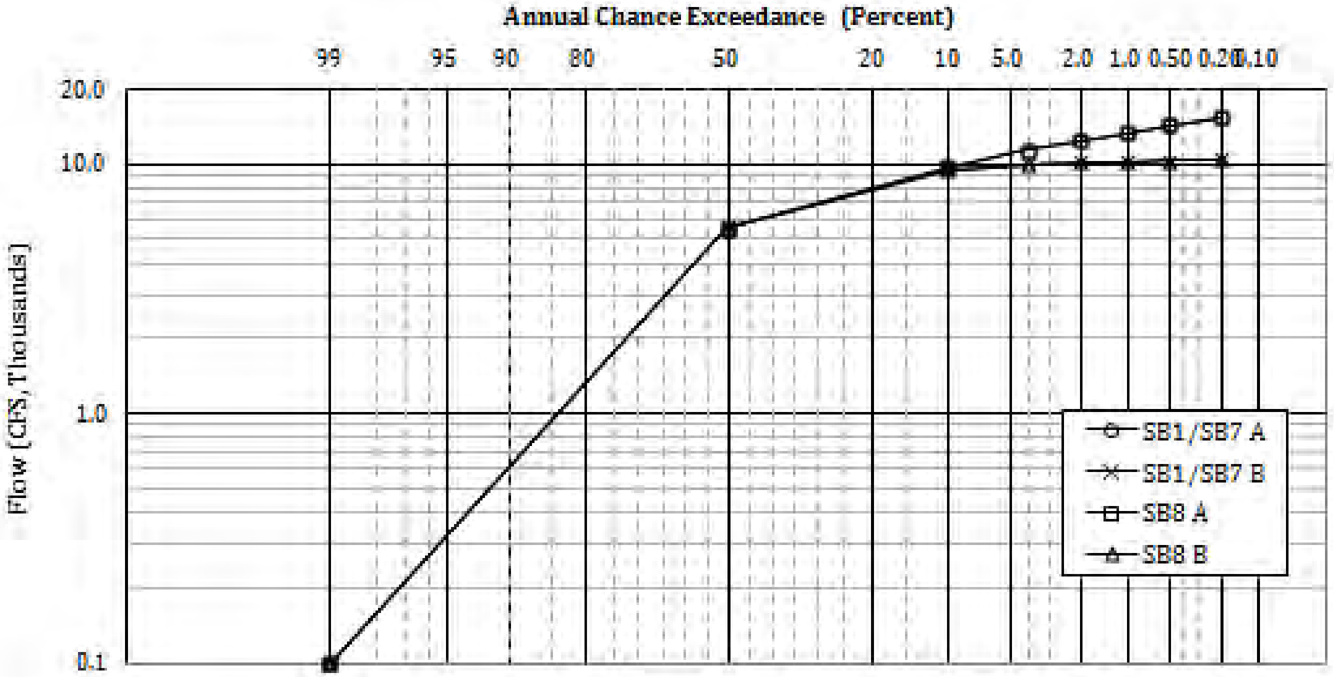
NOTES:
Wadsworth Canal at Comp Study RM 0.25 refers to Geotechnical Index location WADSWORTH – 0.5
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

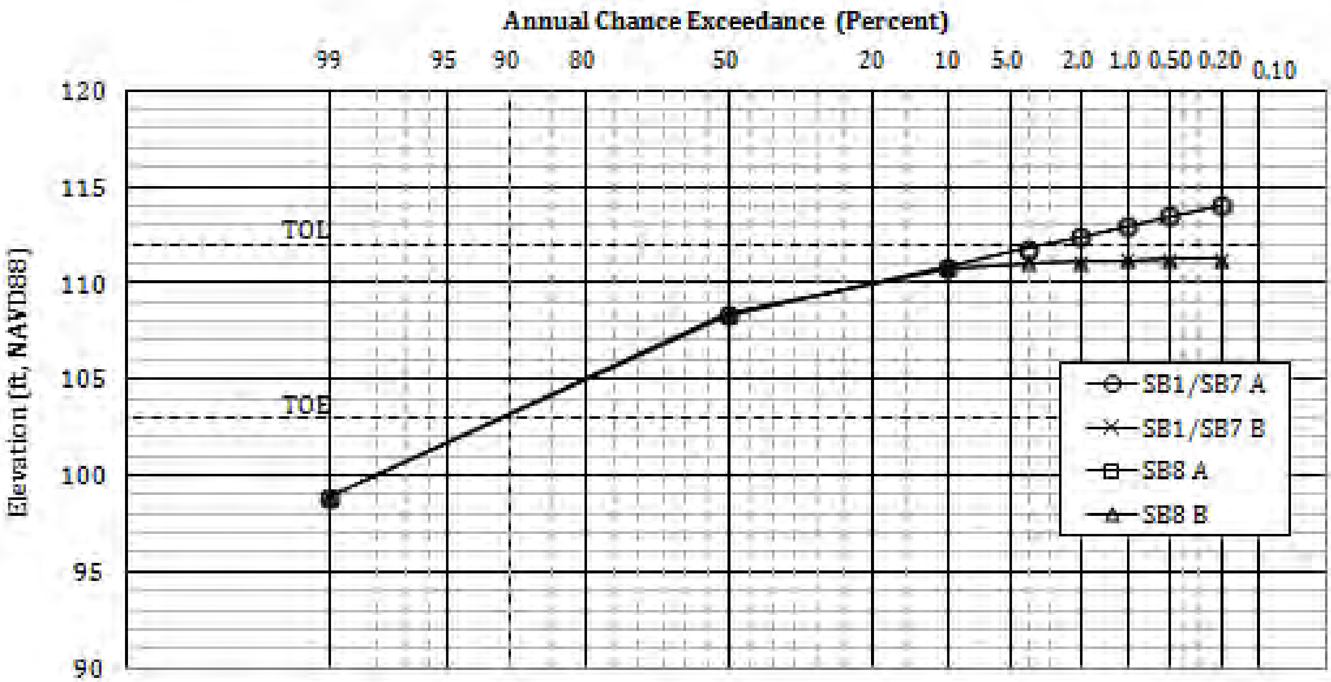
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
WADSWORTH CANAL AT RM 0.25

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





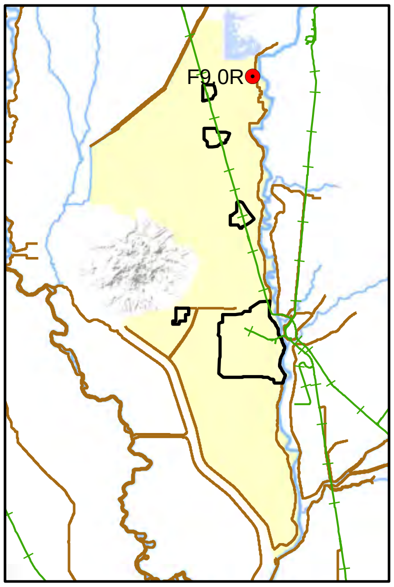
NOTES:
Cherokee Canal at DWR HEC-RAS RM 12.529 refers to Geotechnical index location CHEROKEE – 9.5
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

Source:

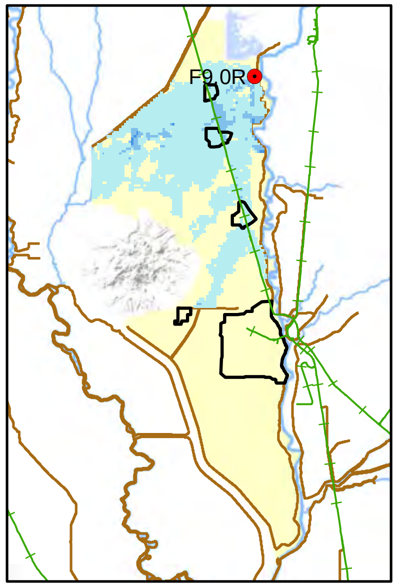
SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES CHEROKEE CANAL AT RM 12.529

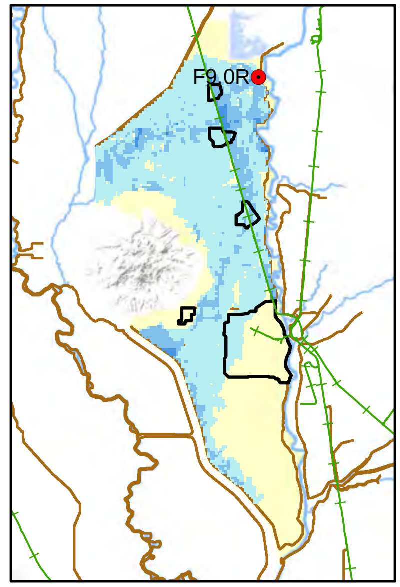
U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



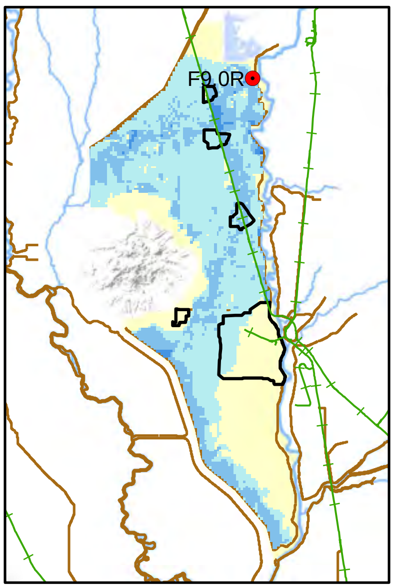
50% (1/2) ACE



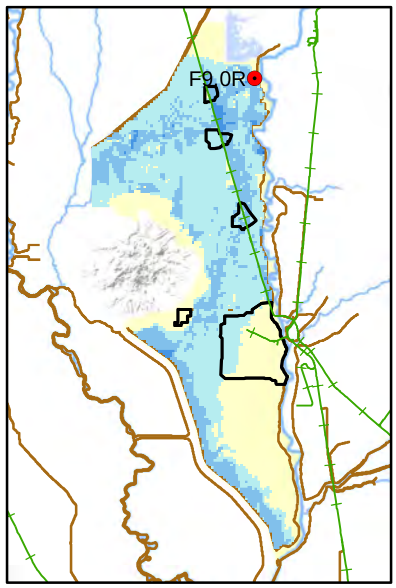
10% (1/10) ACE



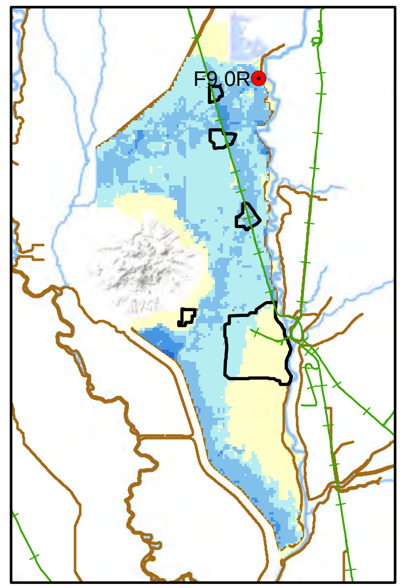
4% (1/25) ACE



2% (1/50) ACE



1% (1/100) ACE



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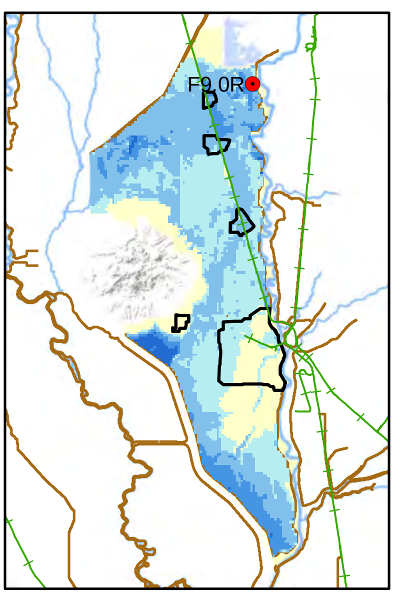


0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

Miles
0 10 20

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

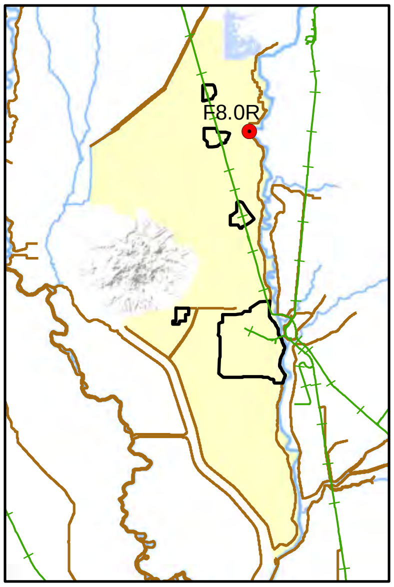
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F9.0R

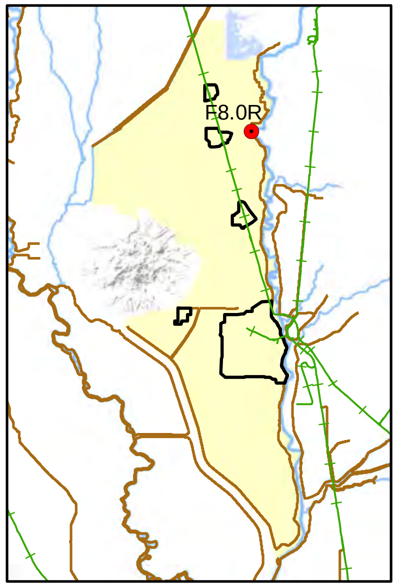
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013



50% (1/2) ACE



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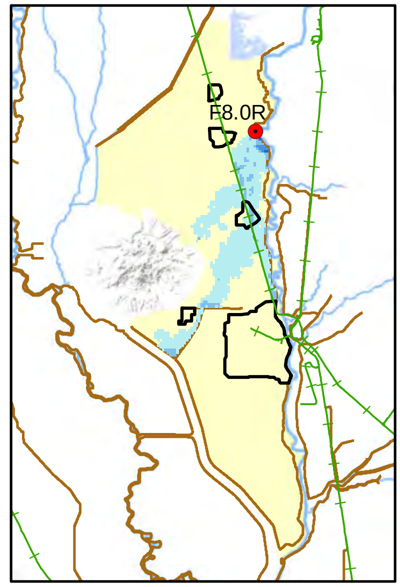
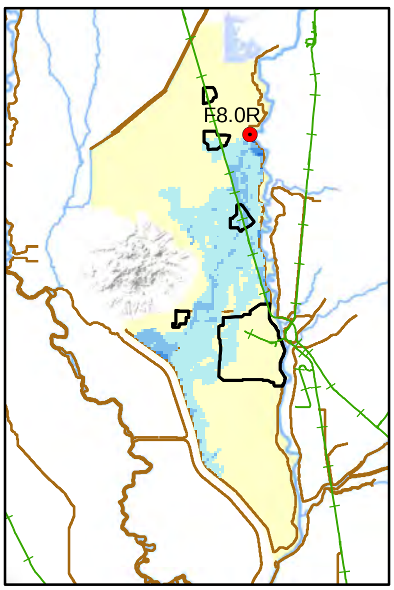


4% (1/25) ACE



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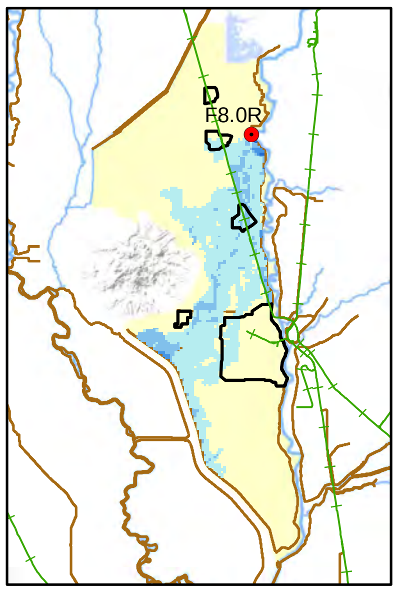

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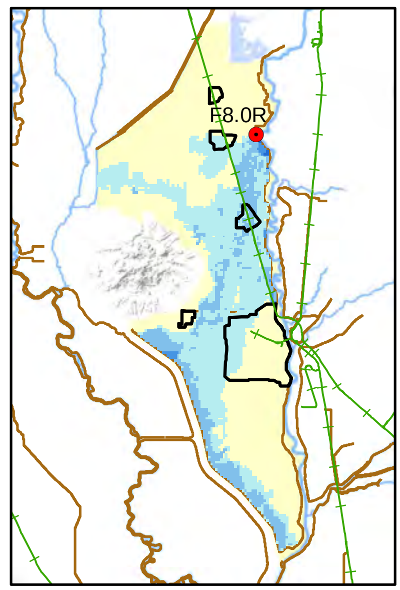

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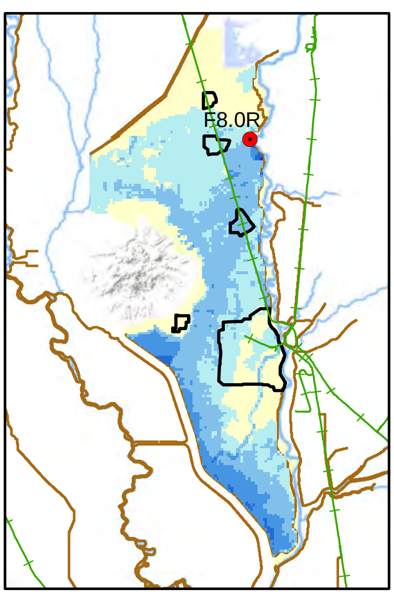


0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

Miles
0 10 20

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

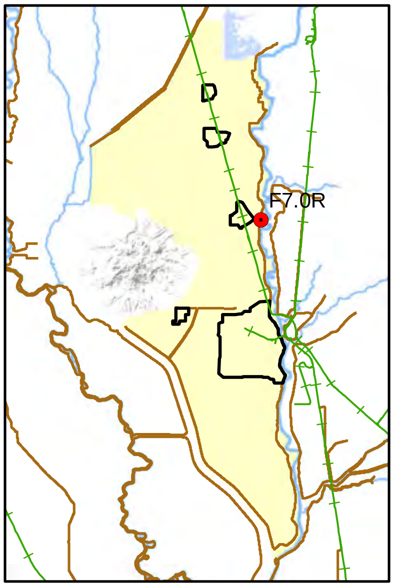
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION
ALTERNATIVE SB-1
FEATHER RIVER WEST LEVEE
LOCATION F8.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013



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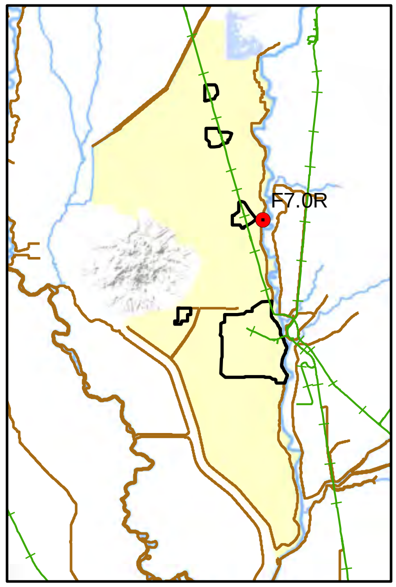

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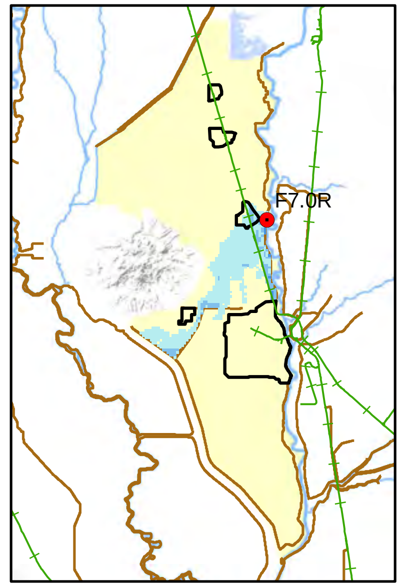

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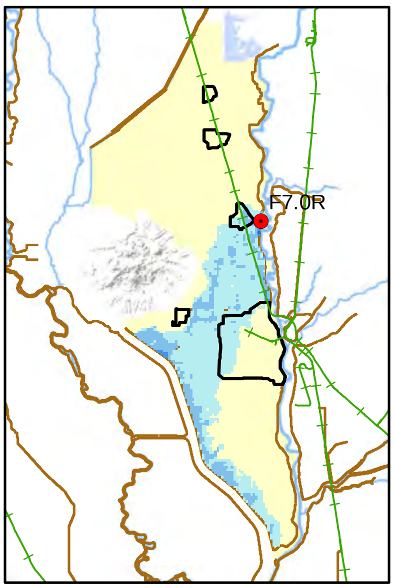

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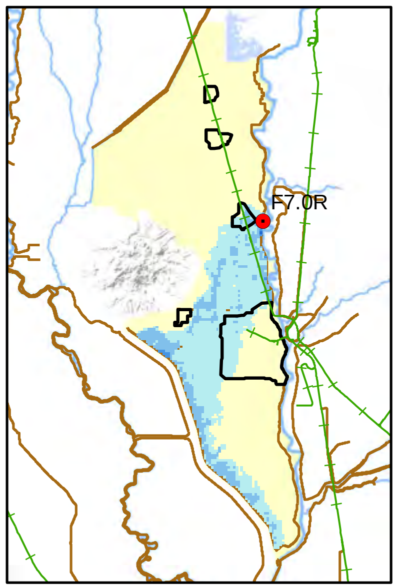

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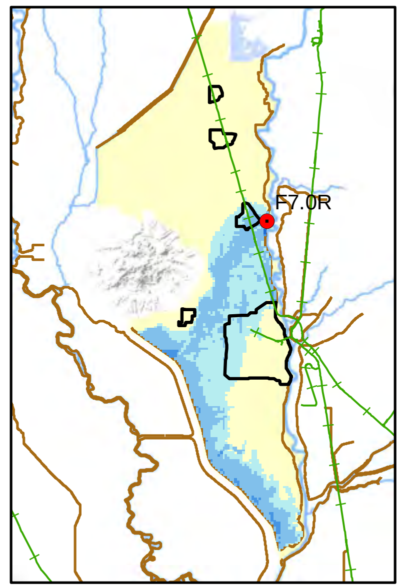

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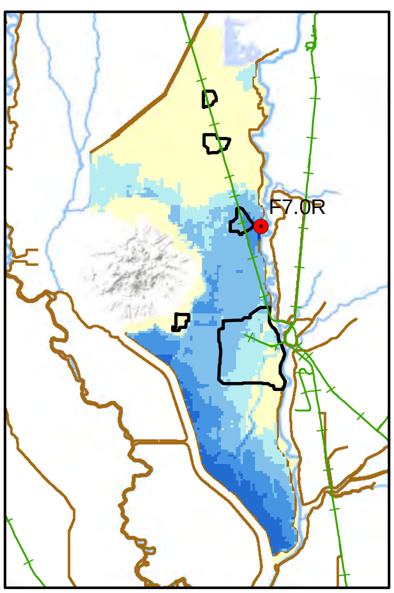


0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

Miles
0 10 20

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

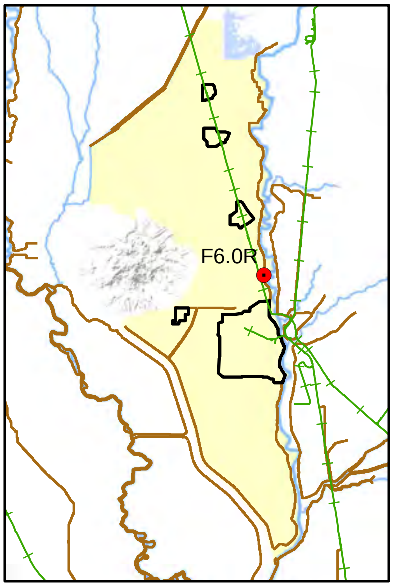
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F7.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013



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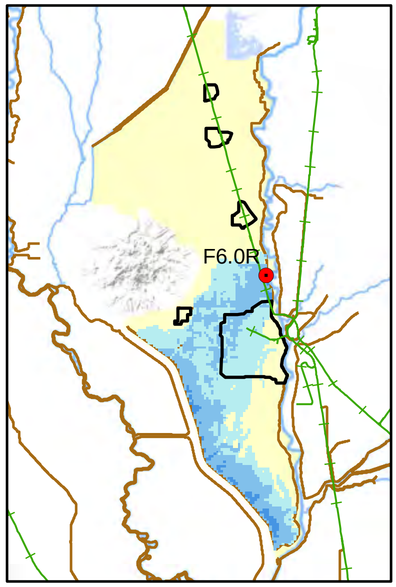

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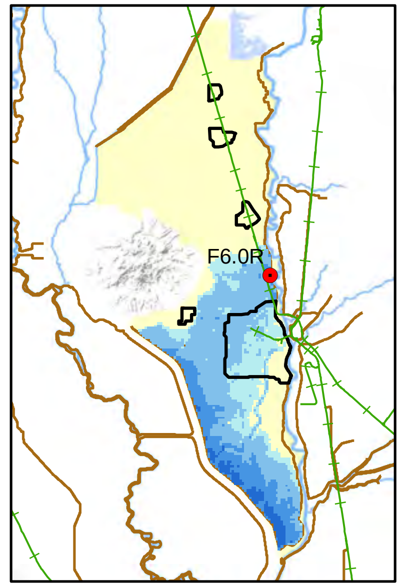

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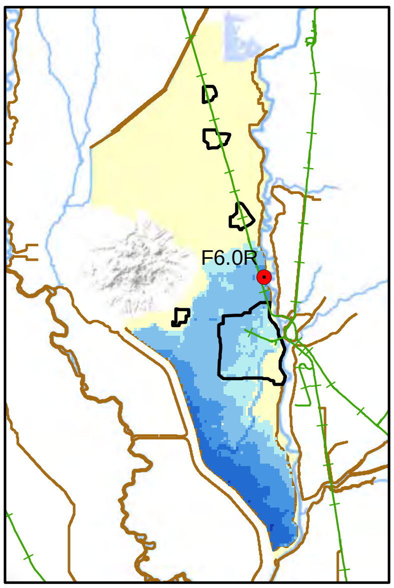

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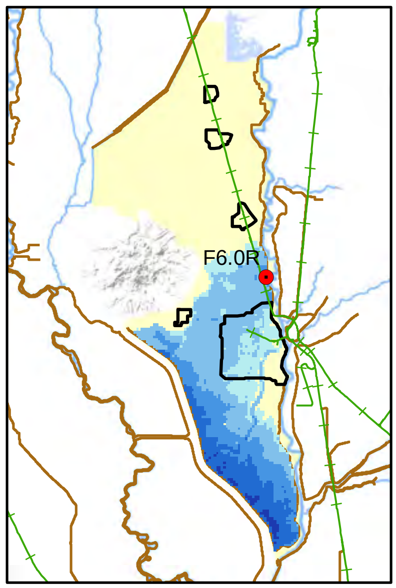

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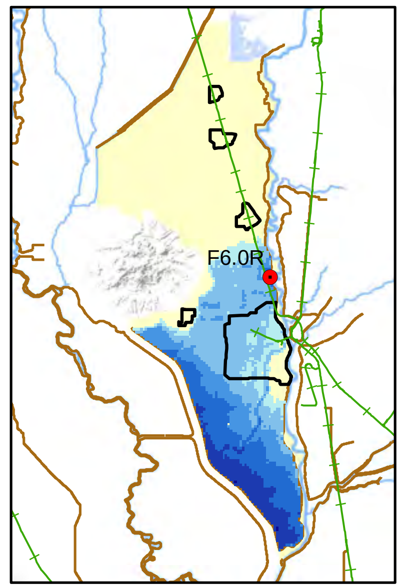

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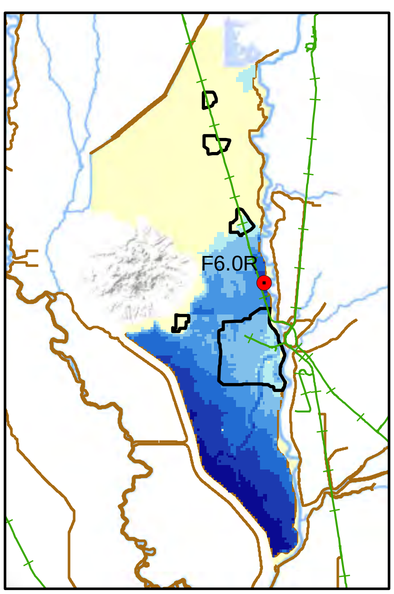


0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

Miles
0 10 20

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

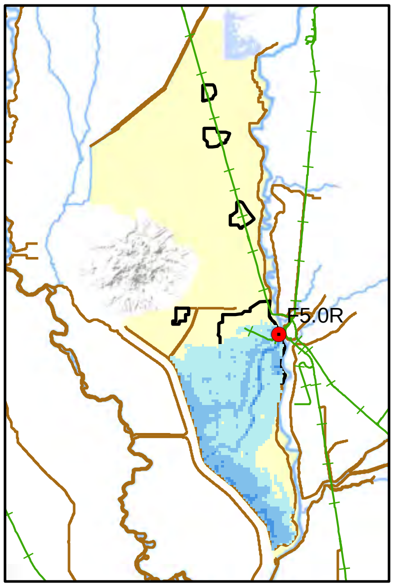
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F6.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013



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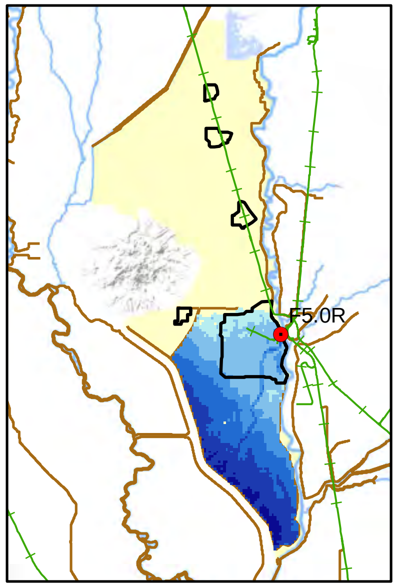
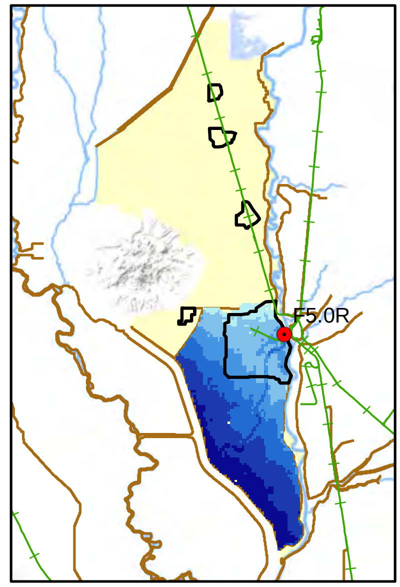


10% (1/10) ACE



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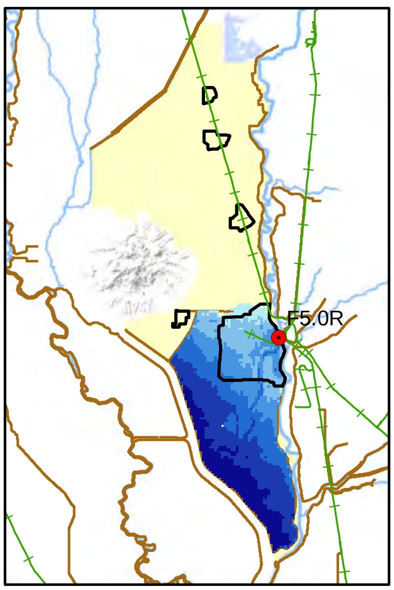

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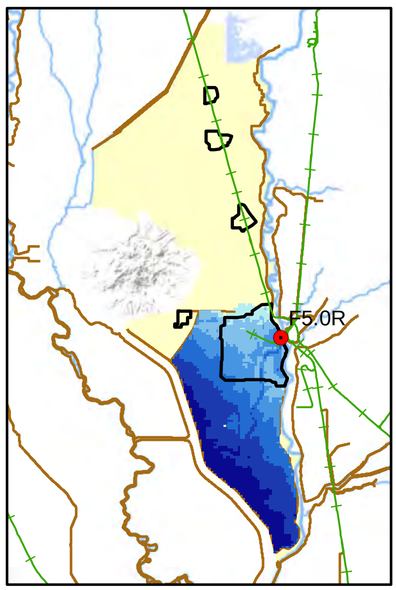
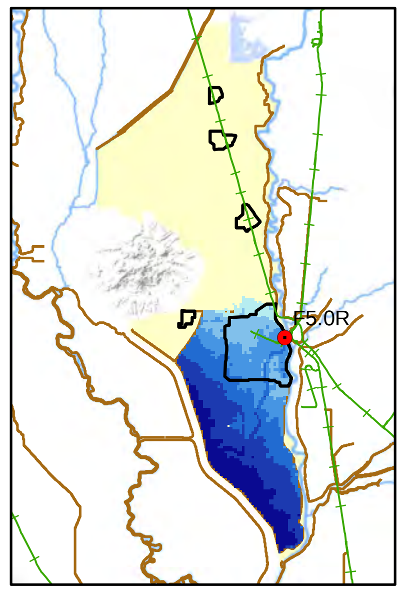


1% (1/100) ACE



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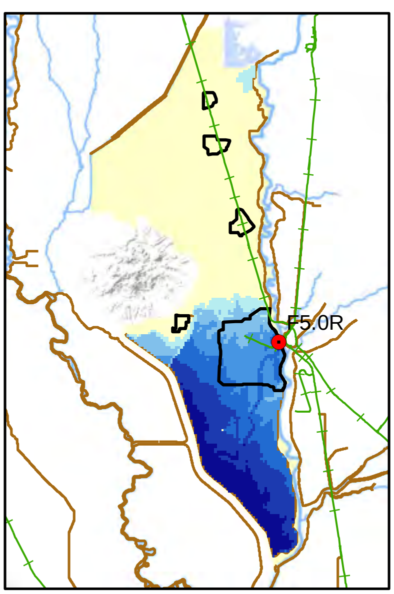


0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

0 10 20 Miles

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

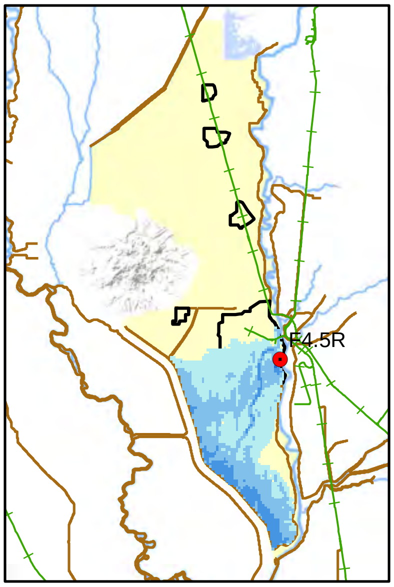
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION
ALTERNATIVE SB-1
FEATHER RIVER WEST LEVEE
LOCATION F5.0R

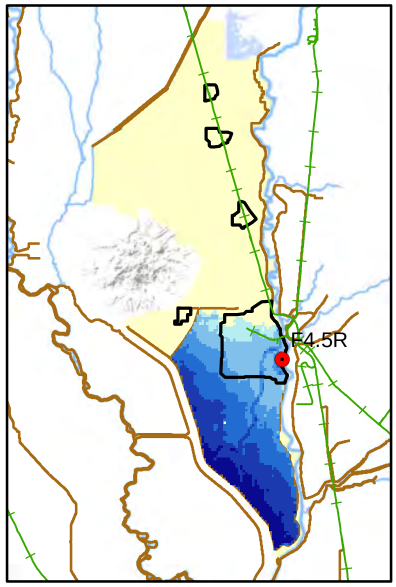
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

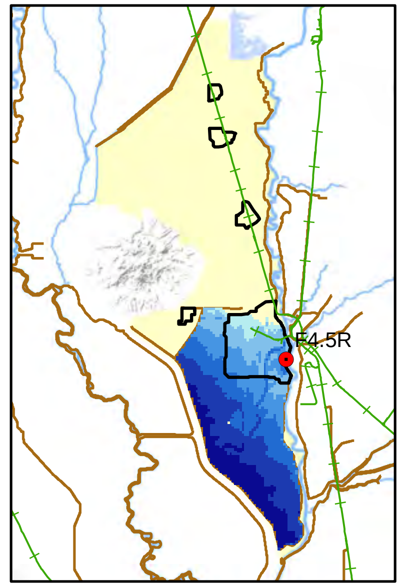
FEB 2013



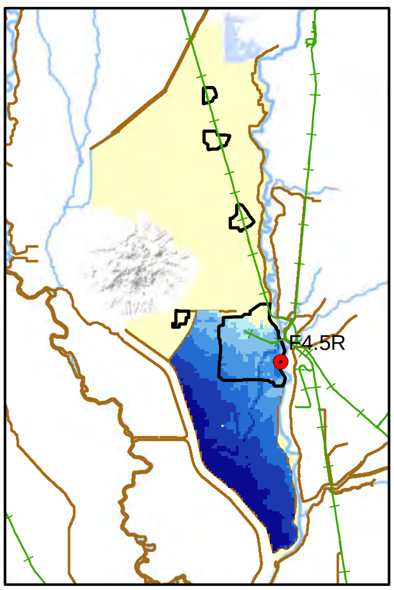
50% (1/2) ACE



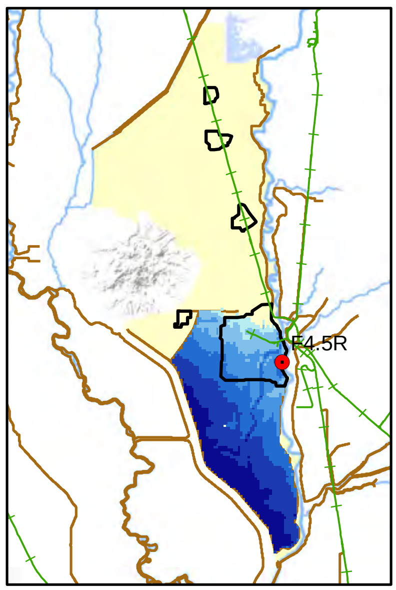
10% (1/10) ACE



4% (1/25) ACE



2% (1/50) ACE



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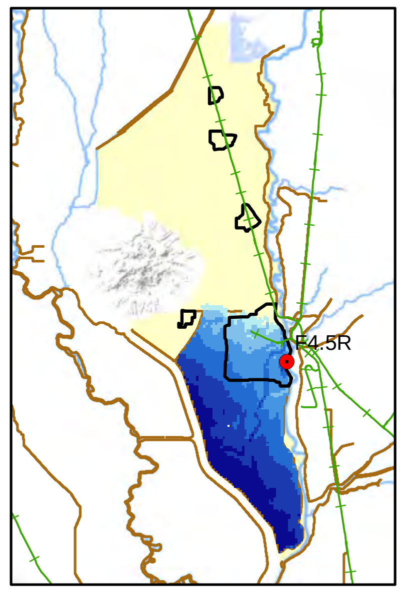
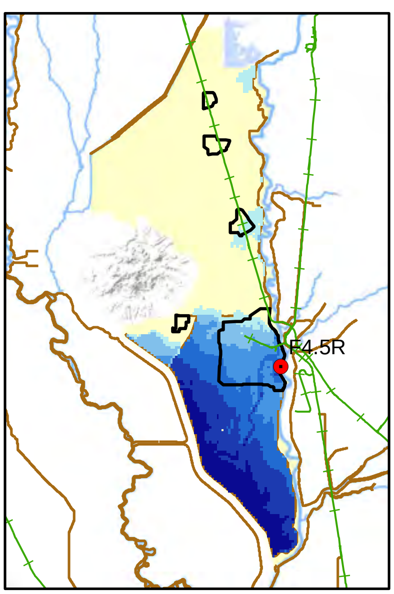


0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

0 10 20 Miles

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

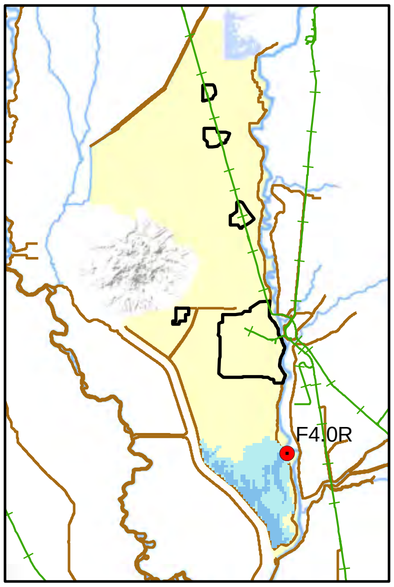
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F4.5R

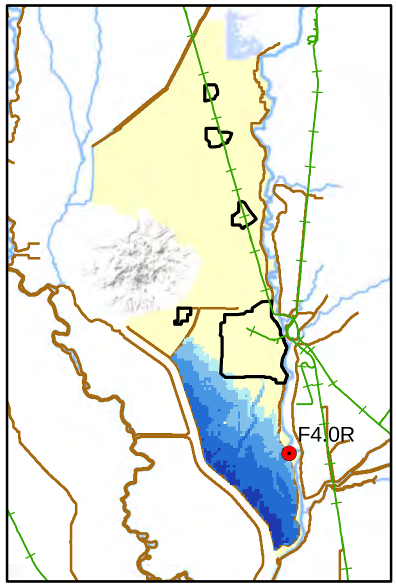
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

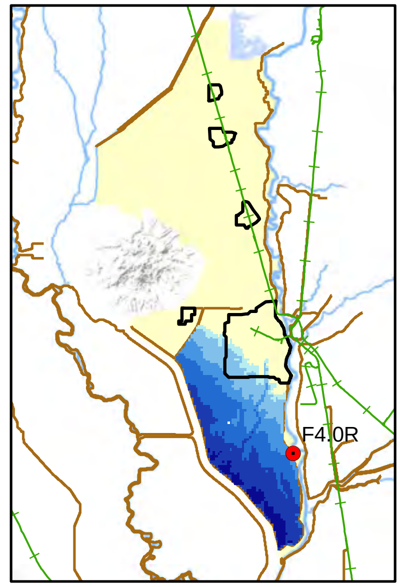
FEB 2013



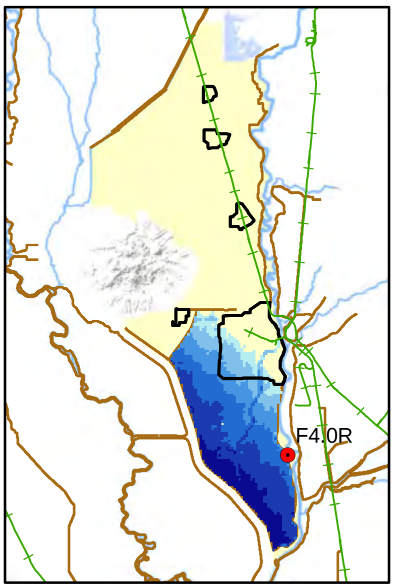
50% (1/2) ACE



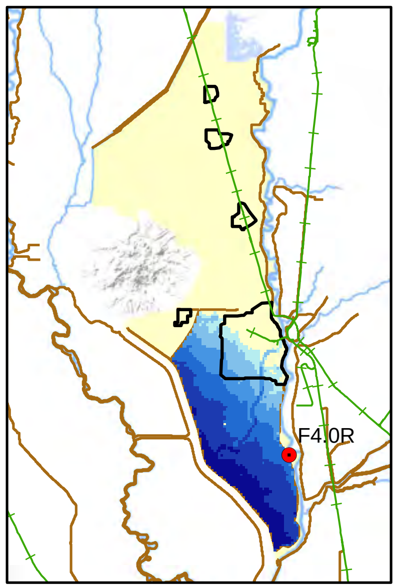
10% (1/10) ACE



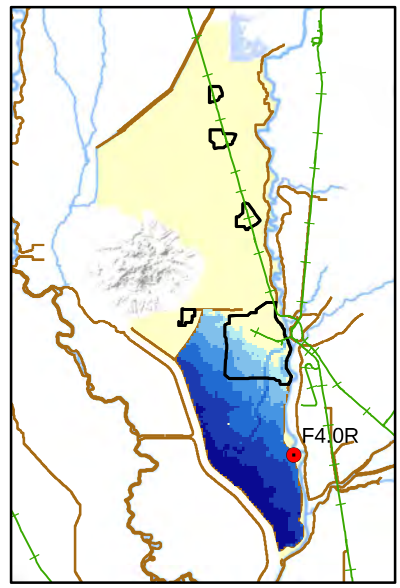
4% (1/25) ACE



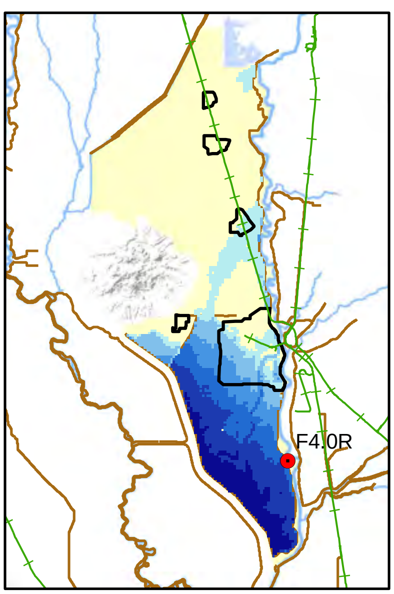
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

Miles
0 10 20

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

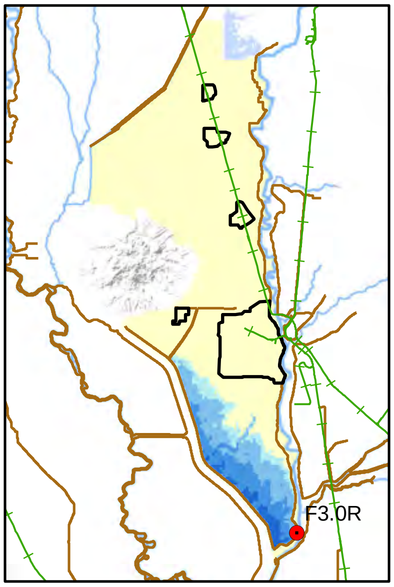
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F4.0R

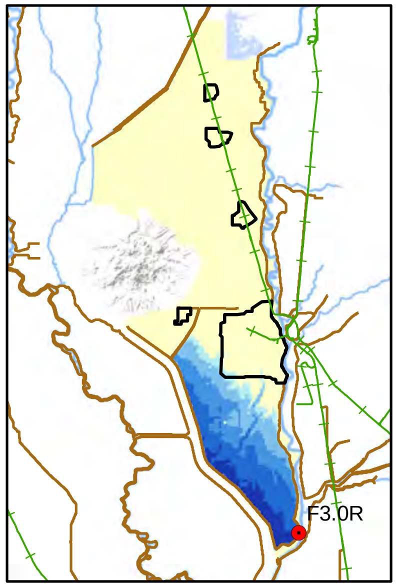
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

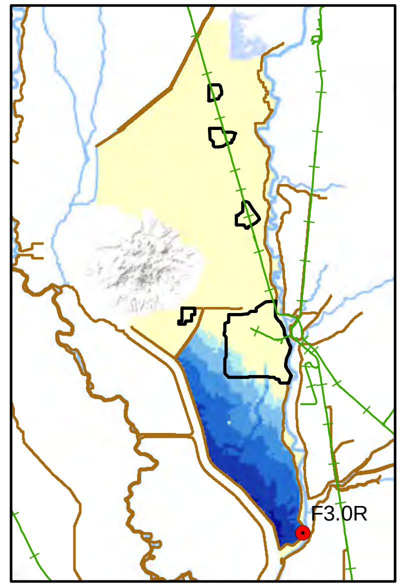
FEB 2013



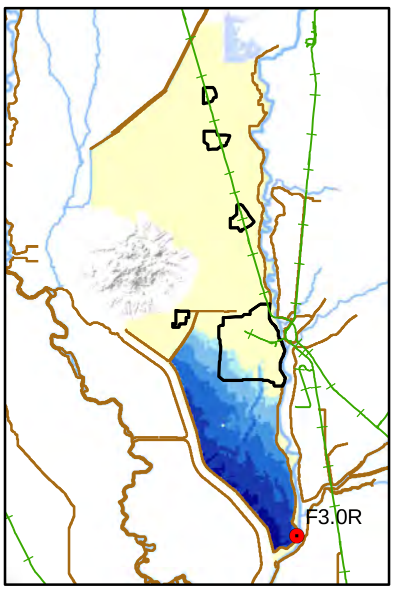
50% (1/2) ACE



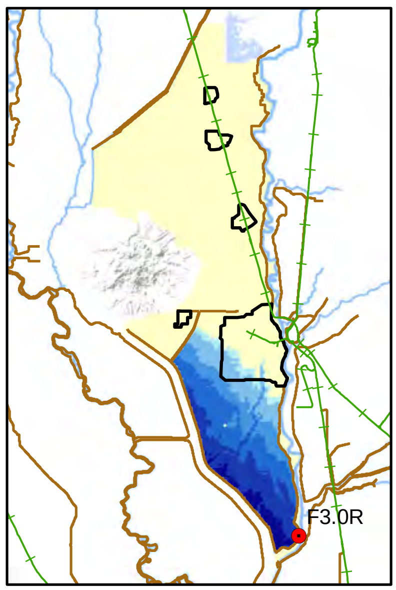
10% (1/10) ACE



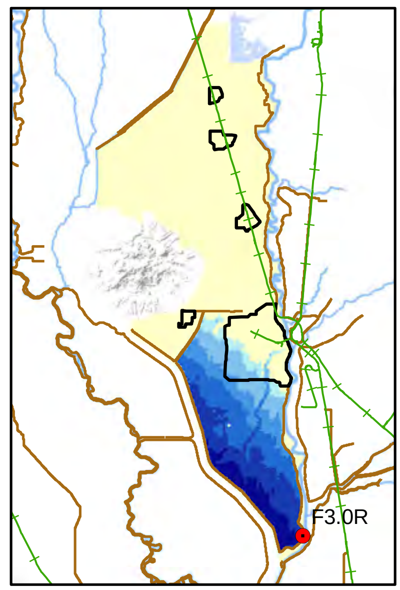
4% (1/25) ACE



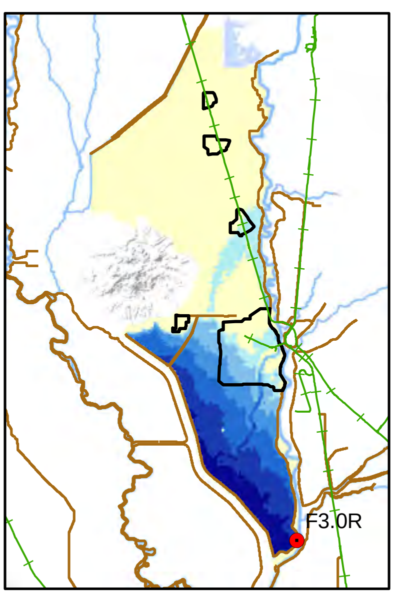
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 25

Railroad

Miles
0 10 20

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

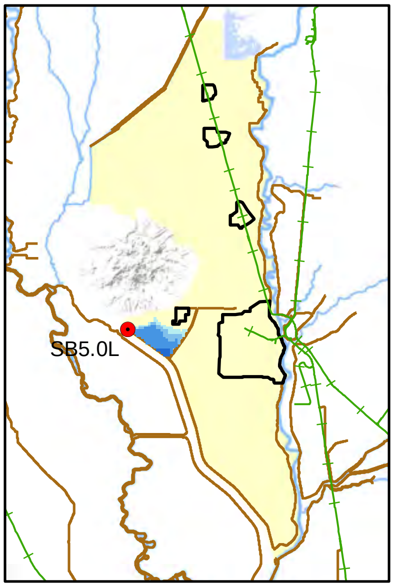
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F3.0R

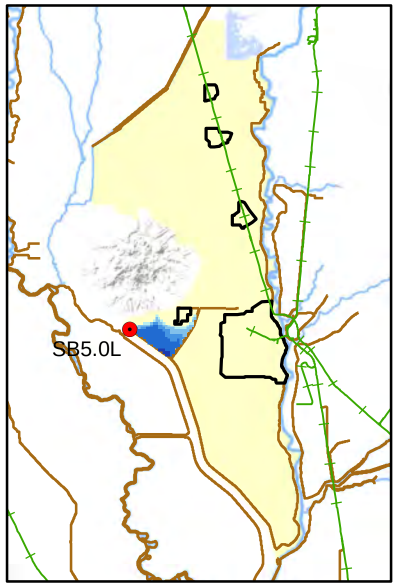
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

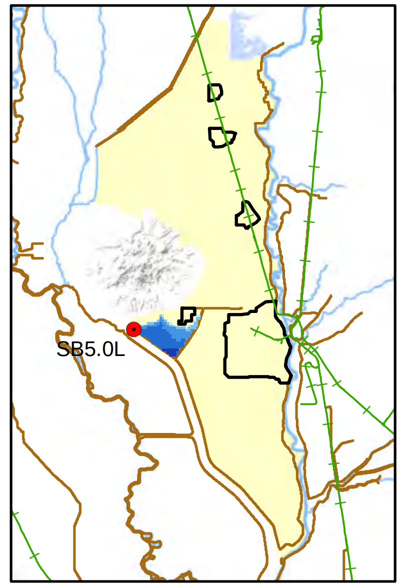
FEB 2013



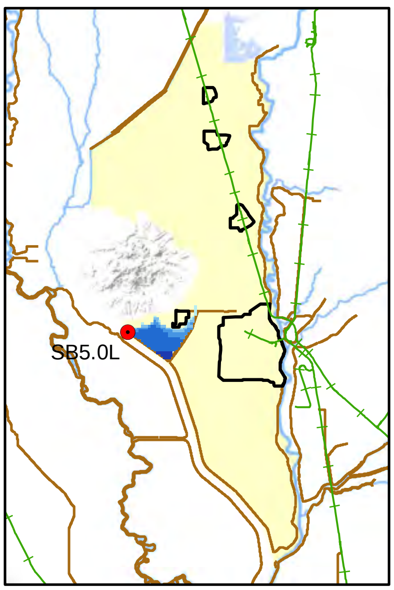
50% (1/2) ACE



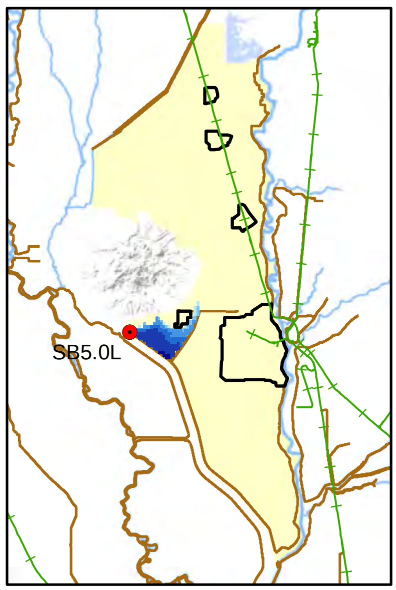
10% (1/10) ACE



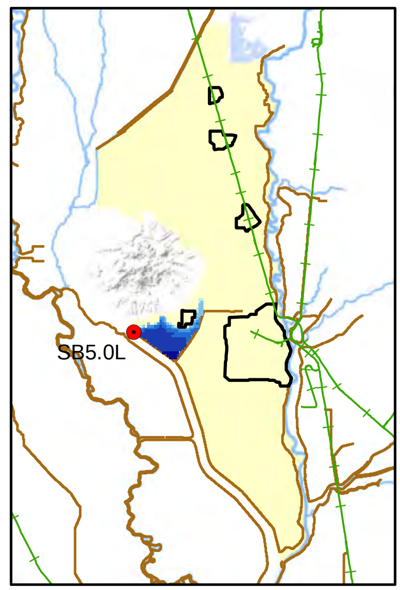
4% (1/25) ACE



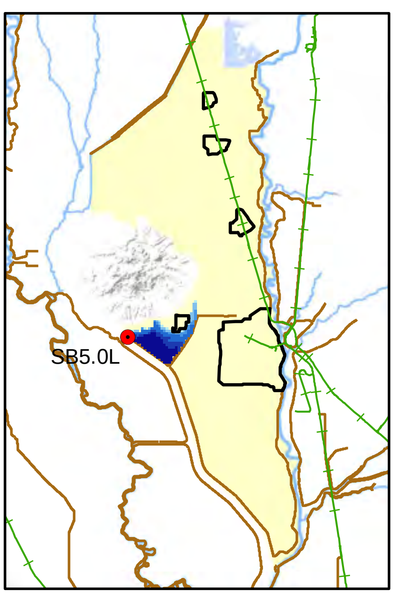
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

0 10 20 Miles

N

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

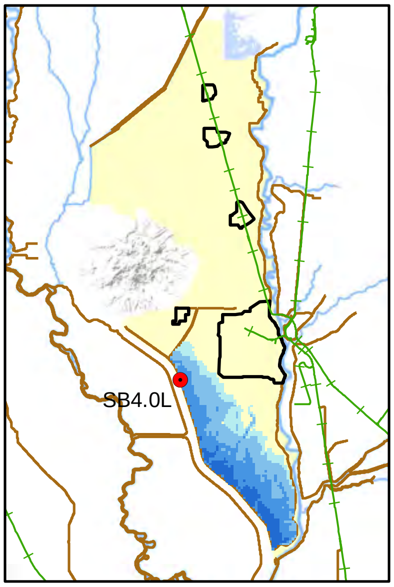
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 SUTTER BYPASS EAST LEVEE LOCATION SB5.0L

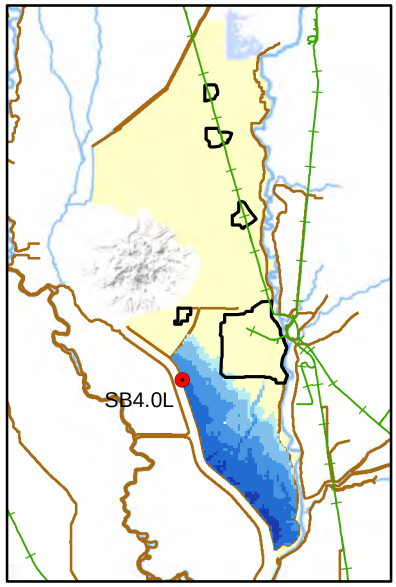
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

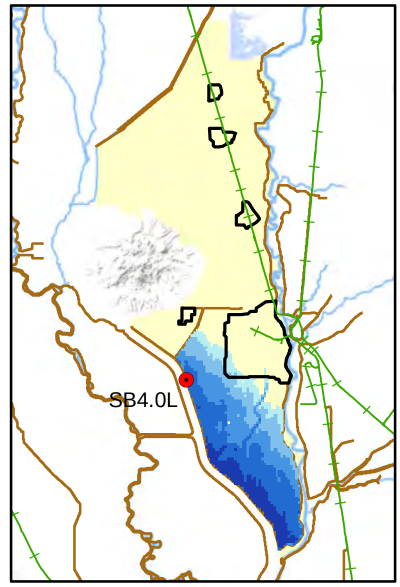
FEB 2013



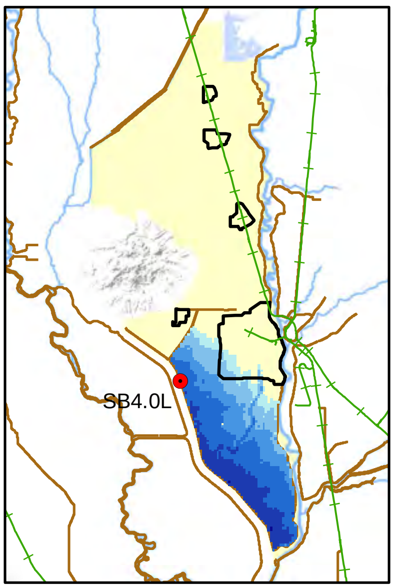
50% (1/2) ACE



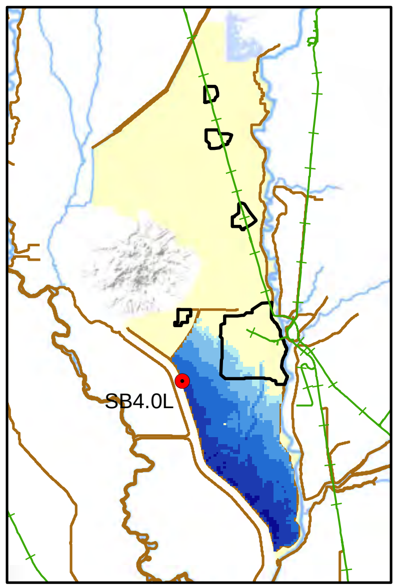
10% (1/10) ACE



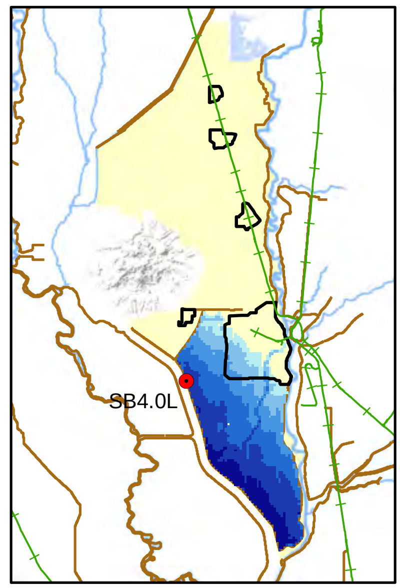
4% (1/25) ACE



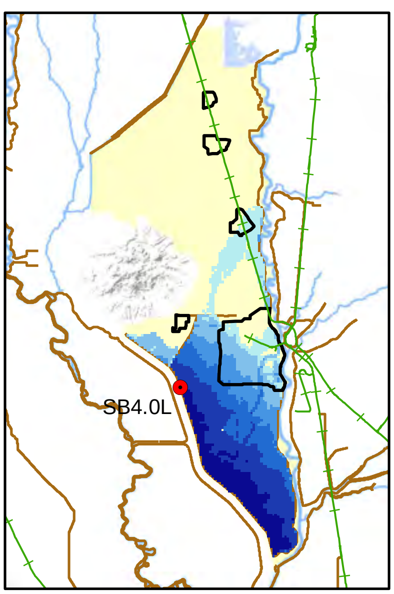
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

Miles
0 10 20

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

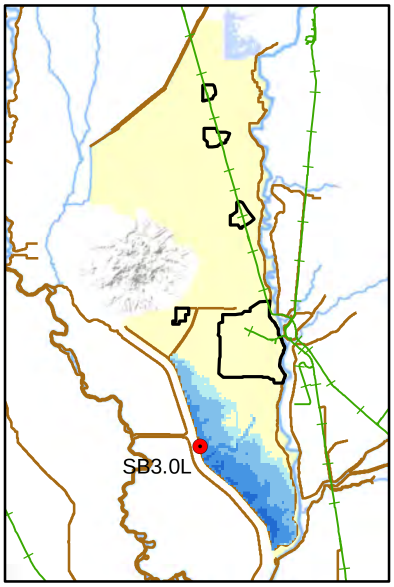
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 SUTTER BYPASS EAST LEVEE LOCATION SB4.0L

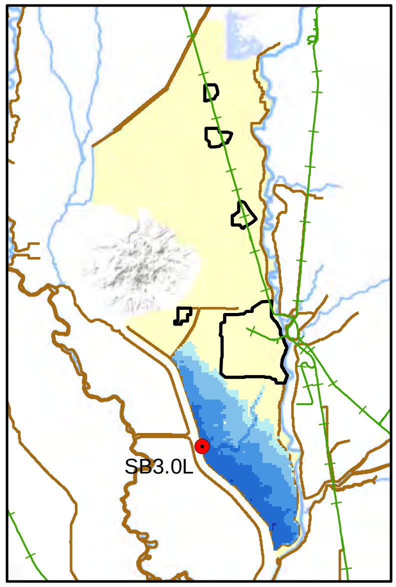
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

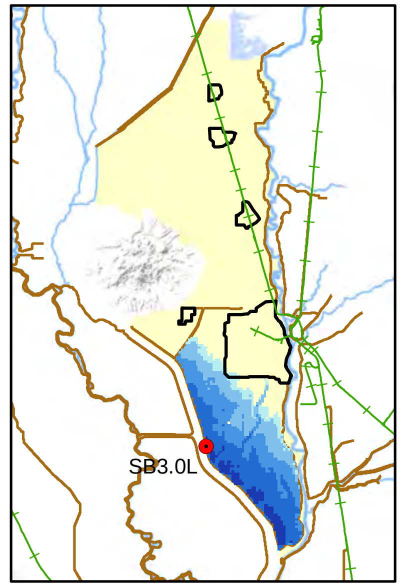
FEB 2013



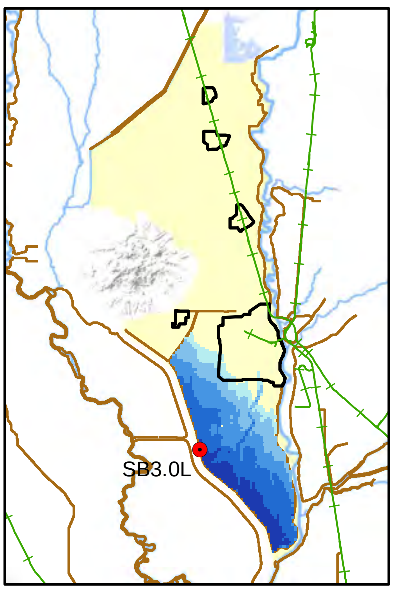
50% (1/2) ACE



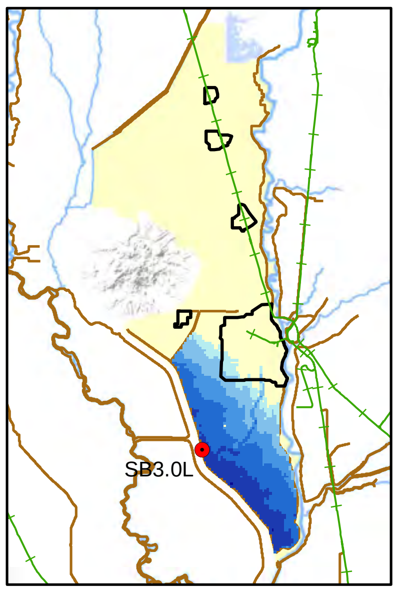
10% (1/10) ACE



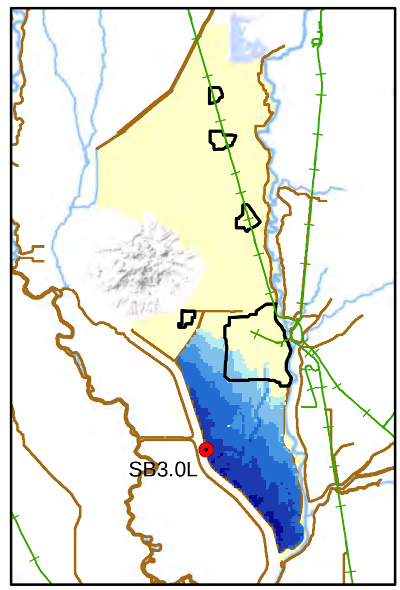
4% (1/25) ACE



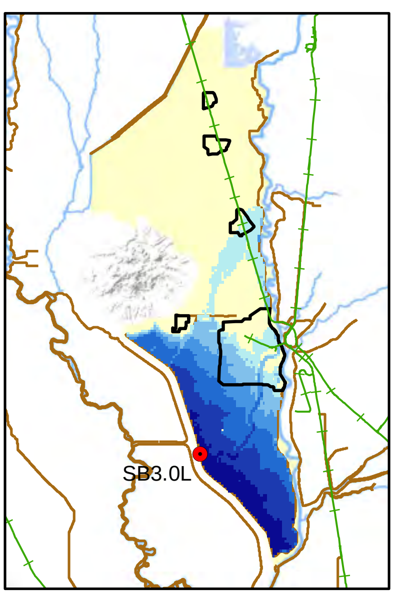
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

0 10 20 Miles

N

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

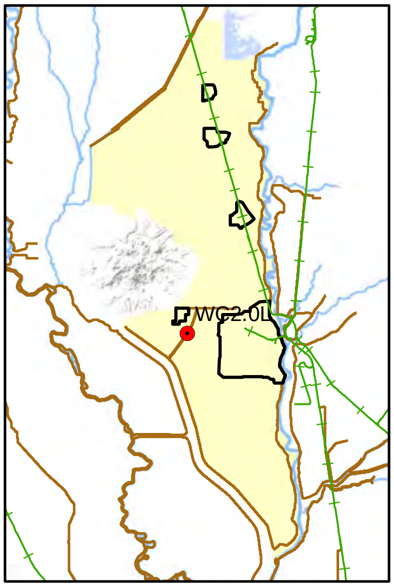
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 SUTTER BYPASS EAST LEVEE LOCATION SB3.0L

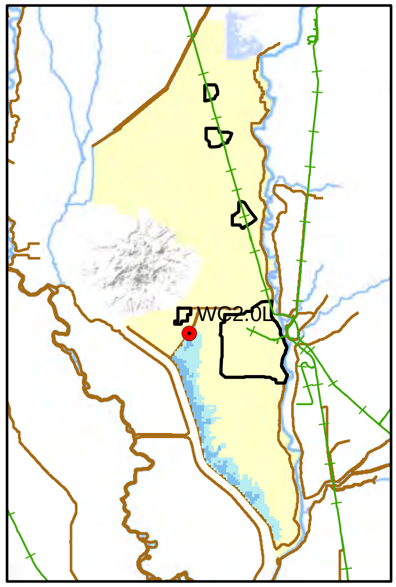
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

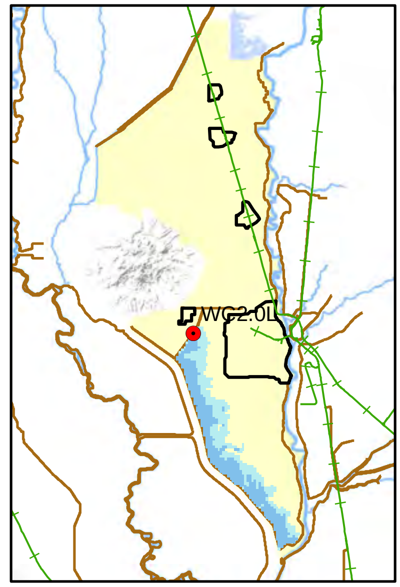
FEB 2013



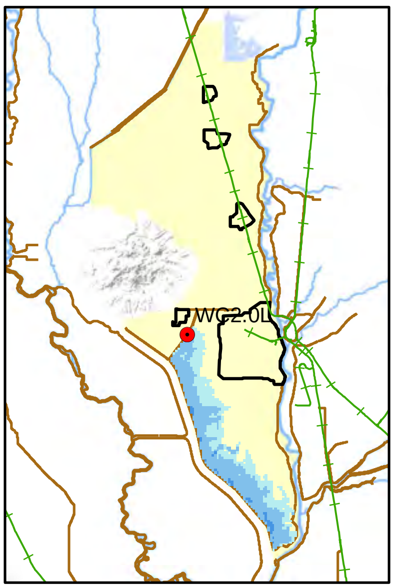
50% (1/2) ACE



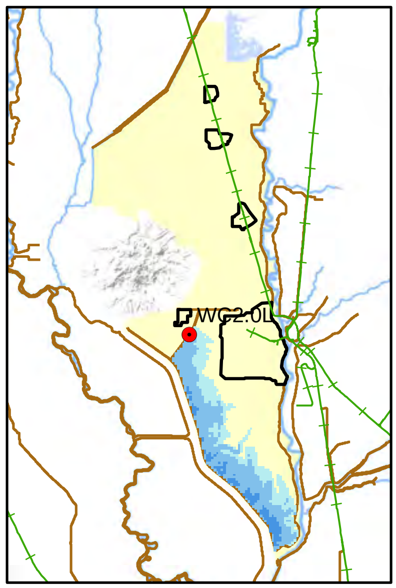
10% (1/10) ACE



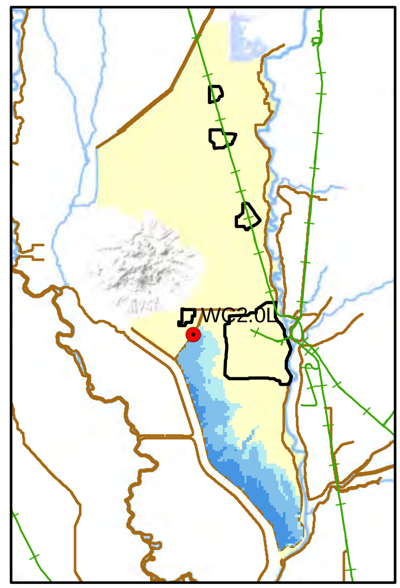
4% (1/25) ACE



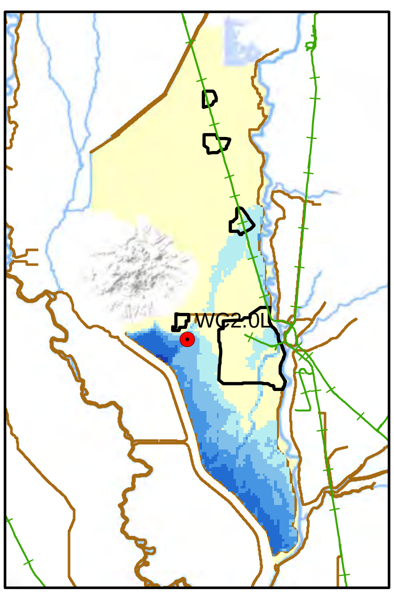
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

0 10 20 Miles

N

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

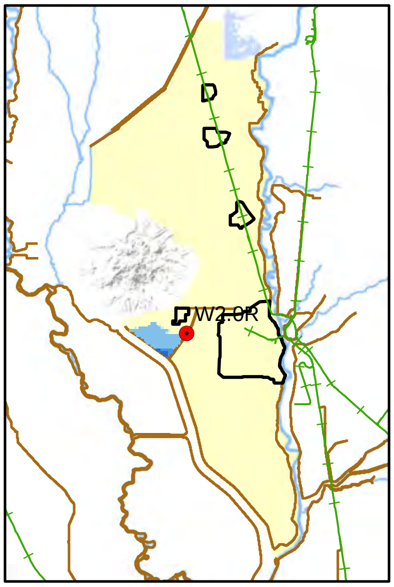
BREACH SIMULATION
ALTERNATIVE SB-1
WADSWORTH CANAL SOUTH LEVEE
LOCATION WC2.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

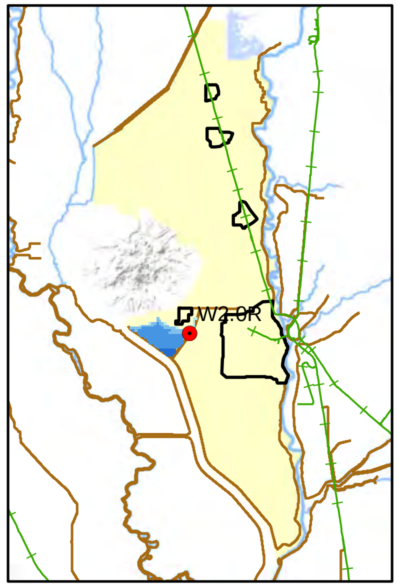
Prepared by T. Hatch

FEB 2013

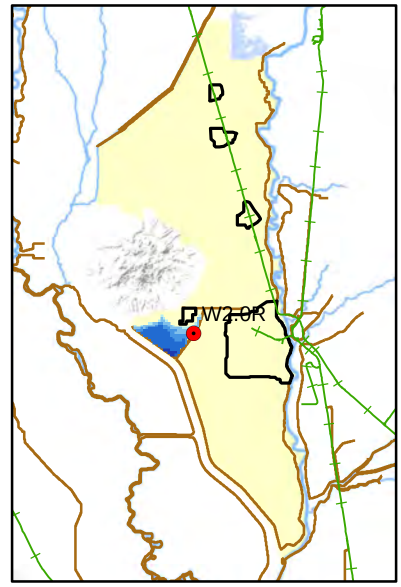
PLATE 42



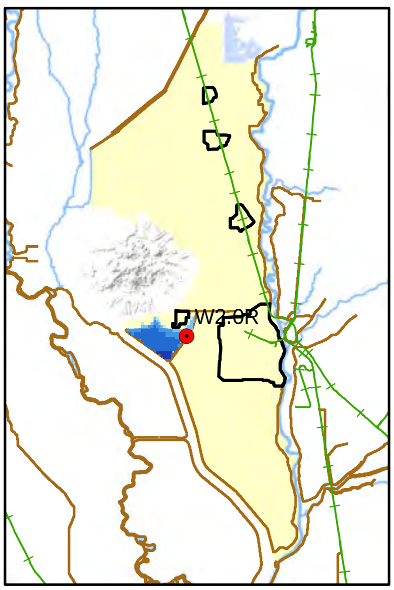
50% (1/2) ACE



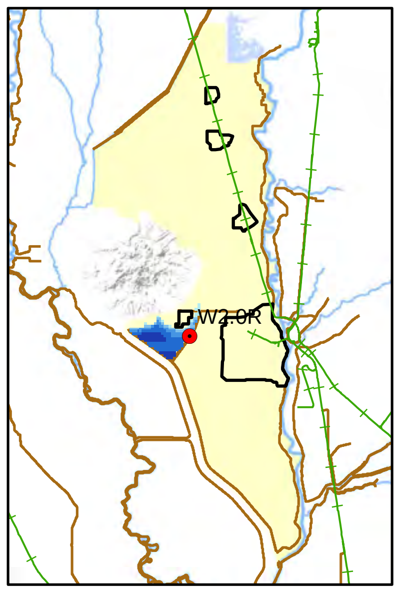
10% (1/10) ACE



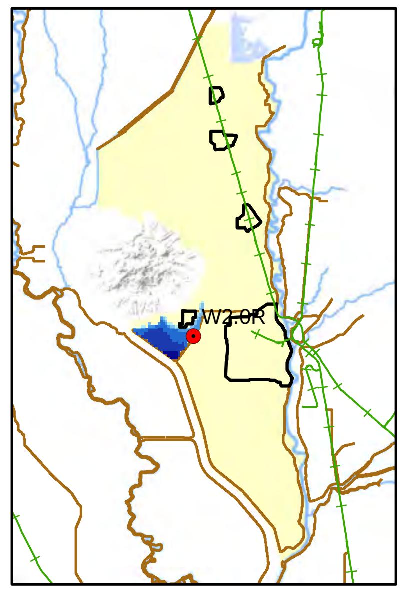
4% (1/25) ACE



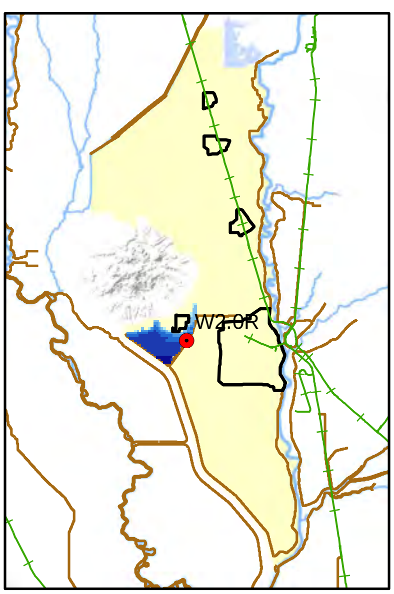
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles
0 10 20

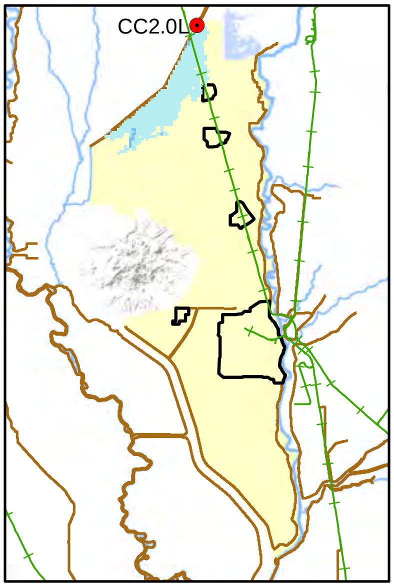
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 WADSWORTH CANAL NORTH LEVEE LOCATION W2.0R

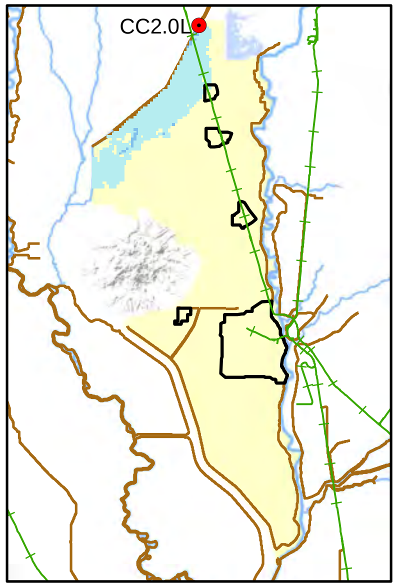
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

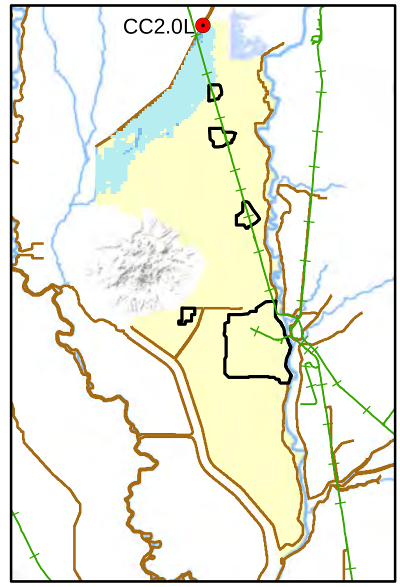
FEB 2013



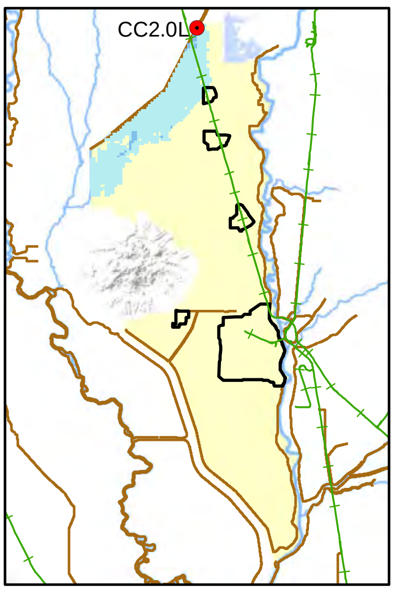
50% (1/2) ACE



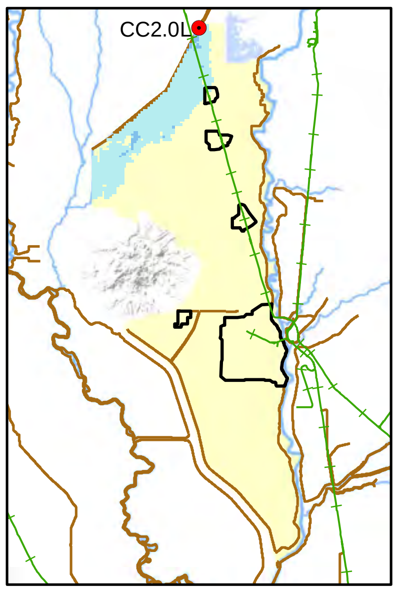
10% (1/10) ACE



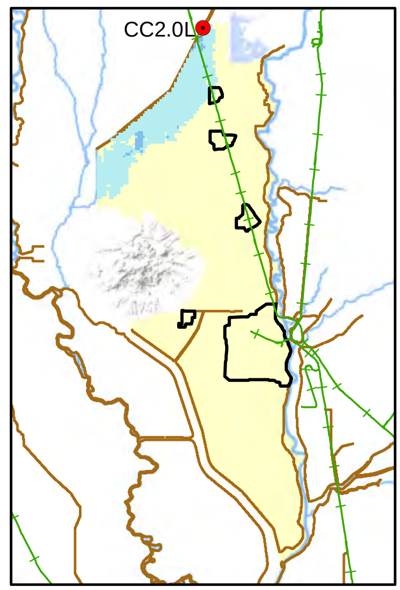
4% (1/25) ACE



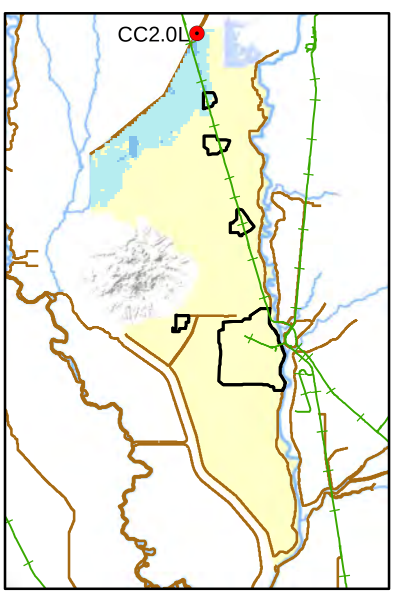
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

0 10 20 Miles

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

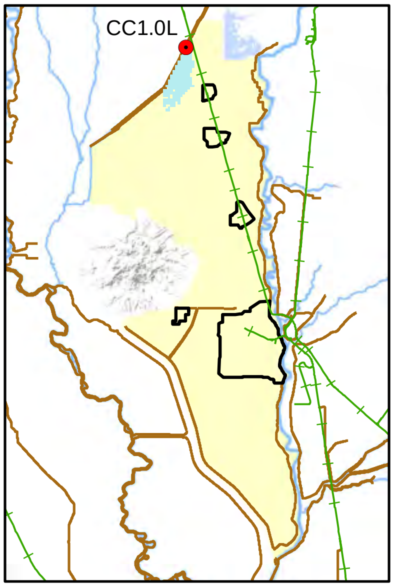
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 CHEROKEE CANAL SOUTH LEVEE LOCATION CC2.0L

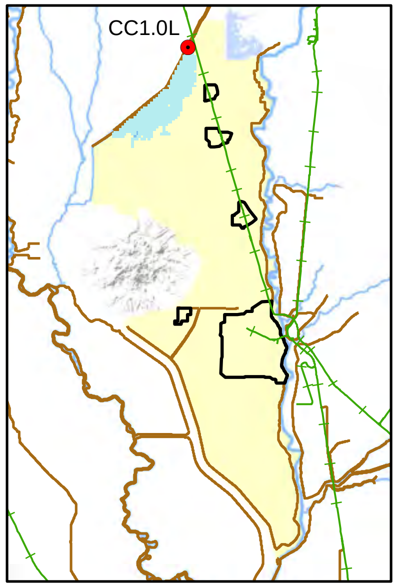
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

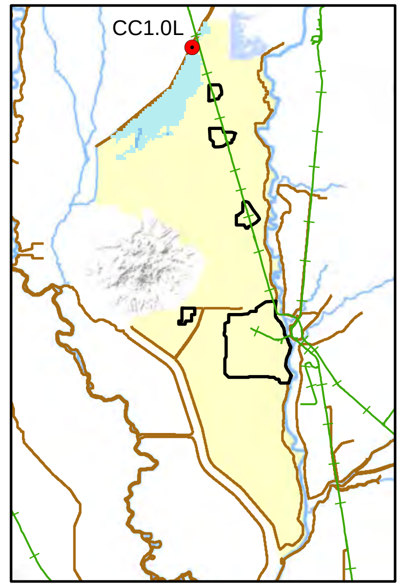
FEB 2013



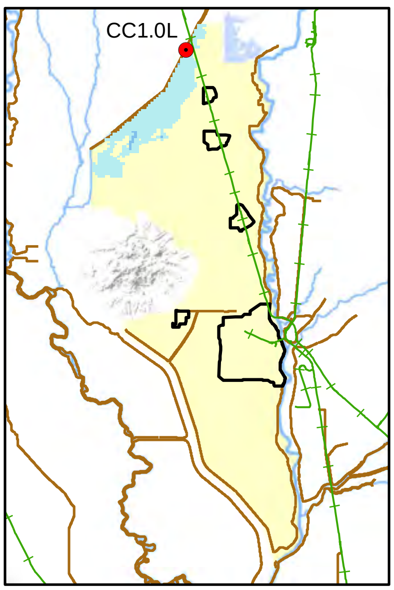
50% (1/2) ACE



10% (1/10) ACE



4% (1/25) ACE



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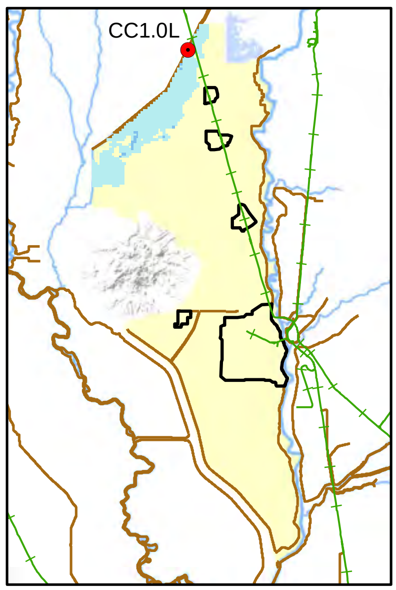
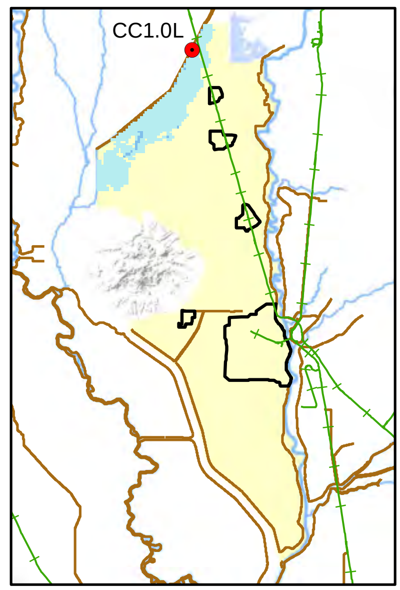
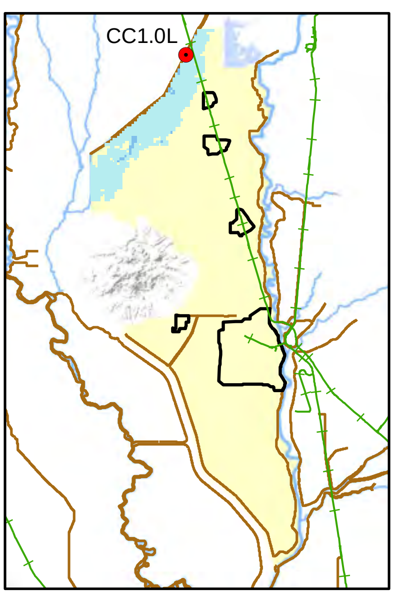


1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

0 10 20 Miles

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

BREACH SIMULATION ALTERNATIVE SB-1 CHEROKEE CANAL SOUTH LEVEE LOCATION CC1.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

NOT MODELED

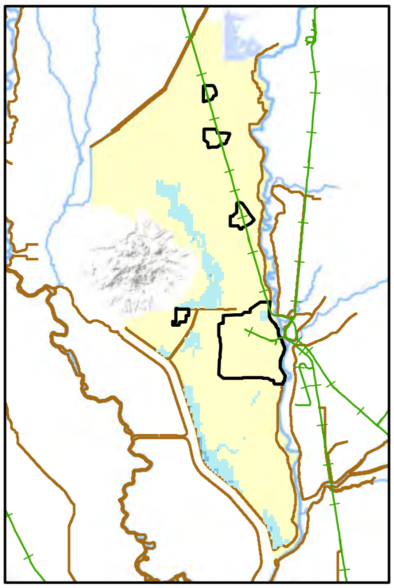
50% (1/2) ACE

NOT MODELED

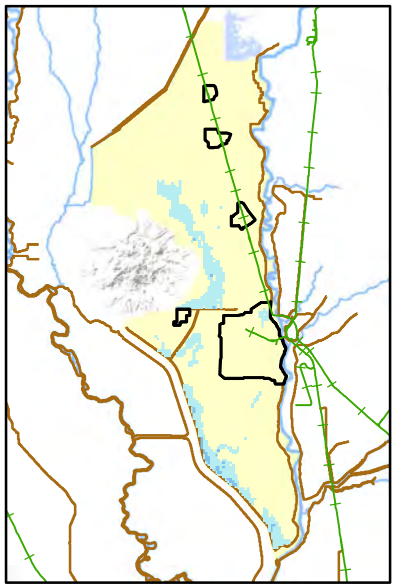
10% (1/10) ACE

NOT MODELED

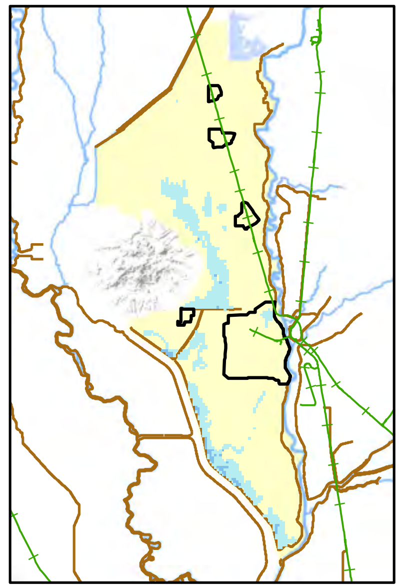
4% (1/25) ACE



2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE

NOT MODELED

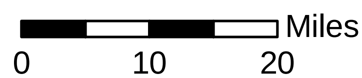
0.2% (1/500) ACE

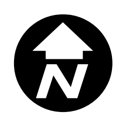
Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

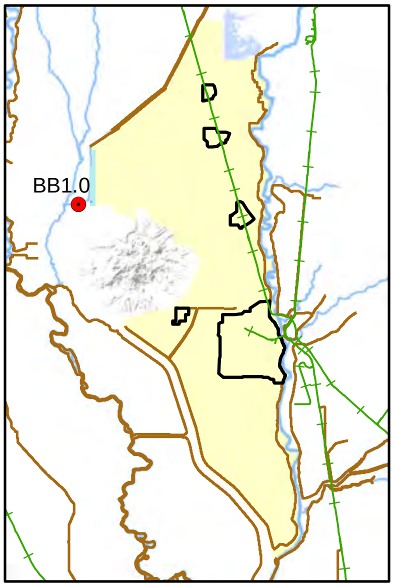




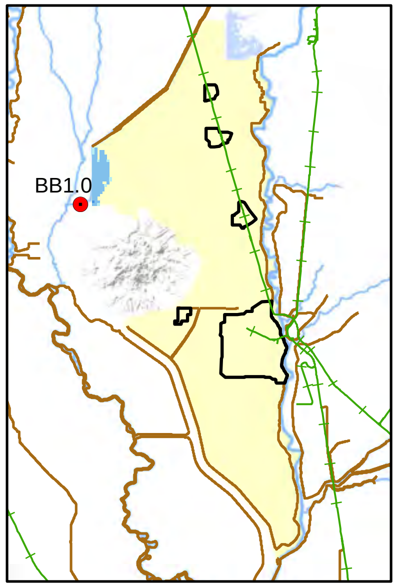
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

INTERIOR DRAINAGE ALTERNATIVE SB-1

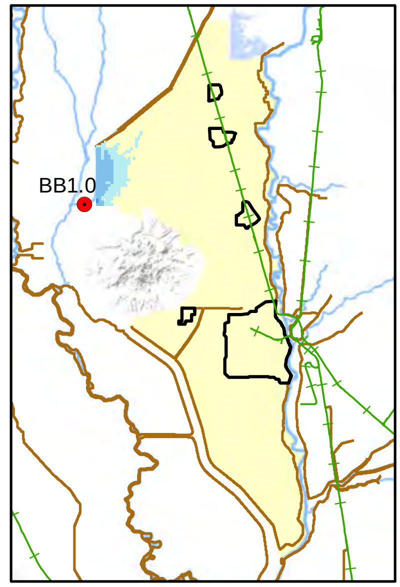
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



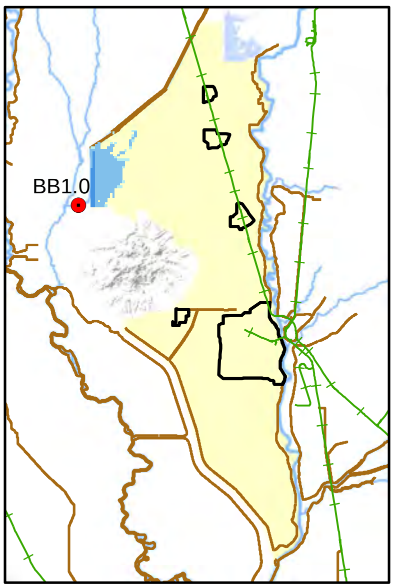
50% (1/2) ACE



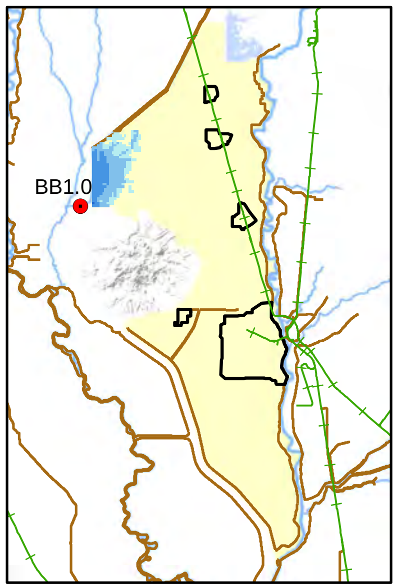
10% (1/10) ACE



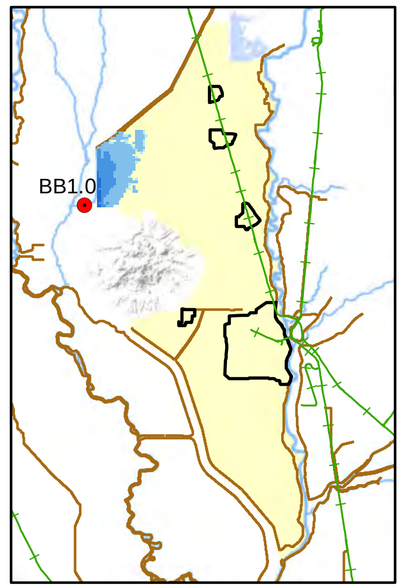
4% (1/25) ACE



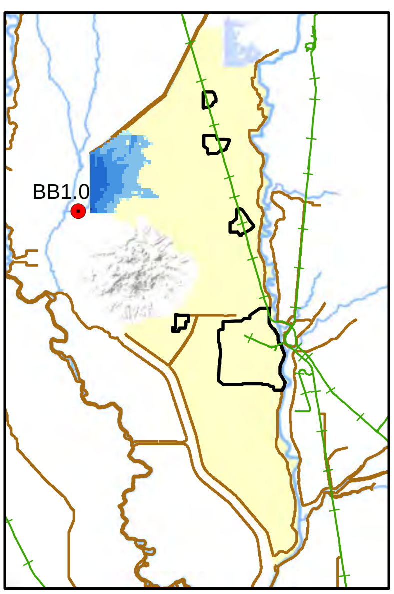
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

0 10 20 Miles

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

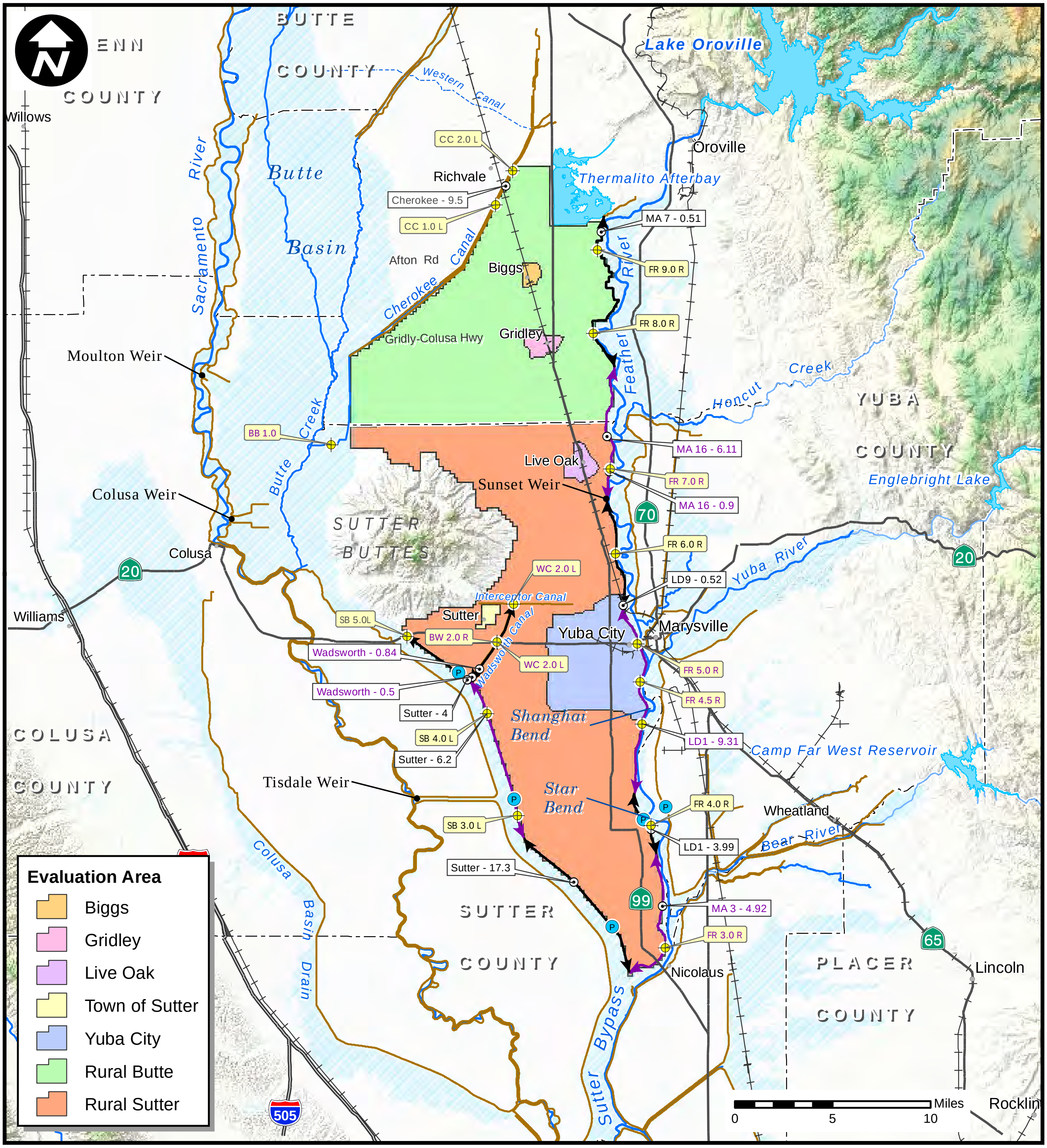
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

ALTERNATIVE SB-1
BUTTE BASIN
LOCATION BB1.0

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013



Legend

- Geotechnical Levee Reach
- Federal Levee
- Breach Simulation Site
- Geotechnical Index Point
- Pump Station
- City or Town
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad
- County Boundary

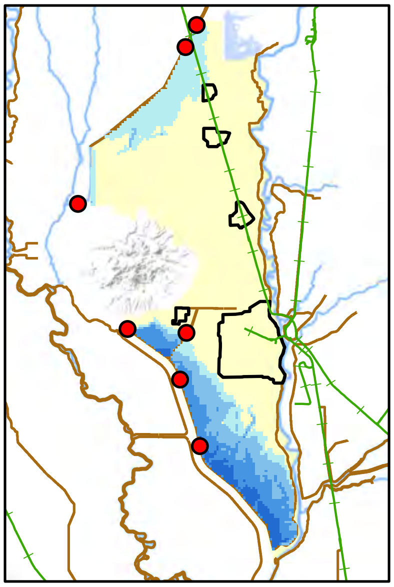
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

INDEX POINTS AND ECONOMIC IMPACT AREAS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



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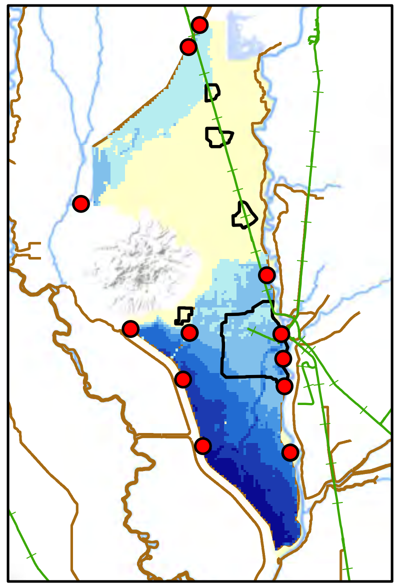
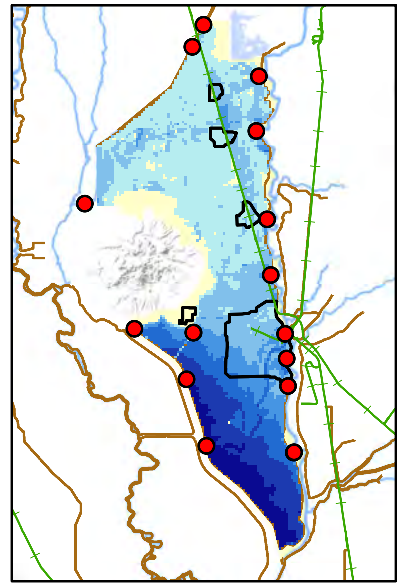
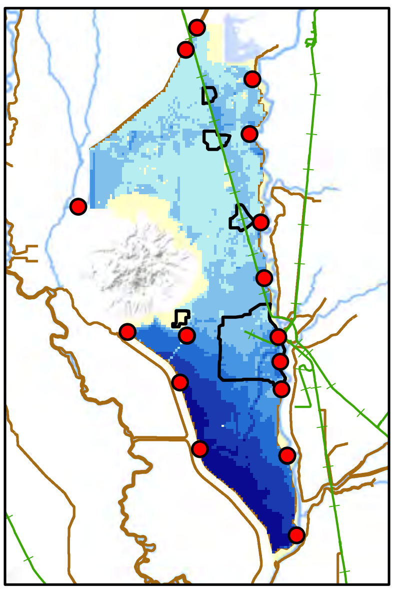


10% (1/10) ACE



4% (1/25) ACE



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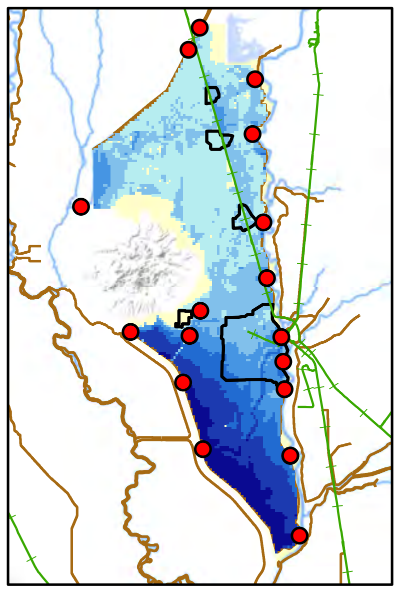
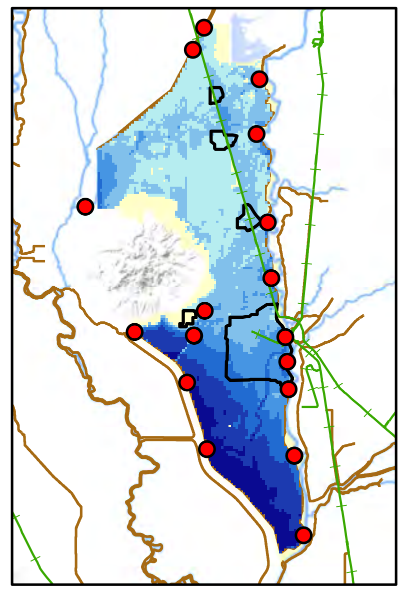


1% (1/100) ACE



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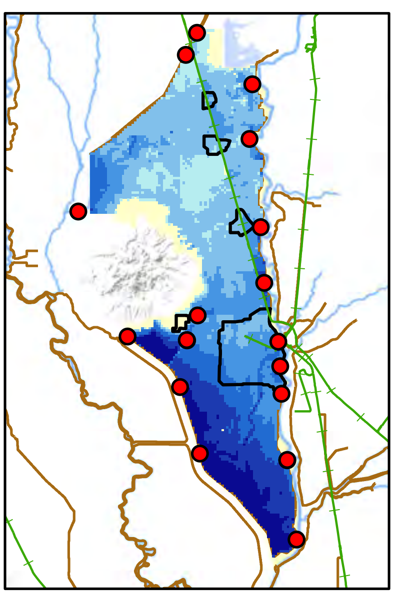


0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

Levee Fails R&U Criteria

NOTE: Breach simulation shown if levee does not pass assurance criteria.1) Assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

0 10 20 Miles

N

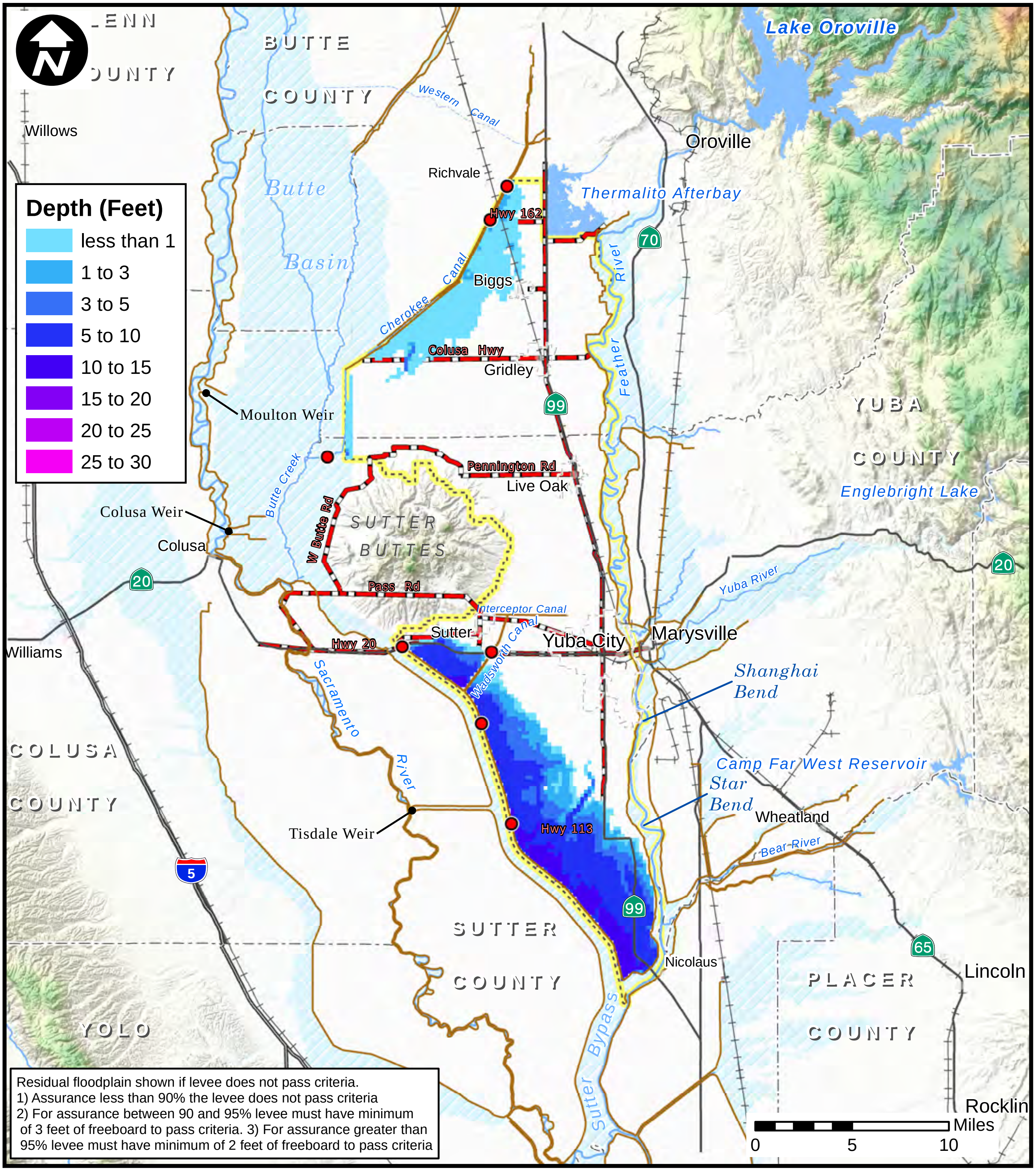
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

COMPOSITE FLOODPLAINS ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

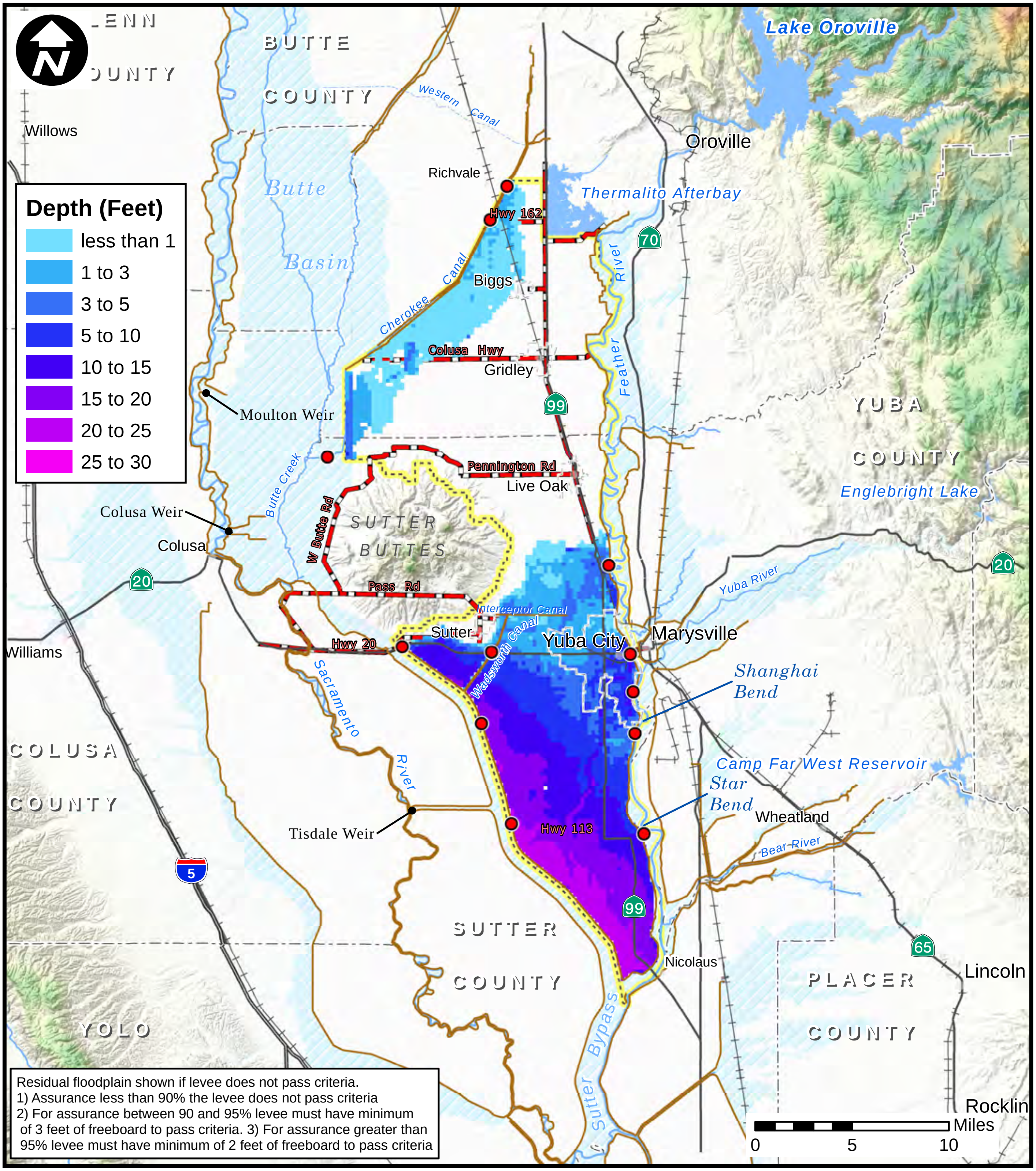
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

50% (1/2) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

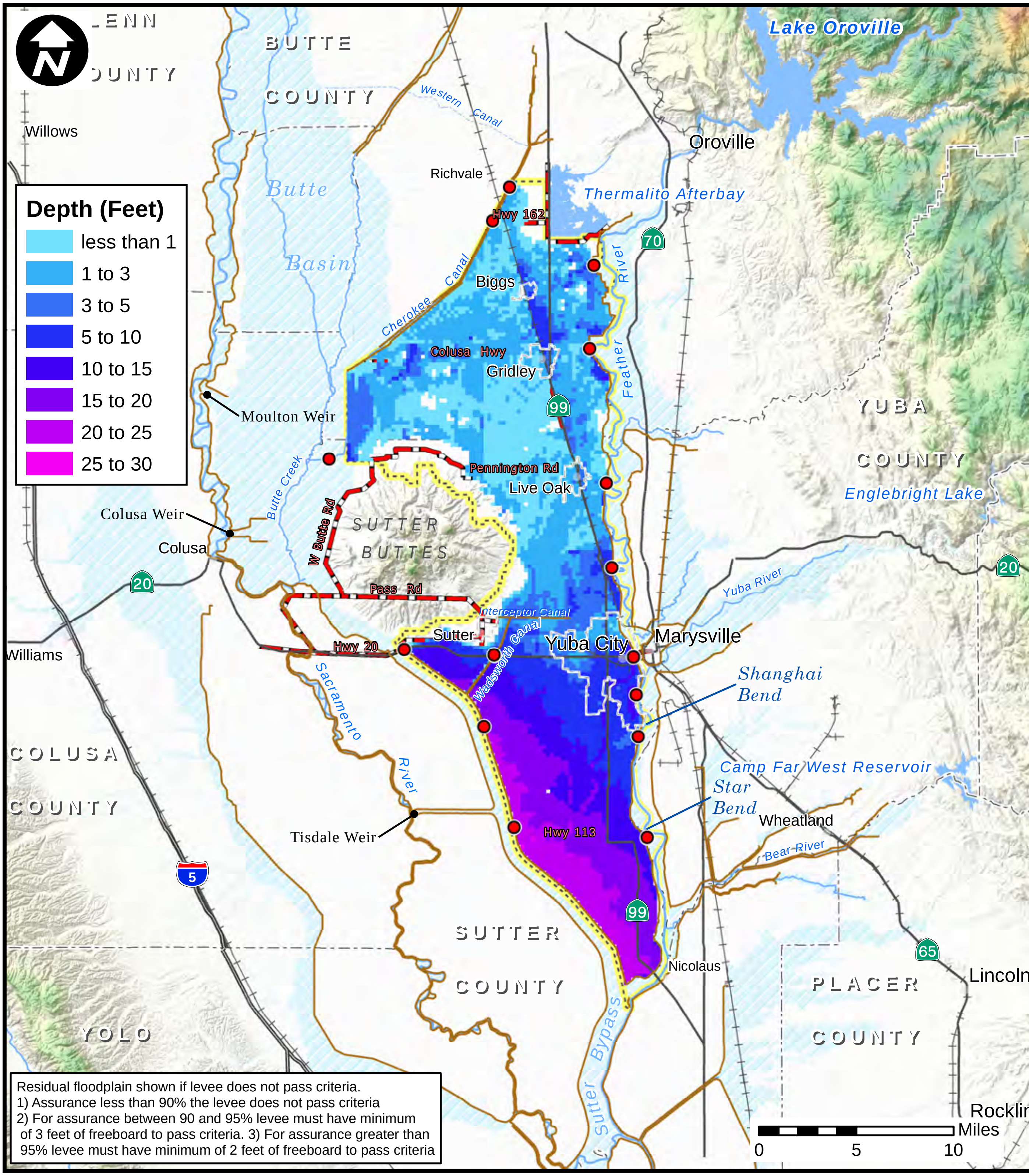
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

10% (1/10) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

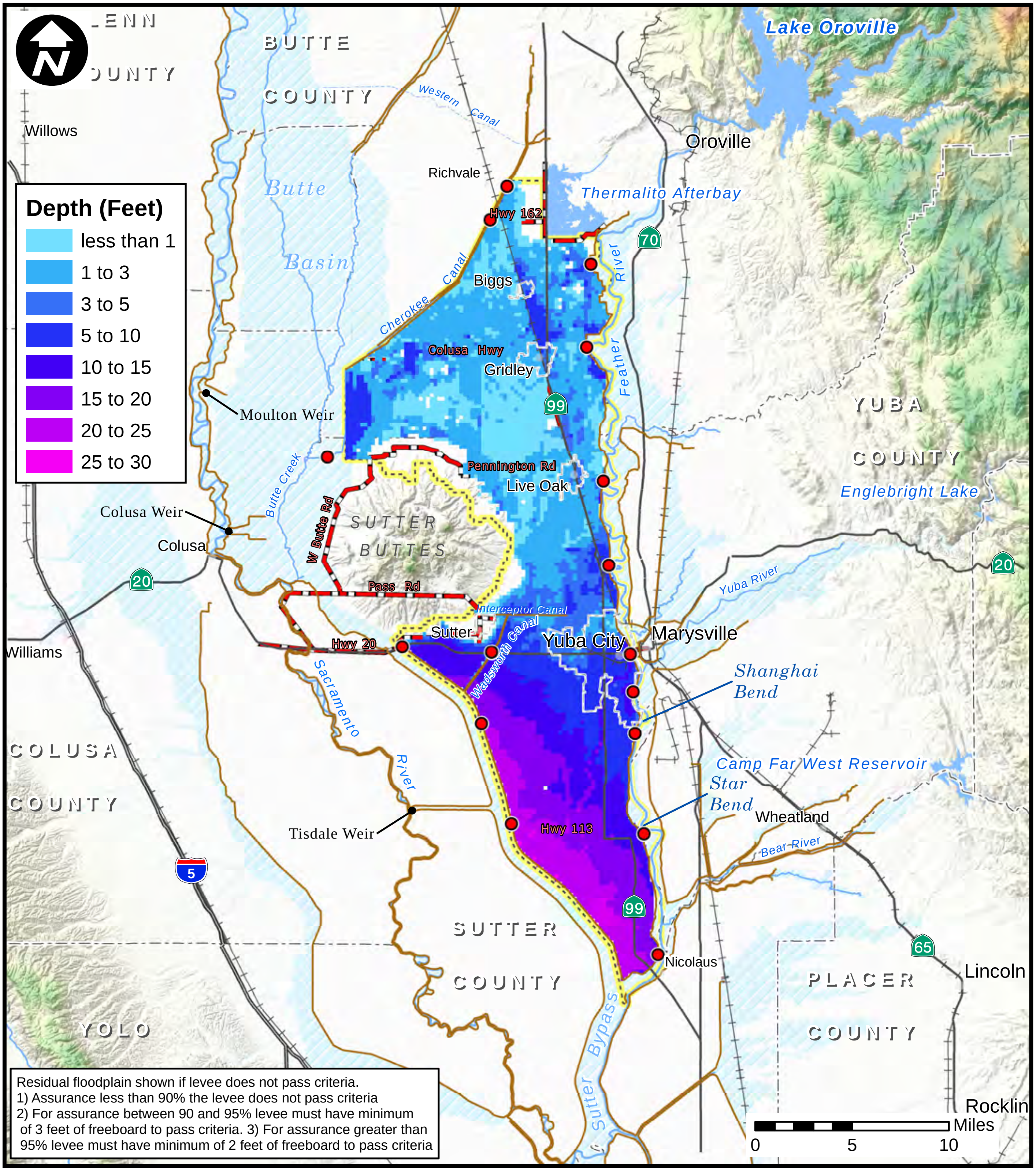
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

4% (1/25) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

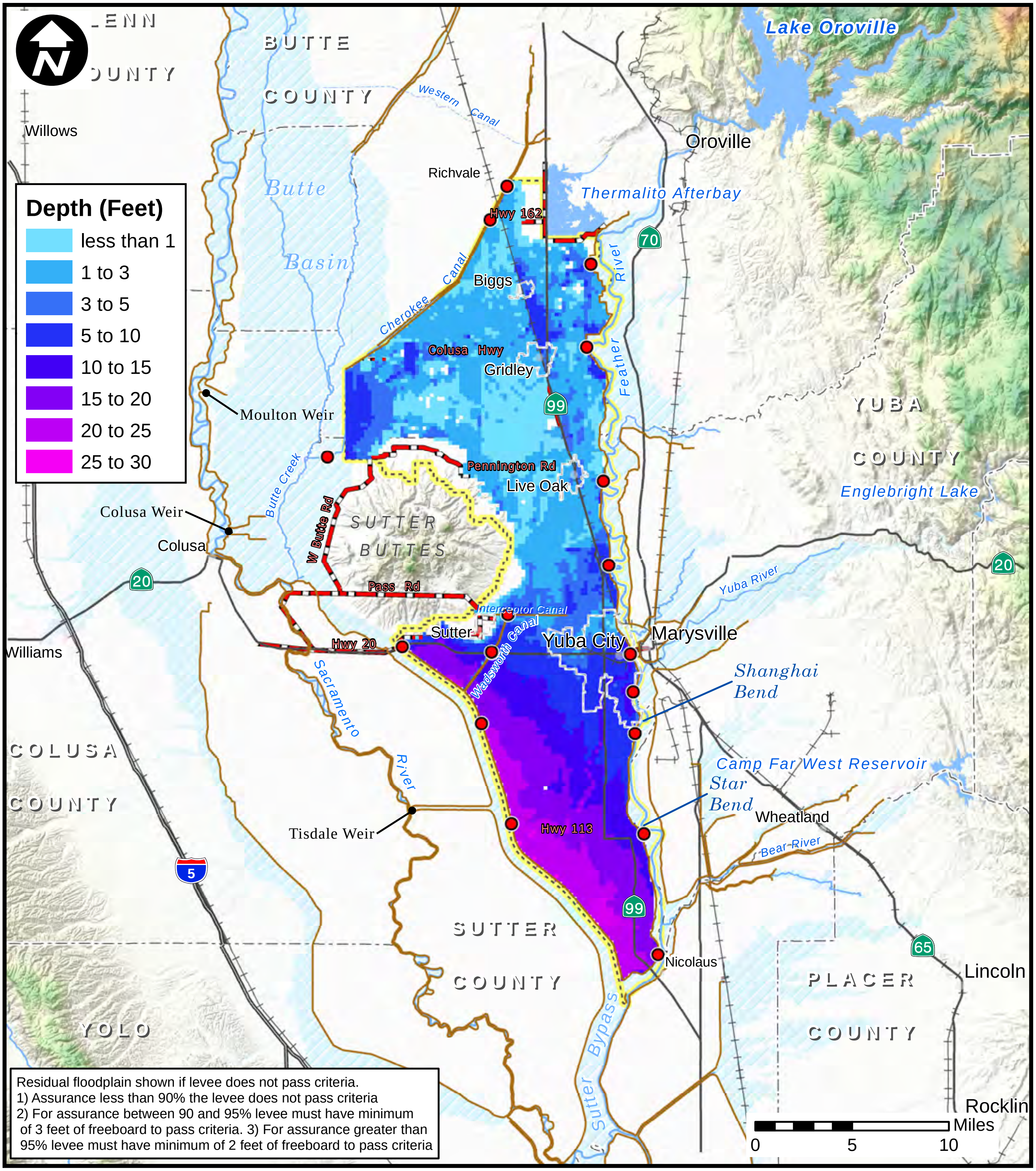
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

2% (1/50) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

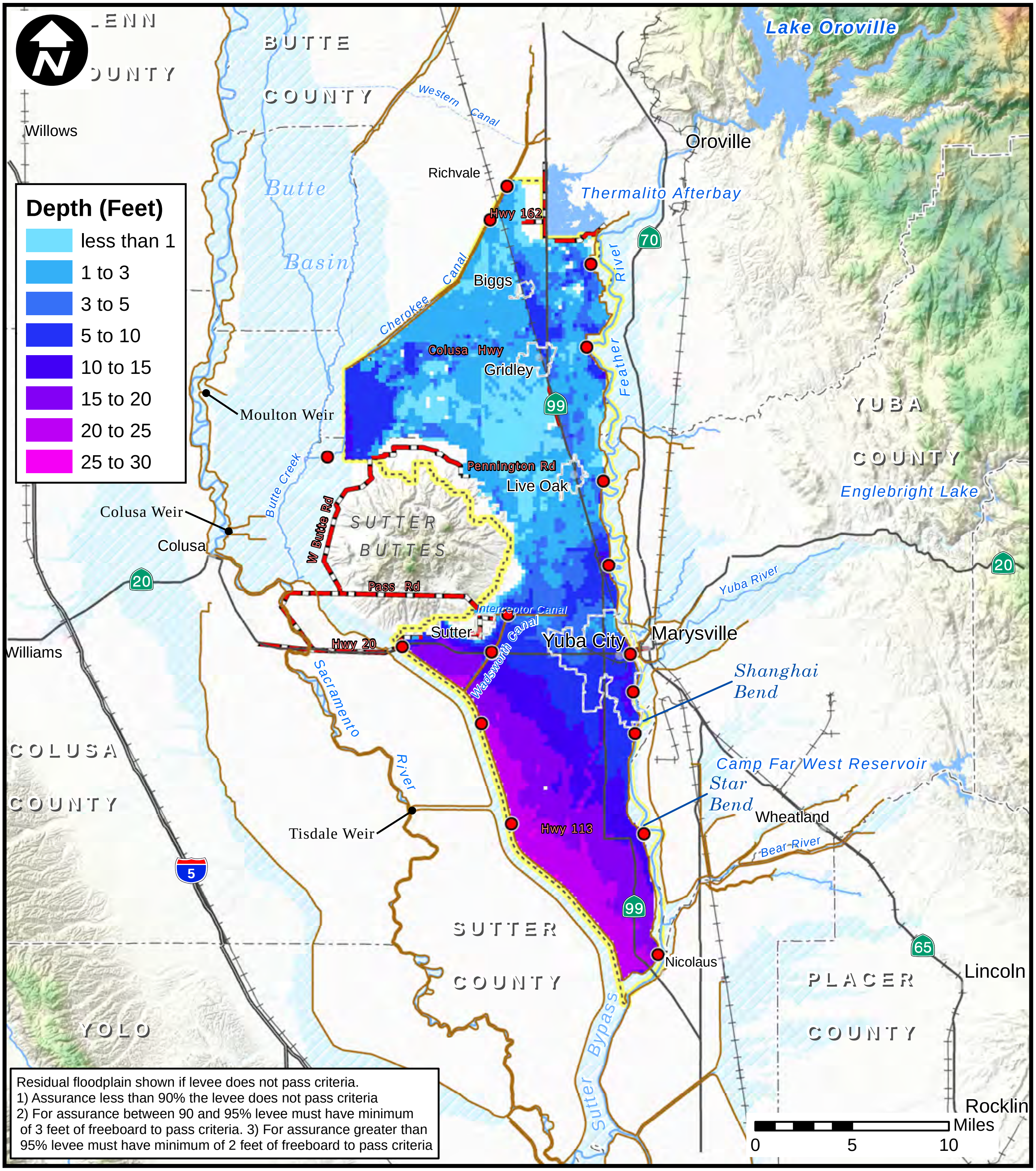
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

1% (1/100) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

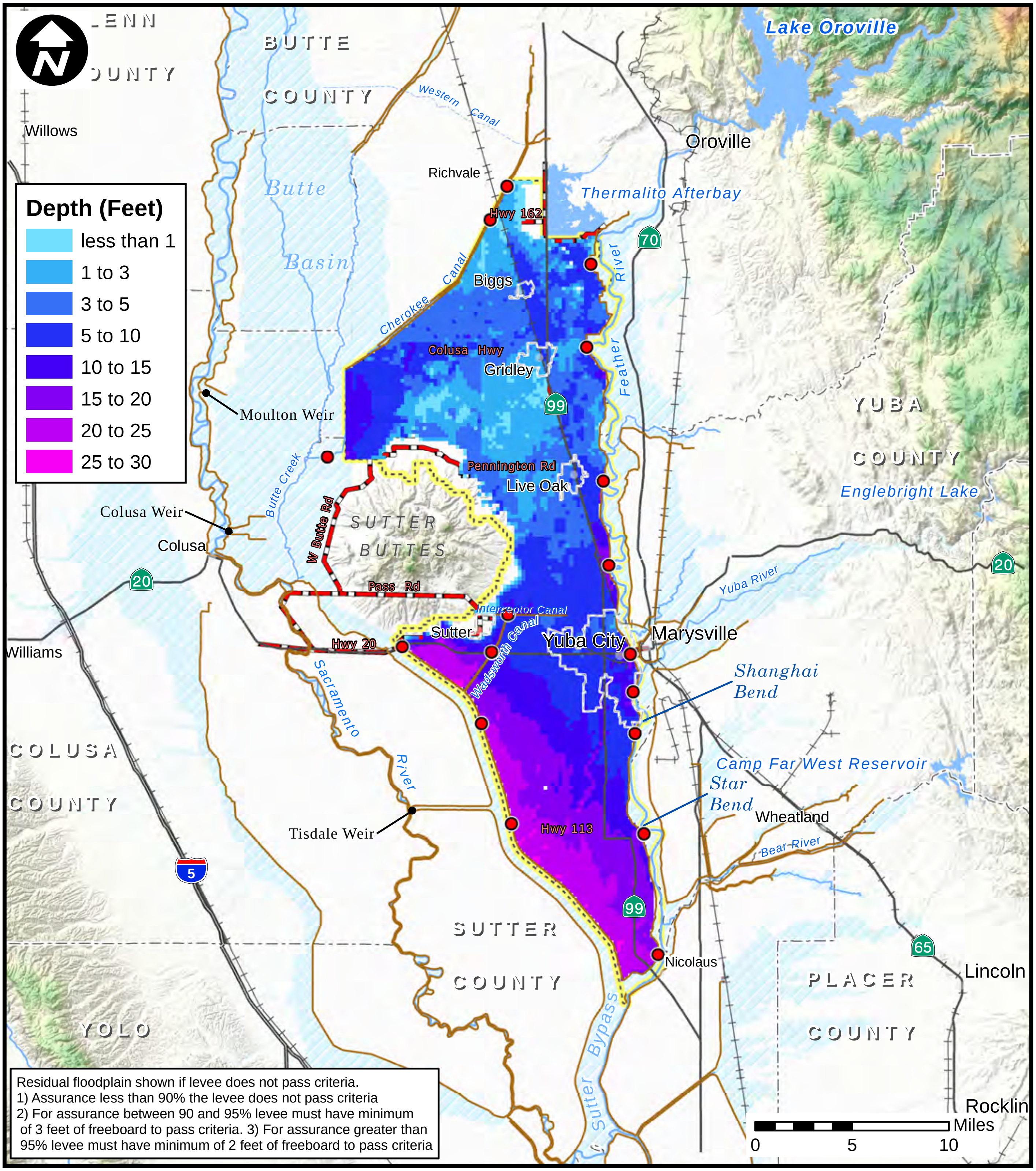
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

0.5% (1/200) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

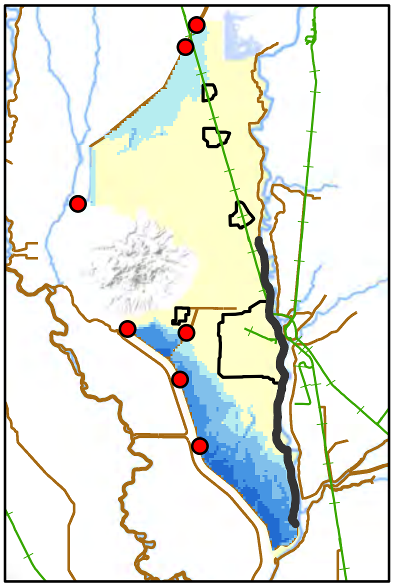
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

0.2% (1/500) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

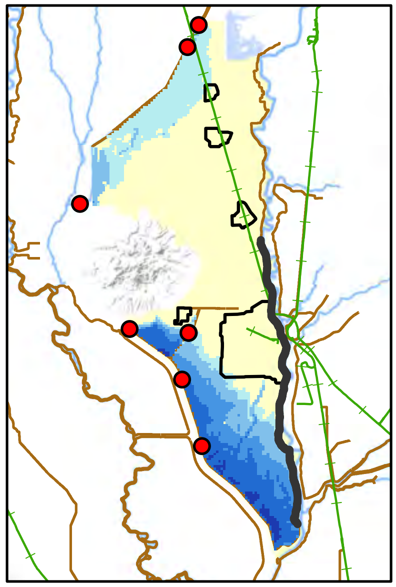
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

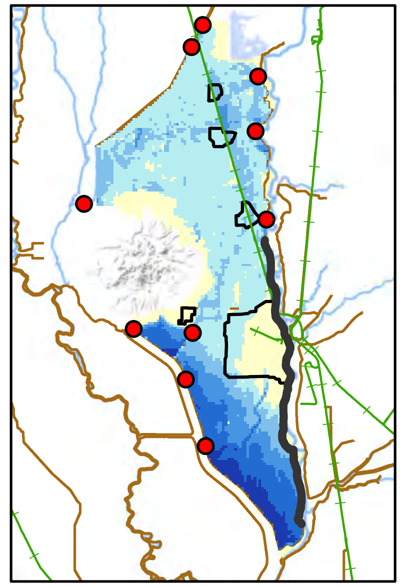
FEB 2013



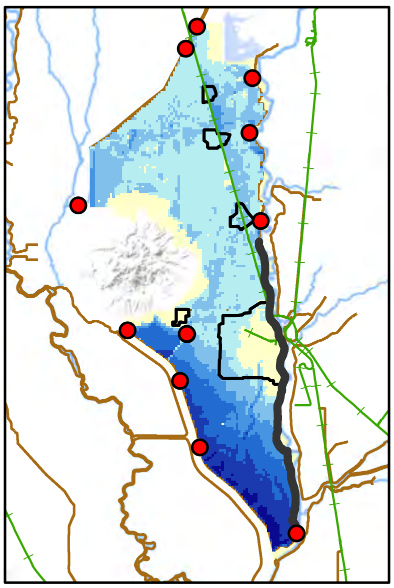
50% (1/2) ACE



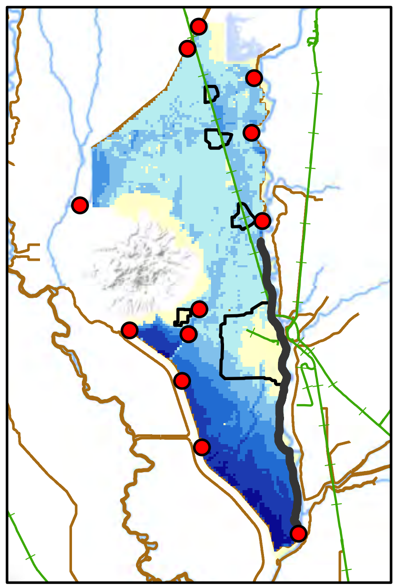
10% (1/10) ACE



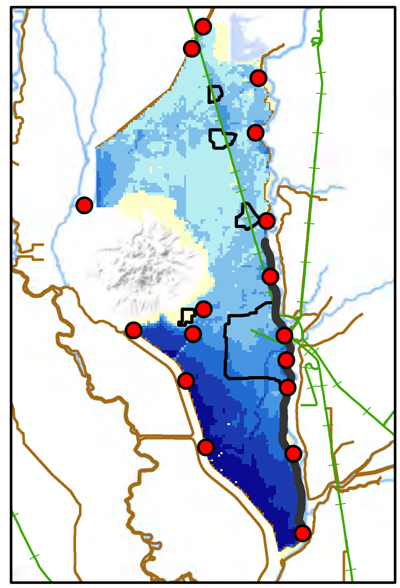
4% (1/25) ACE



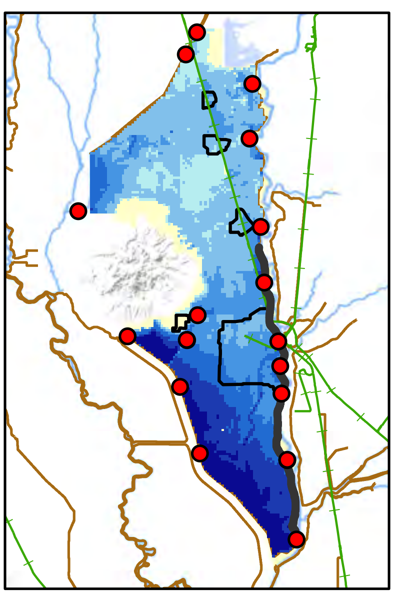
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

Alternative

Levee Fails R&U Criteria

NOTE: Breach simulation shown if levee does not pass assurance criteria.1) Assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

0 10 20 Miles

N

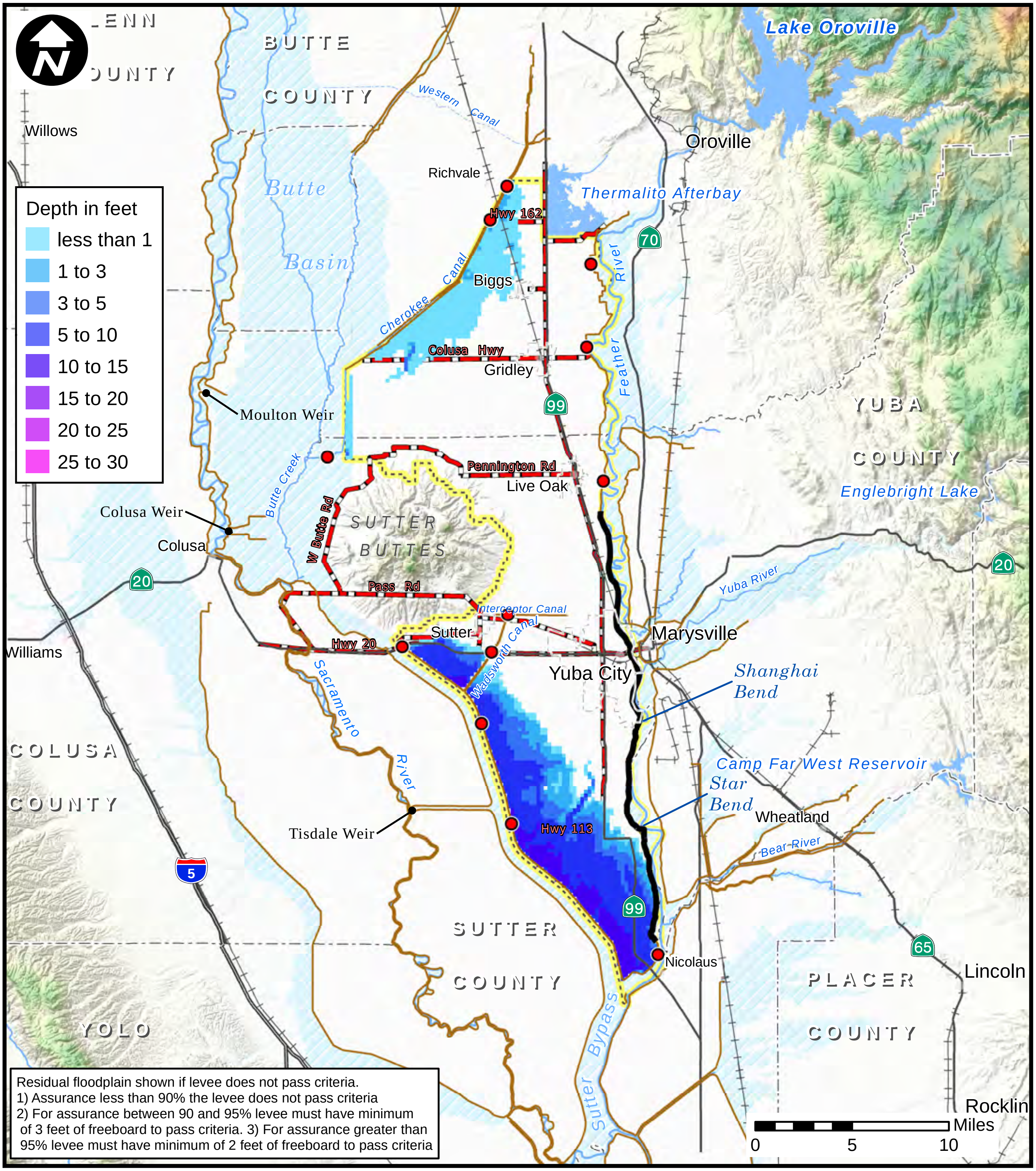
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

R&U ASSURANCE FLOODPLAINS ALTERNATIVE SB-7 FIX-IN-PLACE SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

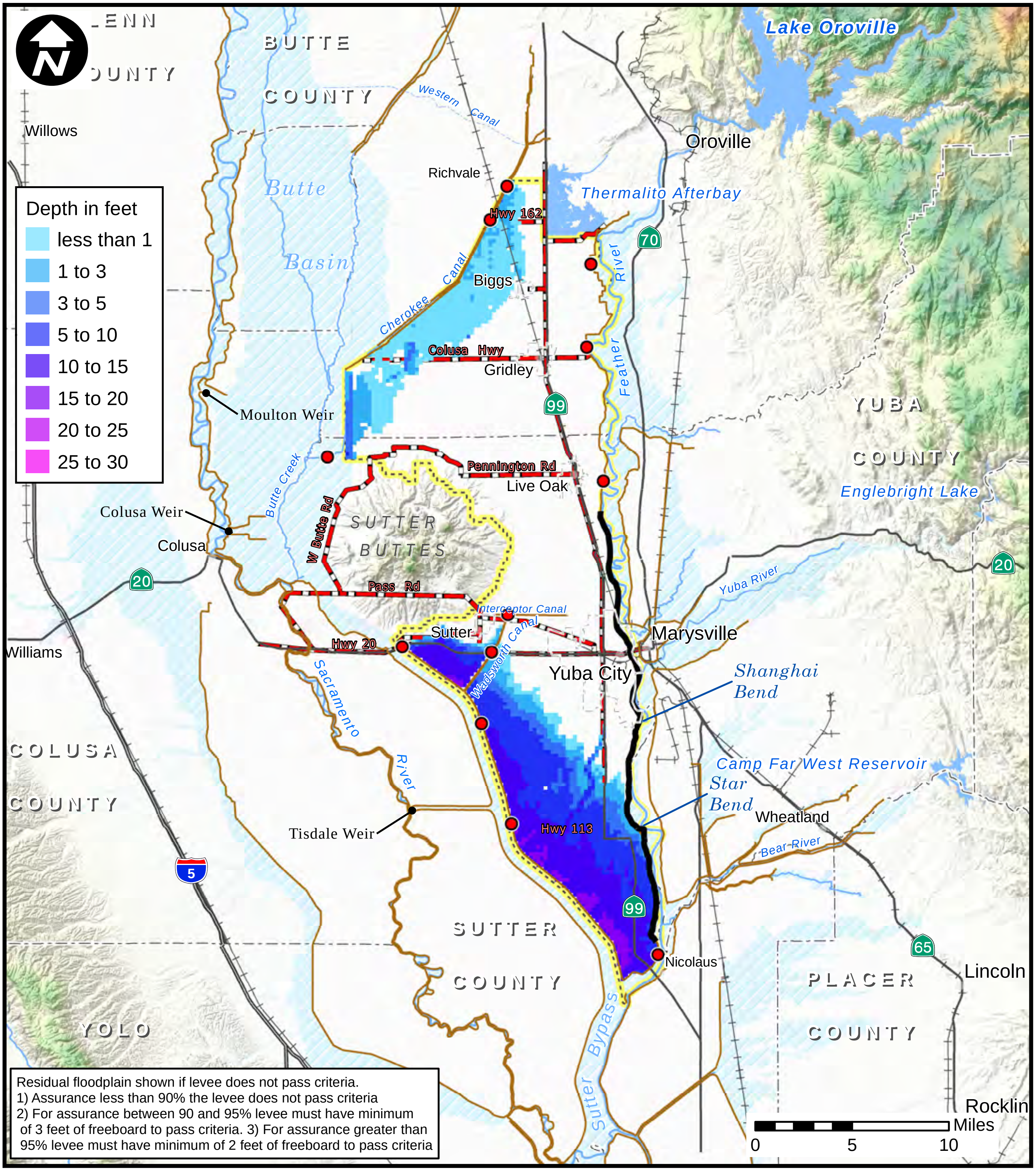
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

50% (1/2) ACE FLOODPLAIN
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

FEB 2013



Legend

Federal Levee	Levee Fails Criteria
Alternative SB-7	Evacuation Routes
River or Stream	Highway
Lake or Reservoir	Railroad
Designated Floodways	County Boundary
Study Area Extent	City Limit

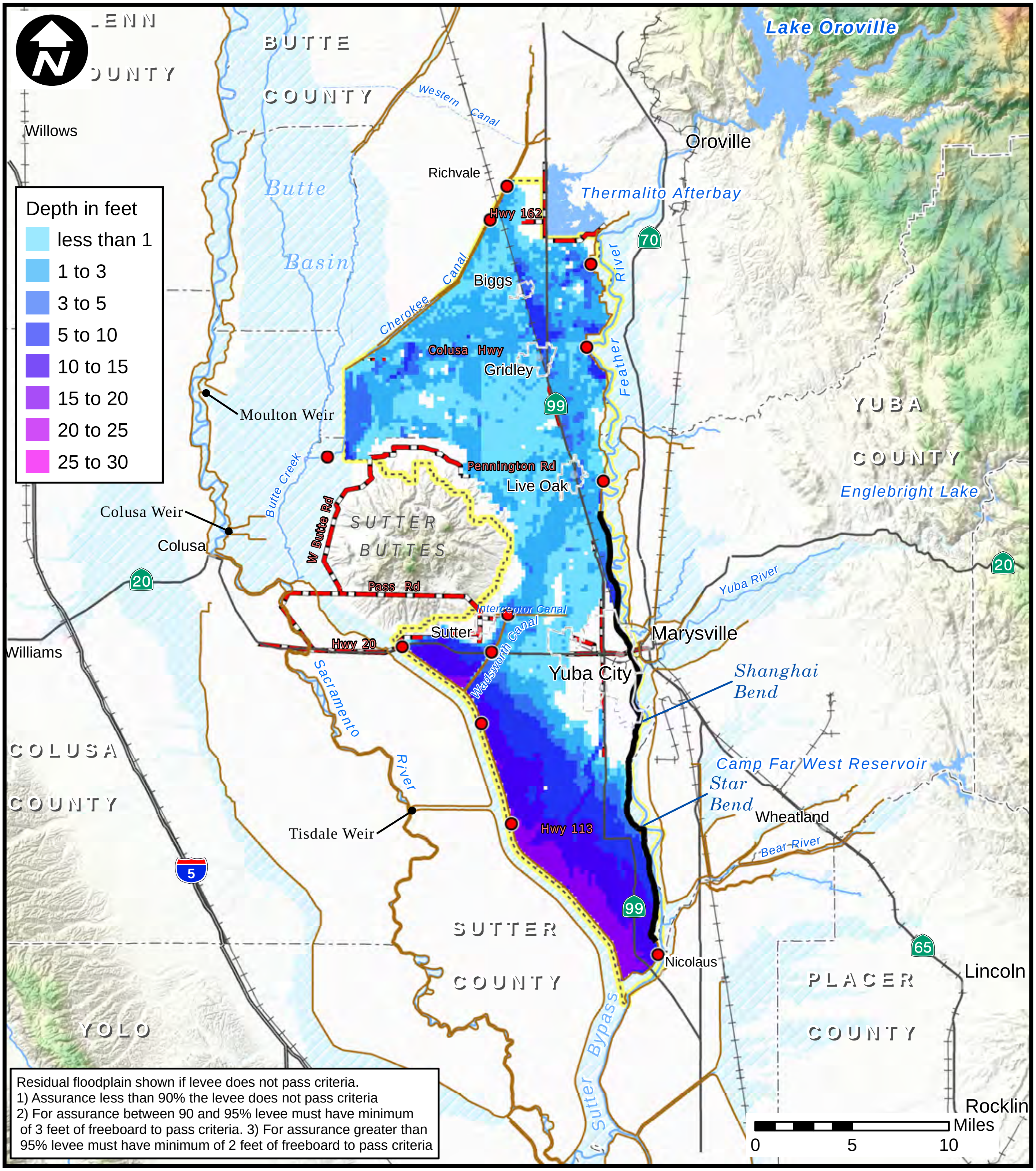
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

10% (1/10) ACE FLOODPLAIN 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

FEB 2013



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

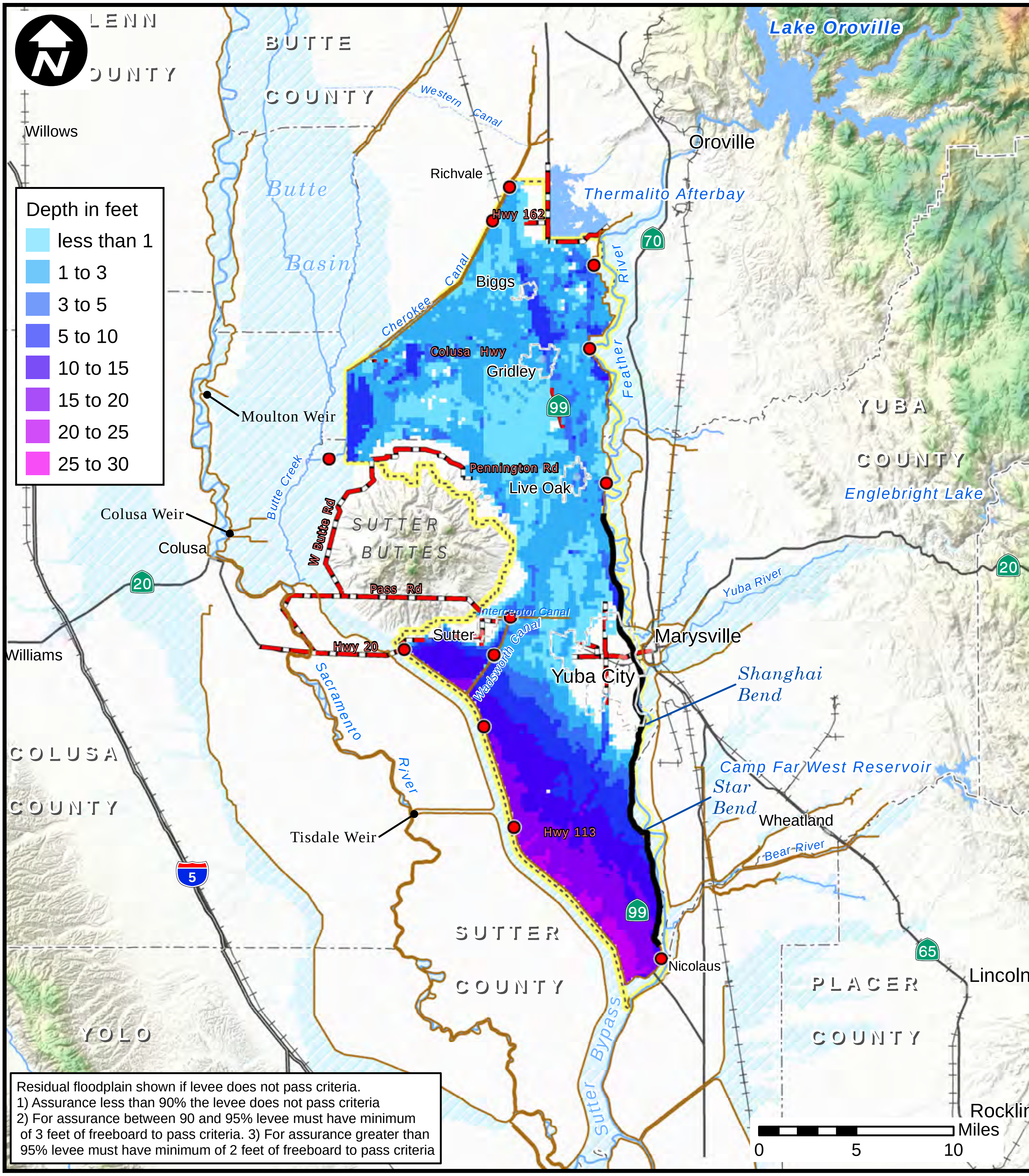
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

4% (1/25) ACE FLOODPLAIN 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

FEB 2013



Legend

Federal Levee	Levee Fails Criteria
Alternative SB-7	Evacuation Routes
River or Stream	Highway
Lake or Reservoir	Railroad
Designated Floodways	County Boundary
Study Area Extent	City Limit

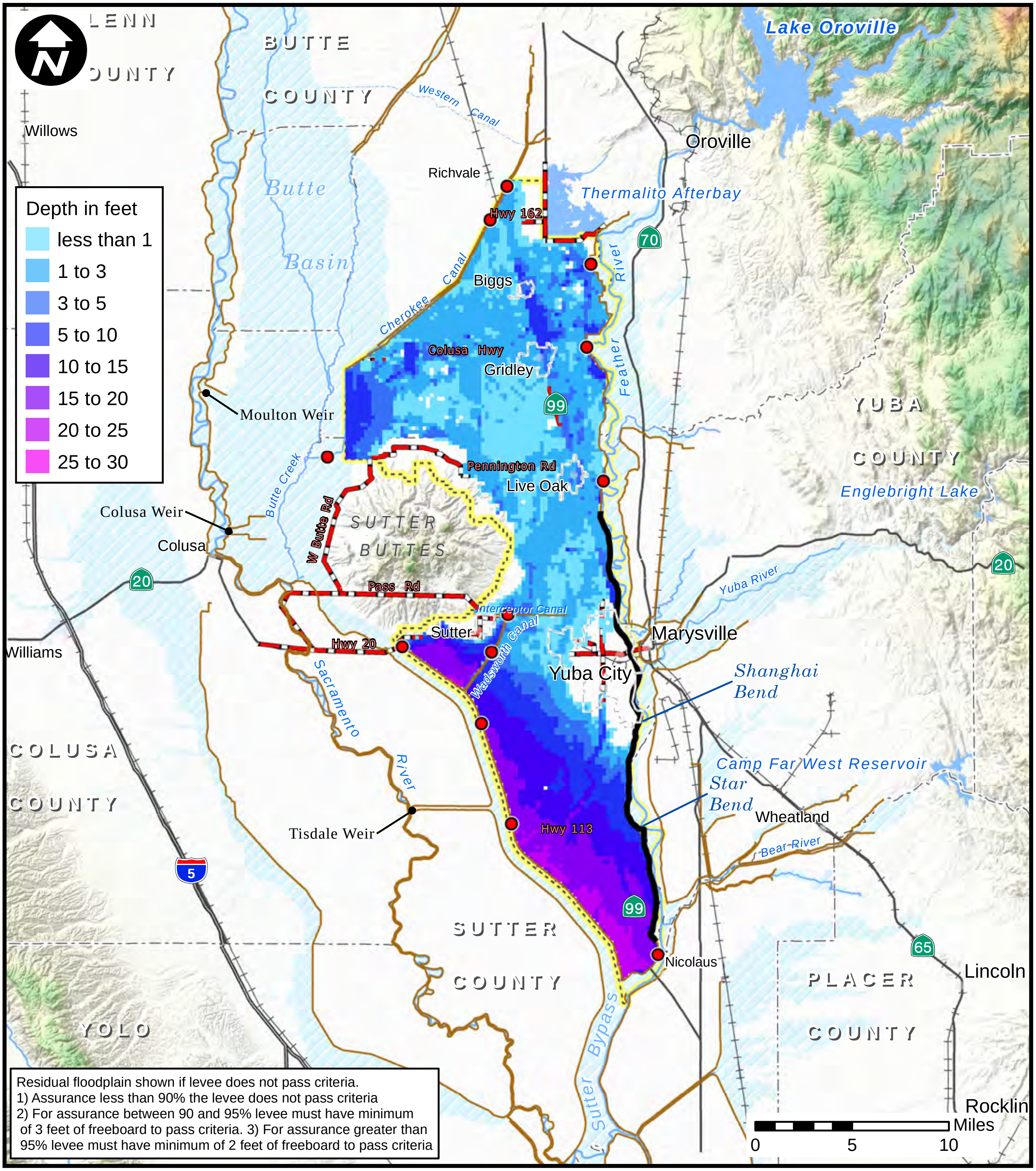
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

2% (1/50) ACE FLOODPLAIN 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

FEB 2013



Legend

Federal Levee	Levee Fails Criteria
Alternative SB-7	Evacuation Routes
River or Stream	Highway
Lake or Reservoir	Railroad
Designated Floodways	County Boundary
Study Area Extent	City Limit

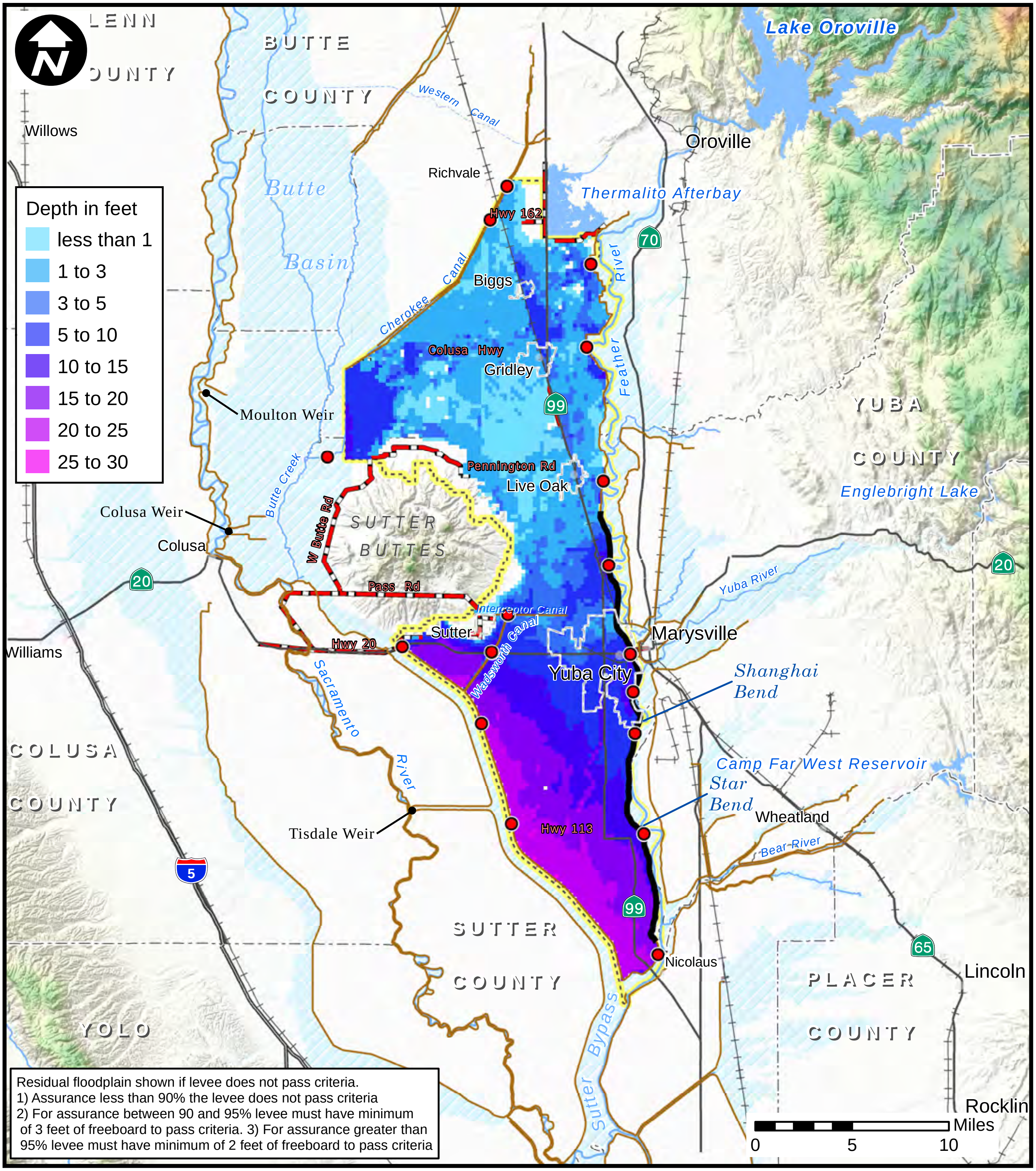
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

1% (1/100) ACE FLOODPLAIN 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

FEB 2013



Legend

Federal Levee	Levee Fails Criteria
Alternative SB-7	Evacuation Routes
River or Stream	Highway
Lake or Reservoir	Railroad
Designated Floodways	County Boundary
Study Area Extent	City Limit

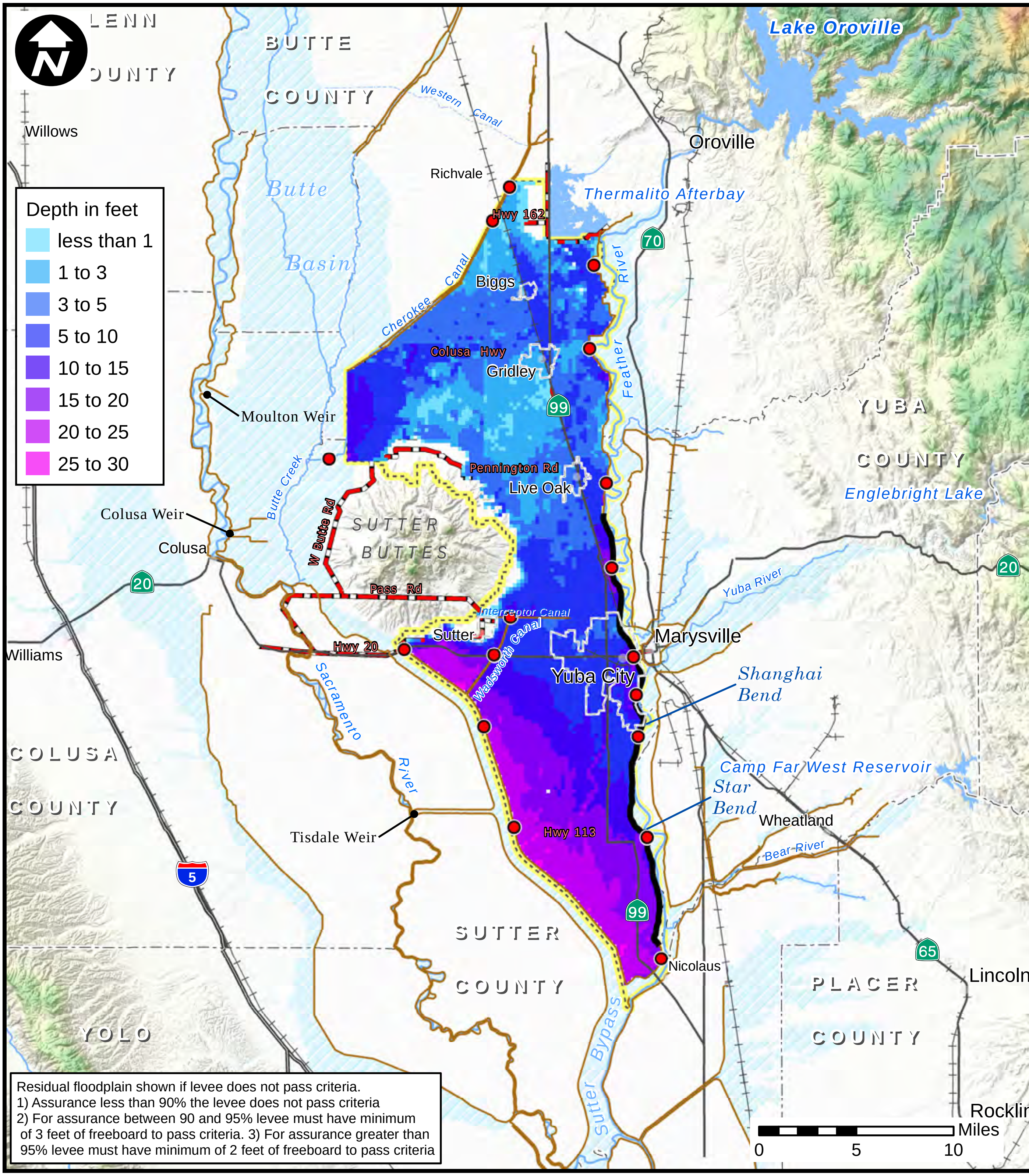
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

0.5% (1/200) ACE FLOODPLAIN 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

FEB 2013



Residual floodplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

Legend

Federal Levee	Levee Fails Criteria
Alternative SB-7	Evacuation Routes
River or Stream	Highway
Lake or Reservoir	Railroad
Designated Floodways	County Boundary
Study Area Extent	City Limit

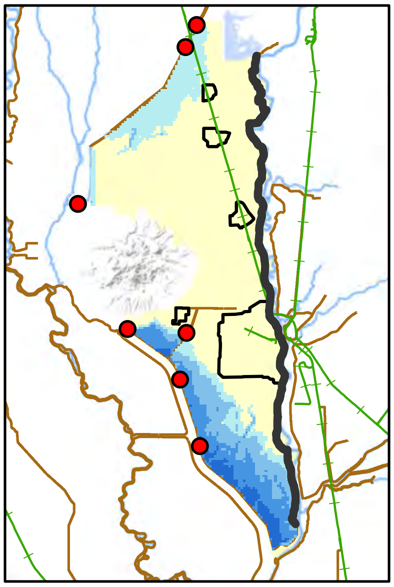
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

0.2% (1/500) ACE FLOODPLAIN ALTERNATIVE SB-7 FIX IN PLACE FEATHER RIVER, SUNSET WEIR TO LAUREL AVE

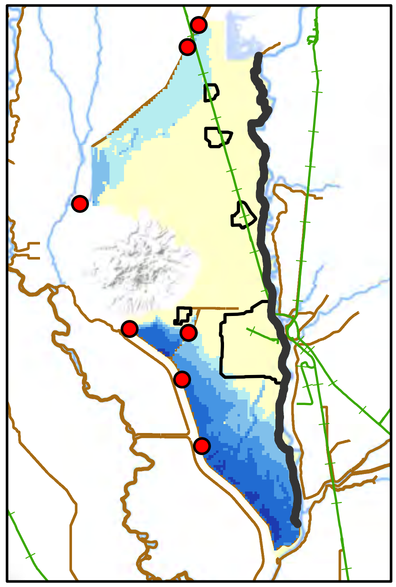
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

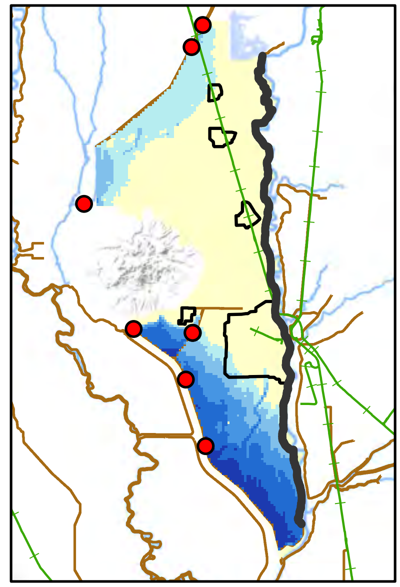
FEB 2013



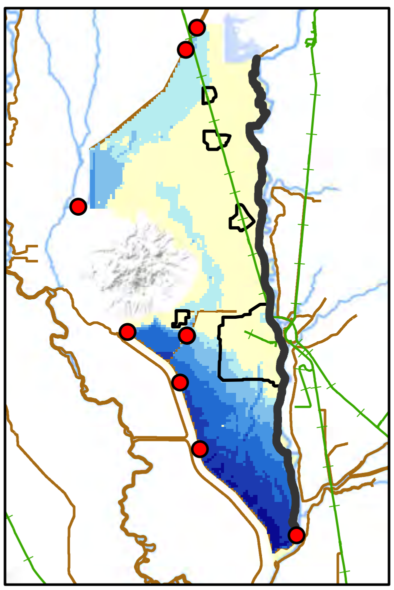
50% (1/2) ACE



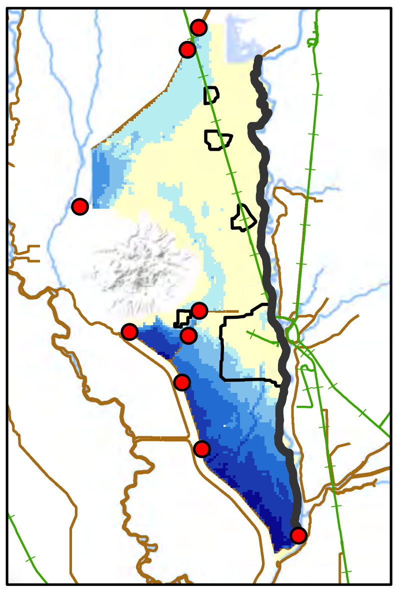
10% (1/10) ACE



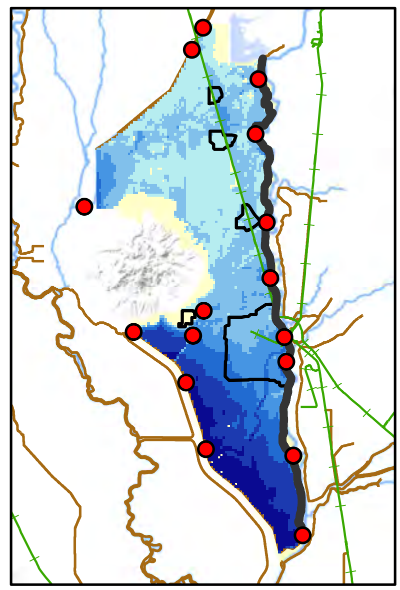
4% (1/25) ACE



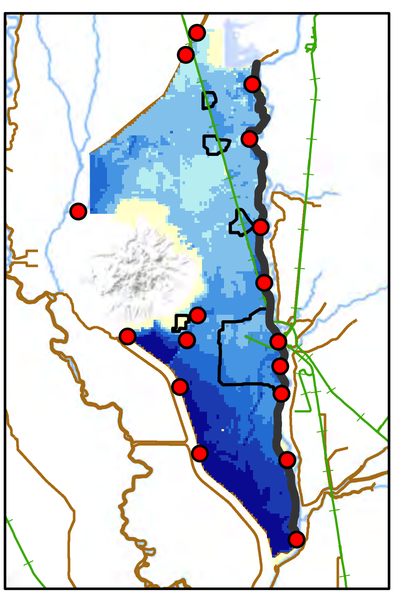
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

- Railroad
- Alternative
- Levee Fails R&U Criteria

NOTE: Breach simulation shown if levee does not pass assurance criteria.1) Assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

Miles
0 10 20

N

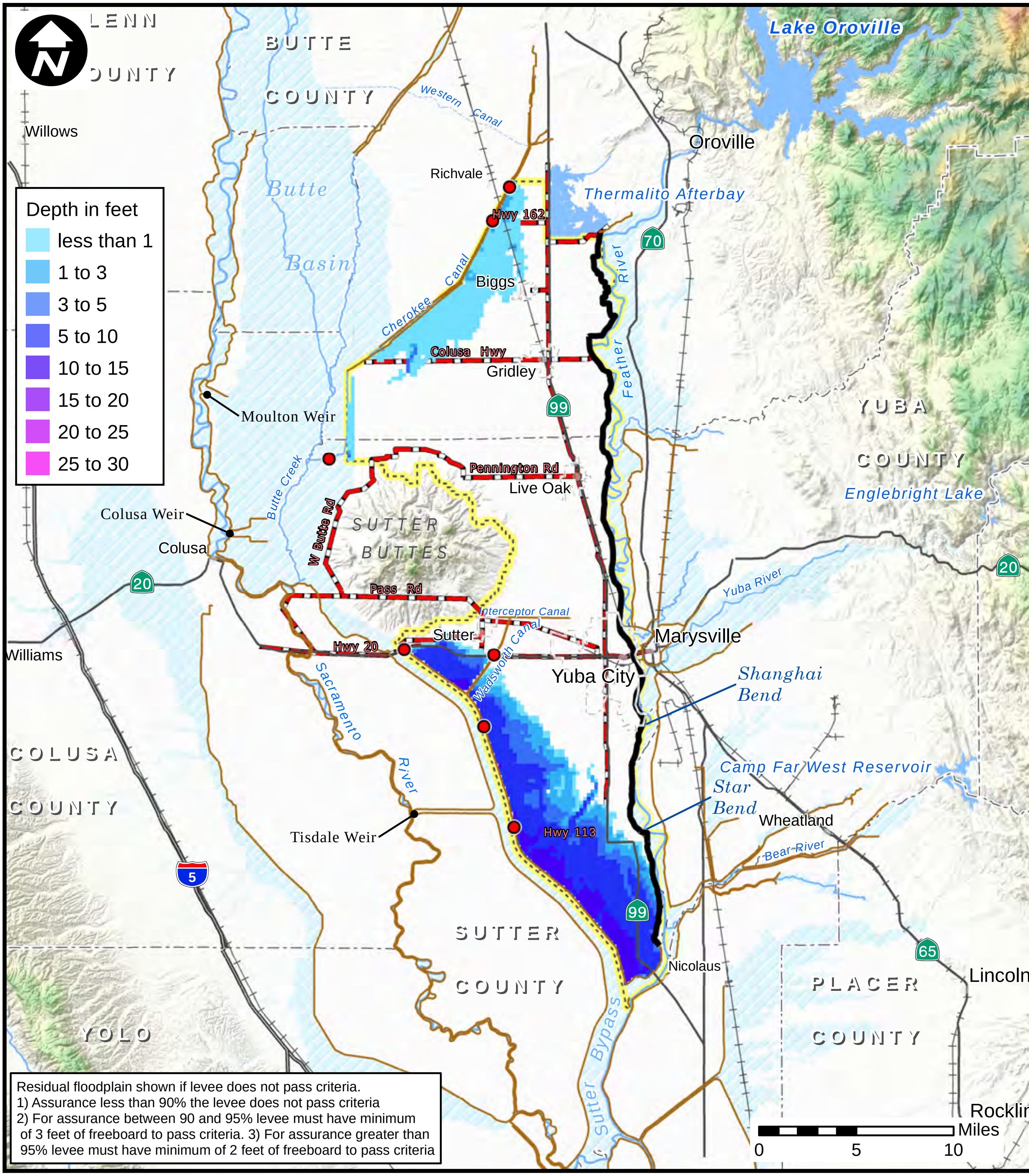
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

R&U ASSURANCE FLOODPLAINS ALTERNATIVE SB-8 FIX-IN-PLACE THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013



Residual floodplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

Legend

Federal Levee	Levee Fails Criteria
Alternative SB-8	Evacuation Routes
River or Stream	Highway
Lake or Reservoir	Railroad
Designated Floodways	County Boundary
Study Area Extent	City Limit

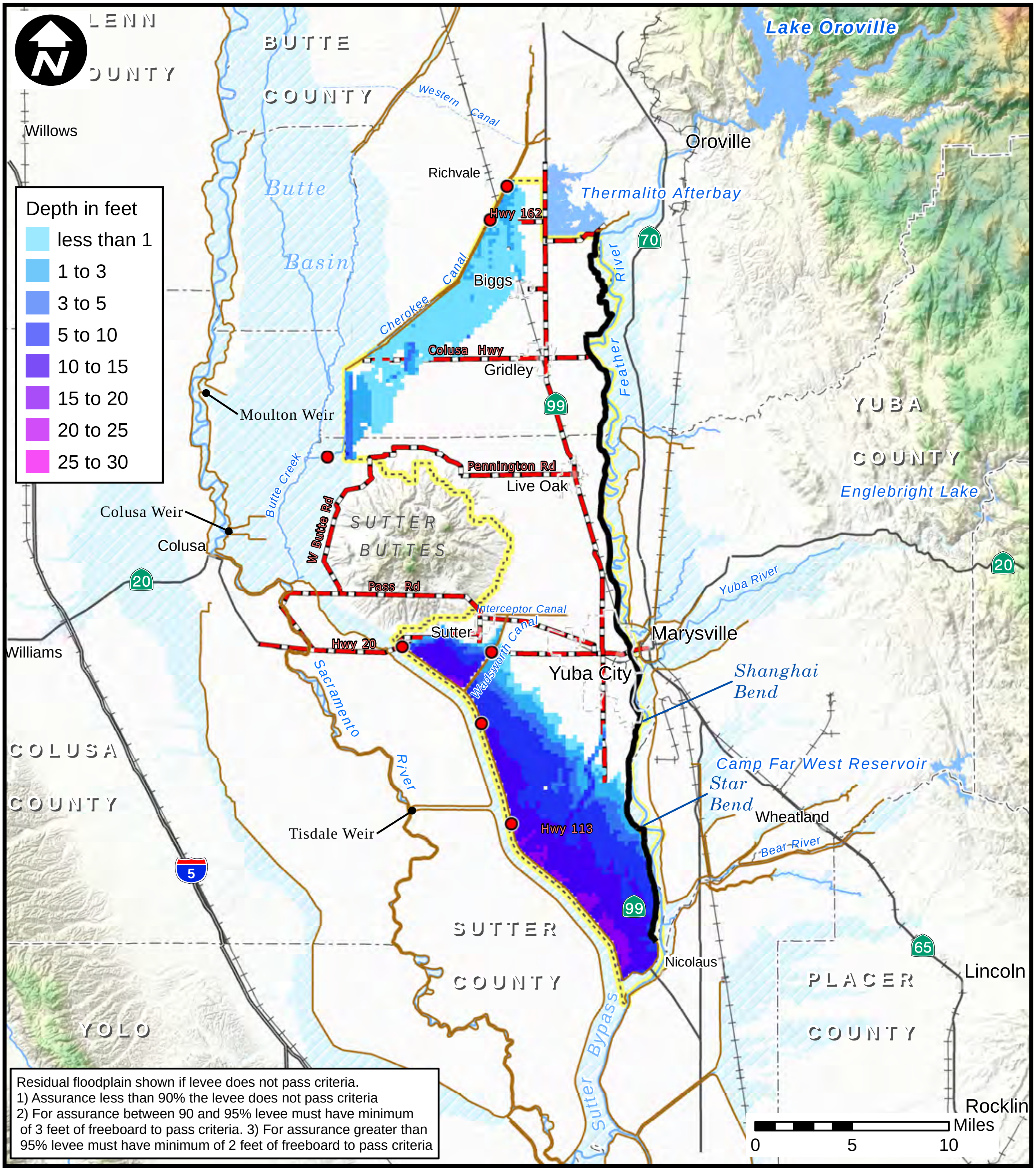
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

50% (1/2) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



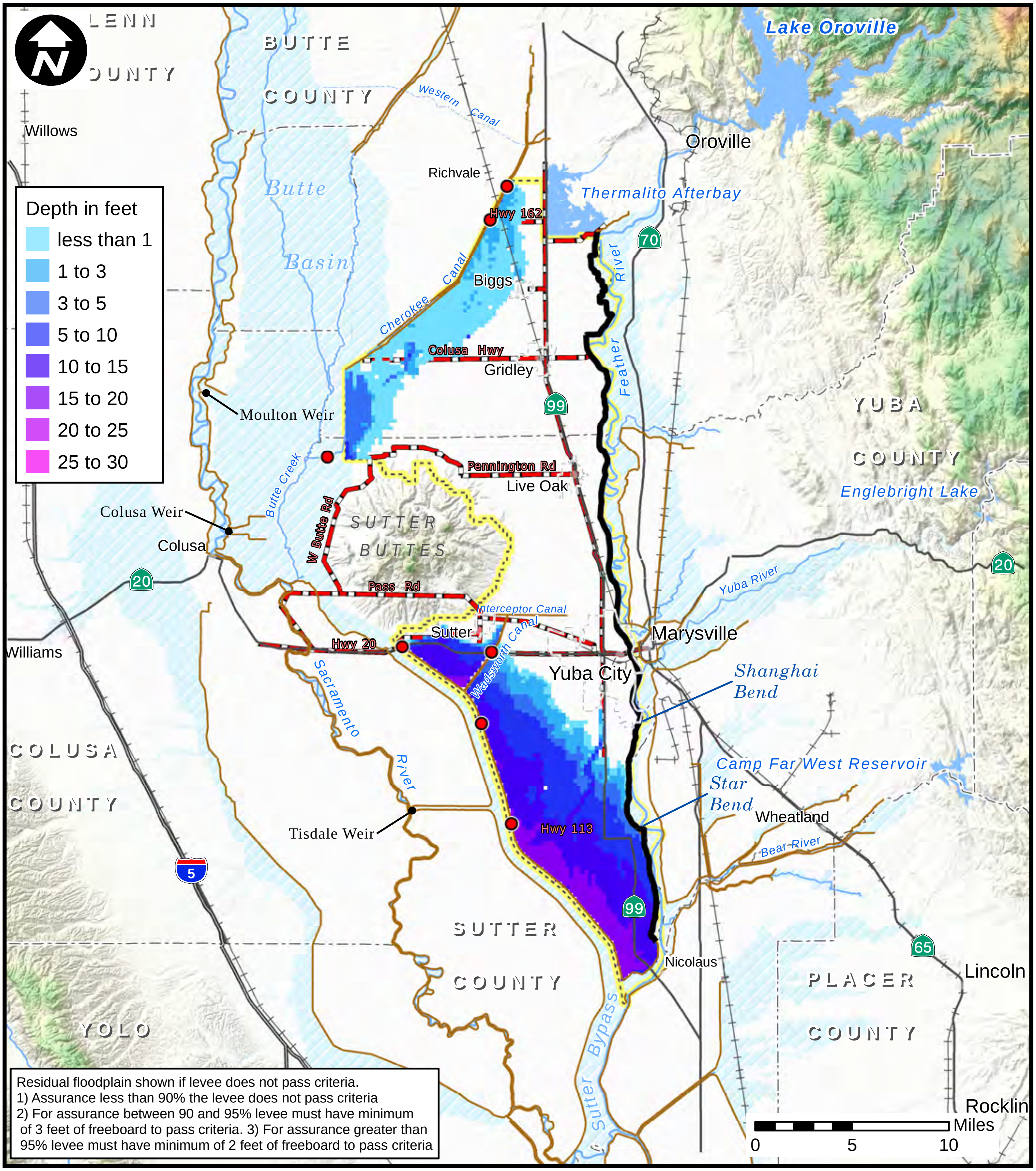
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

10% (1/10) ACE FLOODPLAIN
ALTERNATIVE SB-8
FIX IN PLACE FEATHER RIVER,
THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



Legend

Federal Levee	Levee Fails Criteria
Alternative SB-8	Evacuation Routes
River or Stream	Highway
Lake or Reservoir	Railroad
Designated Floodways	County Boundary
Study Area Extent	City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

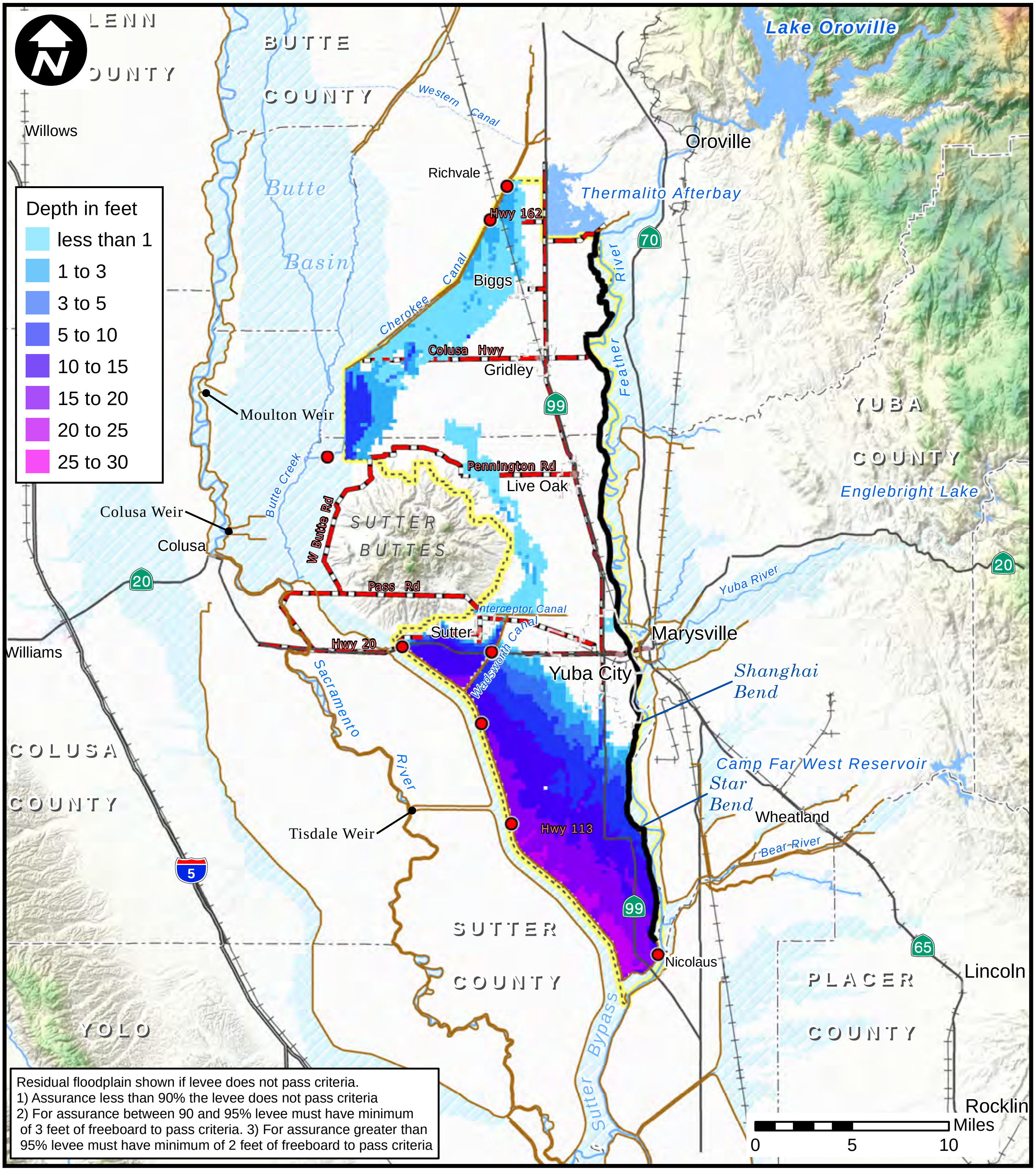
4% (1/25) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 68



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

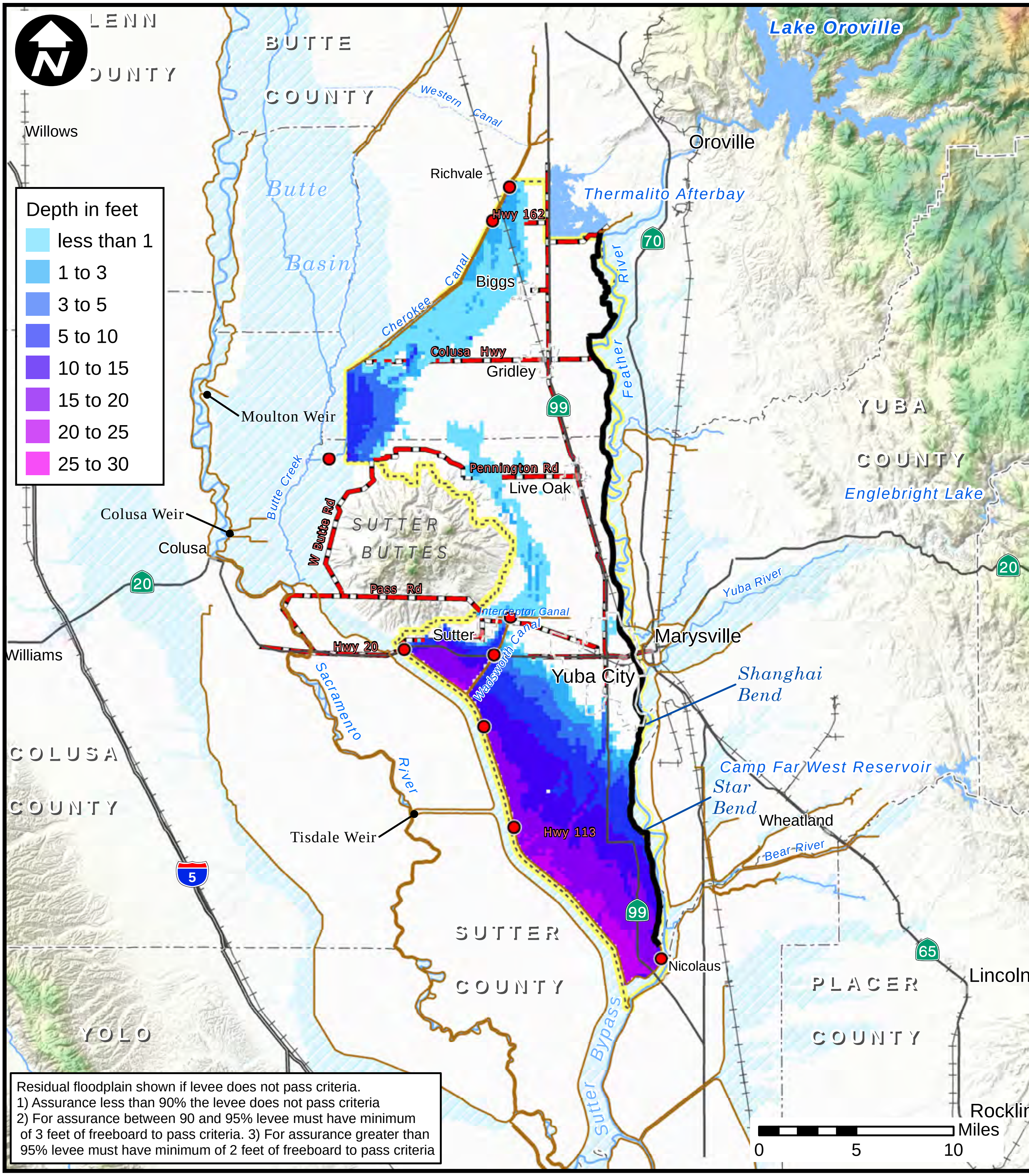
2% (1/50) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 69



Legend

Federal Levee	Levee Fails Criteria
Alternative SB-8	Evacuation Routes
River or Stream	Highway
Lake or Reservoir	Railroad
Designated Floodways	County Boundary
Study Area Extent	City Limit

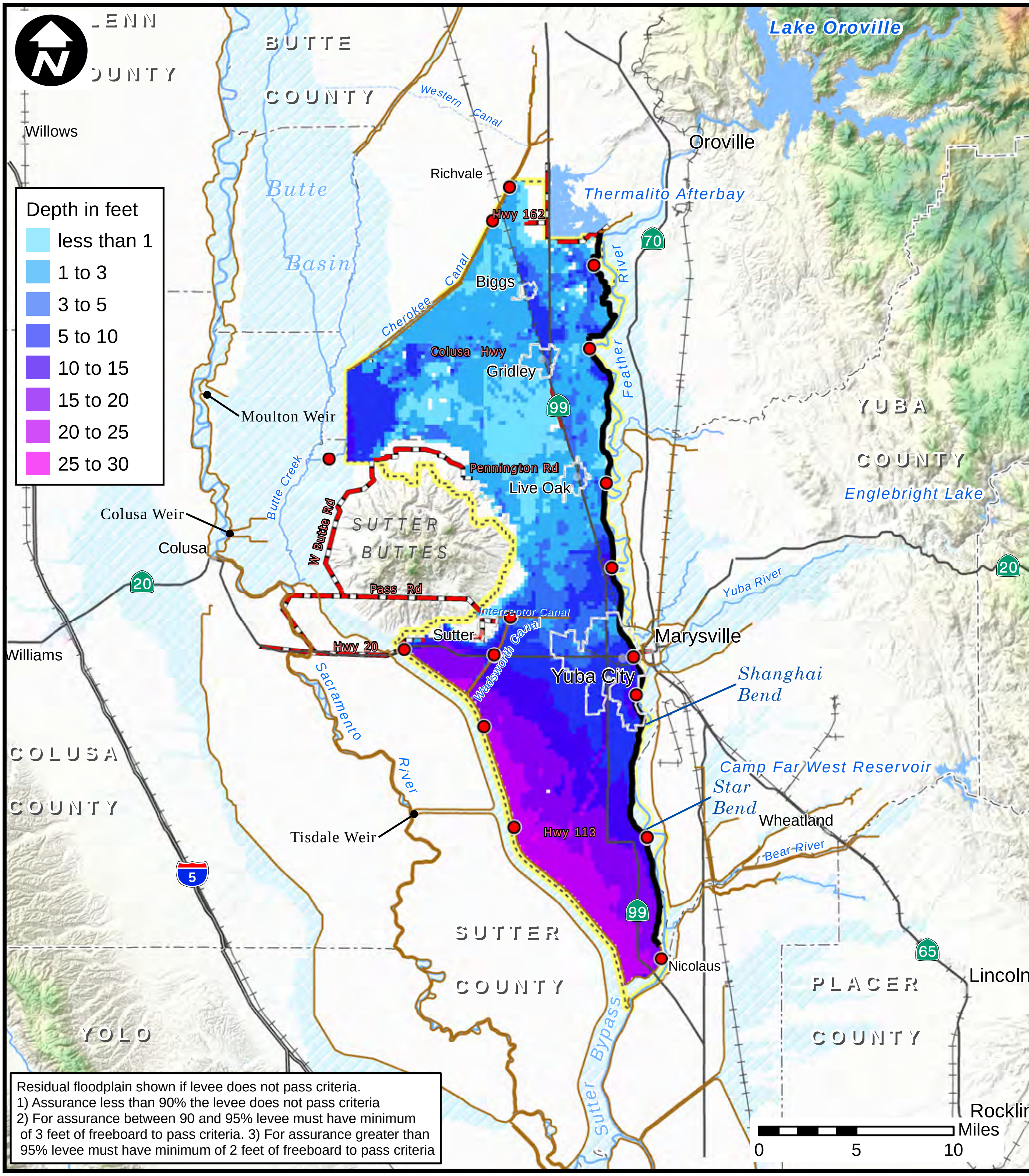
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

1% (1/100) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
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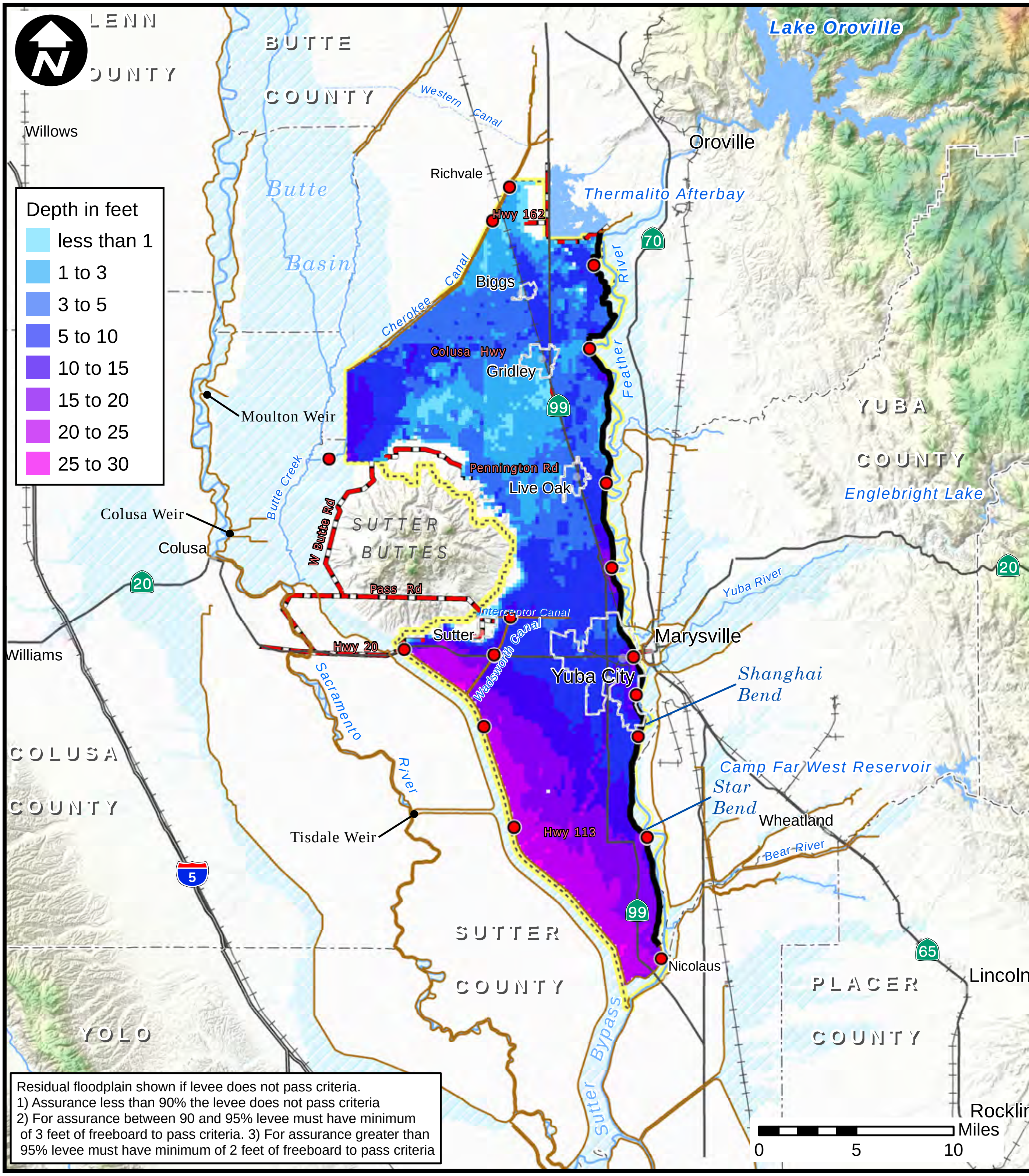
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

0.5% (1/200) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013



Legend

Federal Levee	Levee Fails Criteria
Alternative SB-8	Evacuation Routes
River or Stream	Highway
Lake or Reservoir	Railroad
Designated Floodways	County Boundary
Study Area Extent	City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

0.2% (1/500) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 72

ATTACHEMENT A

Memorandum for File:

Sutter Basin Pilot Feasibility Study,

Hydraulic Analysis of Refined Alternatives

8 June 2012

CESPK-ED-HA 8 June, 2012
23 Oct, 2012 Rev

MEMORANDUM FOR FILE: Sutter Basin Pilot Feasibility Study

SUBJECT: Hydraulic Analysis of Refined Alternatives.

1. REFERENCES:

a. DWR, 2012, Urban Levee Design Criteria, State of California Department of Water Resources, May 2012
b. USACE, 1957, Levee and Channel Profiles, Sacramento River Flood Control Project, File No. 50-10-3334, 4-sheets. 15 March 1957
c. USACE, 1995, Engineering and Design Hydrologic Engineering Requirements for Flood Damage Reduction Studies, EM 1110-2-1419, 31 Jan 1995.
d. USACE, 2002, Sacramento San Joaquin Comprehensive Study, Appendix B-Synthetic Hydrology, December 2002
e. USACE, 2008, Yuba River Basin Project, General Reevaluation Project, Appendix A, Synthetic Hydrology and Reservoir Operations Technical Documentation, April 2004 (Corrected June 2008).
f. USACE, 2010, USACE Process for the National Flood Insurance Program (NFIIP) Levee System Evaluation. 31 August 2010.

2. PURPOSE:

The purpose of this memorandum is to describe hydraulic analysis conducted in support of the Sutter Basin Feasibility Study. A map of the watershed is included as Plate 1 and a map of the study area is included as Plates 2 and 3. The memo documents refined analysis of the existing conditions, without project conditions and alternatives. Identification and evaluation of the alternatives that are refined in this analysis are presented in the report, Sutter Basin Feasibility Study, Progress Document 1, Without Project and Alternative Development.

All elevations provided herein are relative to the NAVD88 vertical datum and NAD83 Horizontal datum. Horizontal coordinates are projected to the California State Plane Zone III coordinate system. The conversion between NAVD88 and NGVD29 ranges from 2.3 to 2.4 feet in this area. Expressed as an equation, the conversion is Elevation (NGVD29) = Elevation (NAVD88) minus 2.40 feet.

3. BACKGROUND:

a. General. 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 and are at risk of breach failure at stages less than overtopping. 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.

b. Alternatives. Alternative plans were evaluated through an iterative planning process. The alternatives evaluated in this memorandum are considered to be the refined array and were the outcome of multi-disciplinary analysis at two levels of increasing detail. Throughout this process the concept of absolute accuracy versus relative accuracy was considered. At each level of analysis the assessment of the existing and without project conditions was improved. Although it would appear that every plan should be compared to the most accurate assessment of existing conditions, this is not necessary because the relative accuracy between plans is sufficient to select the most optimal plan to move forward.

Conceptual alternatives were developed from a broad array of measures. The measures were evaluated at a qualitative level of detail using hydraulic assumptions and calculations. The measures were then combined into conceptual alternatives during a planning Charrette attended by the project sponsors and subject matter experts. Development of the conceptual alternatives is described in Progress Document 1.

Refined alternatives were derived from the conceptual alternatives. The conceptual alternatives described above were evaluated using qualitative and quantitative engineering analyses. Analyses included floodplain hydraulic modeling, cost estimating, and economic benefit estimations. The level of detail was limited to that required to decide which plans to carry forward. Results were evaluated at a combined VE study and planning charette attended by the project sponsors and subject matter experts. At the conclusion of the planning charette, a refined array of alternatives was identified for further analysis. Analysis of the refined array of alternatives is described in this report.

4. STUDY AREA:

a. General. The study area covers approximately 300 square miles and is approximately 43 miles long and 9 miles wide. 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.

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 population density within the study area is provided in Plate 4. The majority of land use in the study area is related to agricultural. A map of land use types in the study area is presented in Plate 5.

b. Topography. Elevations within the study area range from 110 ft NAVD88 in the north to 30 ft NAVD88 in the south. The study area has a general slope from northeast to south west. The general slope of the study area is interrupted by two major linear features which would impact hydraulic conveyance within the study area if a levee breach were to occur. The raised embankment of the Union Pacific Railroad traverses the study area in a north south alignment. The Sutter Bypass east levee traverses the study area in a north south alignment. A topographic map of the study area is presented in Plate 2.

c. Stream Gages: A list of applicable stream gages within the study area is provided in Table 1. The stream gages are operated by the United States Geological Survey (USGS) and California Department of Water resources. Steam gages shown on Plate 7.

Table 1 Stream Gages, Sutter Basin Study Area

Gage Name	Area (Sq Mi)	Agency	Gage Number	Period of Record	Type
Bear R Nr Wheatland Ca	292	USGS	11424000	1928-2010	S,Q
Bear River at Pleasant Grove	300	DWR	A06535	1987-2010	S,Q
Butte Creek near Gridley	NA	DWR	A04150	1991-1999	S,Q
Butte Slough at Outfall Gates near Colusa	NA	WDL	A02967	1992-2010	S
Butte Slough near Meridian	NA	WDL	A02972	1981-2010	S,Q
Cherokee Canal nr Gridley	NA	DWR	A00910	1991-1998	S,Q
Cherokee Canal nr Richvale	NA	DWR	A02984	1976-2010	S,Q
Camp Far West Reservoir	NA	DWR	A65105	1998-2010	Q
Colusa Weir Spill to Butte Basin near Colusa	NA	WDL	A02981	1975-2010	S,Q
Deer C Nr Smartville CA	84.6	USGS	11418500	1935-2010	S,Q
Feather River at Nicholaus	5,921	DWR	A05103	1942-2010	S,Q(P)
Feather River at Oroville	3,624	USGS	11407000	1902-2010	S,Q
Feather River at Yuba City	3,974	DWR	A05135	1964-2010	S
Feather River near Gridley	3,676	DWR	A05165	1964-2010	S,Q
Moulton Weir Spill to Butte Basin nr Colusa	NA	DWR	A02986		
Sacramento R at Colusa Ca	12,090	USGS	11389500	1941-2010	S,Q
Sacramento R at Verona Ca	21,251	USGS	11425500	1929-2010	S,Q
Sacramento R Blw Wilkins Slough nr Grimes Ca	12,915	USGS	11390500	1931-2010	S,Q
Sacramento River at Butte Slough Outfall Gates	NA	DWR	A02400	1992-2004	S
Sacramento River at Fremont Weir (East)	NA	DWR	A02160	1935-2010	S
Sacramento River at Fremont Weir (West)	NA	DWR	A02170	1934-2010	S
Sacramento River at Knights Landing	14,535	DWR	A02200	1982-2010	S
Sacramento Slough near Karnak	NA	DWR	A02925	1981-2010	S
Sutter Bypass at R.D. 1500 P.P. near Karnak	NA	DWR	A02927	1975-2010	S
Sutter Bypass Channel at Pumping Plant #1	NA	DWR	SB1	2008-2010	S
Sutter Bypass Channel at Pumping Plant #2	NA	DWR	SB2	2008-2010	S
Sutter Bypass Channel at Pumping Plant #3	NA	DWR	SB3	2008-2010	S
Tisdale Weir near Grimes	NA	DWR	A02960	1975-2010	S,Q
Willow Slough near Nicolaus	NA	DWR	A02943	1991-2010	S
Yolo Bypass nr Woodland Ca	NA	USGS	11453000	1939-2011	S,Q
Yuba R blw Englebright Dam near Smartsville	1,108	USGS	11418000	1941-2011	S,Q
Yuba R Nr Marysville CA	1,339	USGS	11421000	1940-2011	S,Q
Wadsworth Canal near Sutter (lower)	96	DWR	A05927	1982-1997	S,Q
Wadsworth Canal near Sutter (upper)	96	DWR	A05929	1976-1997	S,Q
Note: S-Stage, Q-Discharge, NA- Not Available, (Partial Record)					

5. SOURCES OF FLOODING:

The following describes significant sources of flooding within the study area.

a. Butte Basin. 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 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 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).

b. 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 River to the confluence of the Sacramento River and Yolo Bypass at 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 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, Feather River to Sacramento River.

c. 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.

d. Cherokee Canal. 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.

e. Wadsworth Canal. 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 96 square miles of into the Wadsworth Canal.

6. RECENT FLOODS:

The following is a description of recent significant flood events within the study area. The magnitudes of historical floods are difficult to compare due to significant historical changes in the flood management system.

a. December 1955. The last major flood to damage the study area occurred in December 1955 when the west levee of the Feather River breached near Shanghai Bend. The peak flow measured at the Feather River at Oroville stream gage was 203,000cfs. This flood occurred prior to construction of Oroville and New Bullards Bar reservoirs. Therefore, the flood does not reflect existing hydrologic conditions. A hypothetical flood routing of the 1955 flood is presented in the Oroville Dam water control manual. The flood routing indicates the reservoir would have regulated the peak outflow to 150,000cfs.

b. November 1982 - March1983. 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 percent 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.

c. 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. System breaks in the Sacramento River Basin included disastrous levee breaks in the Olivehurst and Linda area on the Feather River, adjacent to the study area.

d. 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.

e. 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. Levee failures due to breaks or overtopping in the Sacramento River Basin resulted in extensive damages.

f. December 2005 - January 2006. Between 28 December 2005 and 9 January 2006, the State of California experienced a series of severe storms which impacted the levees within the Sacramento District's boundaries. 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. The State of California Department of Water Resources and/or their maintaining agencies conducted the actual flood fight activities while the U.S. Army Corps of Engineers provided technical assistance to the State.

7. FLOOD RISK ASSESSMENT APPROACH

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 model approach and is described in the economics report. The report presents results for seven economic impact areas within the study area. A map of the economic impact areas is presented as Plate 6.

The FDA approach 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.

The first step in the risk assessment approach was evaluation of potential flood sources with respect to geotechnical fragility, channel hydrology, channel hydraulics, and potential inundation patterns of a levee breach natural overbank (non-levee). Thirteen geotechnical reaches were identified. Within each of these geotechnical reaches a representative geotechnical fragility curve was developed and a stage-discharge relationship was developed using a hydraulic model (see below). Selection of the geotechnical reaches is described in detail in the geotechnical analysis. Fifteen breach sources and one non-leveed flood source locations were identified. All flood source locations identified within a geotechnical reach were assigned to the same geotechnical fragility curve location.

8. FLOOD RISK MAPS

The performance of existing Flood Risk Management features varies by reach. Performance was evaluated using the HEC-FDA computer program and is discussed in detail in the economics section. Levee performance is expressed as an assurance level (conditional non-exceedance probability) for a given median ACE hydrologic event.

Maps showing residual flood risk were developed to demonstrate FRM performance levels relative to a standard assurance criterion. The maps show inundation from any flood source that would not meet an assurance criterion. Maps were developed for each of two assurance criteria.

a. Assurance Criteria#1. This criterion was based on the deterministic approach required by FEMA for 1% ACE and DWR for 0.5% ACE. To meet this criteria a levee reach must have a minimum of 3 feet of freeboard for Hydrology and Hydraulic capacity for the given flood event. The geotechnical performance of a levee reach must meet current USACE geotechnical and civil design standards for the given design flood event. This assurance criterion was used to define residual risk maps for all Annual Chance Exceedance (ACE) events.

b. Assurance Criteria #2. This criterion was based on the 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. Assurance values were based on an USACE FDA risk and uncertainty analysis which included hydrologic uncertainty, hydraulic uncertainty, and geotechnical fragility curves. All values are relative to the median stage for each ACE event. 1) For assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria. Other requirements described in EC1110-2-6067 are not included. For example, operations and maintenance requirements are not included in the criteria.

9. EXISTING CONDITION CHANNEL MODEL

Water surface profiles were computed using HEC-RAS and HEC-UNET one-dimensional flow models. HEC-RAS and UNET calculate steady or unsteady gradually varied flow in natural and manmade channels by performing step-backwater calculations of the 1-D flow energy equation through a series of input geometric cross-sections with empirically defined hydraulic roughness coefficients.

An unsteady system-wide HEC-RAS model was used for the Sacramento River, Feather River, and Sutter Bypass. A steady state HEC-RAS model was used for the Wadsworth Canal. An unsteady HEC-RAS model was used for Cherokee Canal. An unsteady HEC-UNET model developed for the Sacramento-San Joaquin Comprehensive study was used for Butte Basin flood depths. A map of the HEC-RAS hydraulic models cross sections and location of boundary conditions is provided as Plate 7. The following describes hydraulic model input to the FDA hydraulic model and also used in the assessment of project performance and assurance.

a. Non-Failure Infinite Height Levee Profiles. Models were developed to evaluate two profile scenarios. Scenario A assumed all levees were infinitely high and would contain all flows without overtopping. This scenario was used to evaluate the sensitivity of downstream flow conditions relative to upstream overtopping assumptions. The resulting model profiles are provided in Plates 8, 9, 10, and 11.

b. Non-Failure Overtopping Profiles. Scenario B assumed all levees were overtopped without failure. Scenario B was used in the economic FDA analysis. The resulting model profiles are provided in Plates 8, 9, 10, and 11. As described above, these median profiles are for use in the FDA flood damage assessment model. The profiles do not account for risk and uncertainty which is required to evaluate assurance. Assurance estimates are provided in the economics report.

c. Breach Hydrographs. Simulations were performed for fifteen levee breach flood sources and one natural (non-leveed) flood source. These sources were spatially distributed throughout the study area. Breach locations were selected to represent similar levee and floodplain characteristics. All breach scenarios assume levees were overtopped without failure at all locations other than the breach location. 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 upstream and 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. In order to simplify the analysis, breaches were assumed to exist at the start of each flood hydrograph simulation.

c. Stage Uncertainty. Stage uncertainty arises 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.

A standard deviation in stage of 1.5 feet was used for hydraulic uncertainty. This value was estimated following methods in EM-1110-2-1619. The total stage uncertainty was based on the geometric mean of natural and model uncertainty. The total stage uncertainty was based on standard deviations of 0.75 ft and 1.3 feet for natural and model uncertainty respectively.

10. EXISTING CONDITION FLOODPLAIN INUNDATION MODEL

Floodplain inundation was simulated using a FLO-2D two dimensional hydrologic model of the Study Area. The without project condition FLO-2D model was modified from existing USACE models by the Sutter Butte Flood Control Agency as work in kind credit for the study. Models and results underwent Independent Technical Review and District Quality Control. The model includes significant floodplain features which can interfere with the flood conveyance in the floodplain. For example, the model includes railroad embankments and culverts. A map showing the FLO-2D model domain is provided as Plate 12.

a. Breach Scenarios. For each hydrologic frequency event, floodplain inundation breach maps were developed for the fifteen levee breaches and one natural (non-leveed) flood sources throughout the study area. The inundation maps simulate a levee breach during the flood event. The inflow to the FLO-2D model was the outflow from the HEC-RAS model. The specified frequency is not the frequency of inundation. Inundation frequency estimates must account for performance of the levee (probability of the breach). The inundation frequency is computed in the economic flood damage analysis using the geotechnical fragility curves. Simulated inundation maps for levee breaches during a 100-yr event are provided as plates 13 through 28. Digital maps generated for simulated breaches during other ACE flood events are available upon request.

11. REFINED ALTERNATIVES.

The following describes the hydraulic design of new levees, project performance, and residual floodplains for each of the refined project alternatives.

d. SB-1 No Action. Based on a review of historical conditions and proposed actions, the hydraulic conditions in the future are assumed to be the same as existing conditions. Residual flood risk maps for criteria #1 and #2 are presented in Plates 29 and 30 respectively.

e. SB-2 Minimal Fix-In-Place plus NonStructural. This alternative would increase the performance of the levee from Sunset Weir to Star Bend. Residual Flood Risk Maps were based on reducing the fragility curve to overtopping only for breach locations FR6.0R, FR5.0R, and FR4.5R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 31 and 32 respectively.

f. SB-3 Yuba City Ring Levee. This alternative would involve construction of a ring levee around Yuba City. The height of the ring levee was determined by reviewing the flood elevations from the hypothetical levee breaches. Wind wave runup analysis was also conducted and the levee height was increased as necessary to provide 95% assurance from a levee breach outside the ring levee during a 0.5% (1/200) ACE flood. The hypothetical levee breach simulations were conducted for the 0.2% (1/500) ACE flood event with the levee in place. The resulting levee design profile is provided as Plate 33. Residual flood risk maps were based on reducing the fragility curve to overtopping only for breach locations FR5.0R and FR4.5R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 34 and 35 respectively.

g. SB-4 Yuba City J-Levee. This alternative would involve fixing the levees from Thermalito to Shanghai Bend and construction of a partial ring levee around Yuba City. The height of the new portion of levee was determined by reviewing the flood elevations from the hypothetical levee breaches. Wind wave runup analysis was also conducted and the levee height was increased as necessary to provide 95% assurance from a levee breach during a 0.5% (1/200) ACE flood in the unfixed levees. The hypothetical levee breach simulations were conducted for the 0.2% (1/500) ACE flood event with the levee in place. The resulting levee design profile is provided as Plate 36.Residual flood risk maps were based on reducing the fragility curve to overtopping only for breach locations on the Feather River FR9.0R, FR8.0R, FR7.0R, FR6.0R, FR5.0R, and FR4.5R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 37 and 38 respectively.

h. SB-5 Fix in Place Feather River, Thermalito to Star Bend. This alternative would involve fixing the levees from Thermalito to Star Bend. The hypothetical levee breach simulations are the same as the no action plan. Residual flood risk maps were based on reducing the fragility curve to overtopping only for breach locations on the Feather River FR9.0R, FR8.0R, FR7.0R, FR6.0R, FR4.5R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 39 and 40 respectively.

i. SB-6 Fix in Place Feather River, Sutter Bypass and Wadsworth Canal. This alternative would involve fixing the east levee of the Sutter Bypass downstream of Wadworth Canal, Wadsworth Canal south levee and Feather River west levee. The hypothetical levee breach simulations are the same as the no action plan. Flood Residual flood risk maps were based on reducing the fragility curve to overtopping only for all breach locations except BB1.0, CC2.0L,CC1.0L, SB 5.0L, and BW2.0R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 41 and 42 respectively.

j. SB-7 Fix-In-Place Sunset Weir to Laurel Avenue . This alternative would increase the performance of the levee from Sunset Weir to 2200 feet downstream of Laurel Ave. Residual Flood Risk Maps were based on reducing the fragility curve to overtopping only for breach locations FR6.0R, FR5.0R, and FR4.5R, and FR4.0R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 43 and 44 respectively.

k. SB-8 Fix in Place Feather River, Thermalito to Laurel Avenue. This alternative would involve fixing the levees from Thermalito to 2200 feet downstream of Laurel Ave. The hypothetical levee breach simulations are the same as the no action plan. Residual flood risk maps were based on reducing the fragility curve to overtopping only for breach locations on the Feather River FR9.0R, FR8.0R, FR7.0R, FR6.0R, FR4.5R, and FR4.0R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 45 and 46 respectively.

12. CONCLUSIONS

For questions on the technical content of this report, contact Peter Blodgett, P.E., Hydraulic Design Section, (916) 557-7529.

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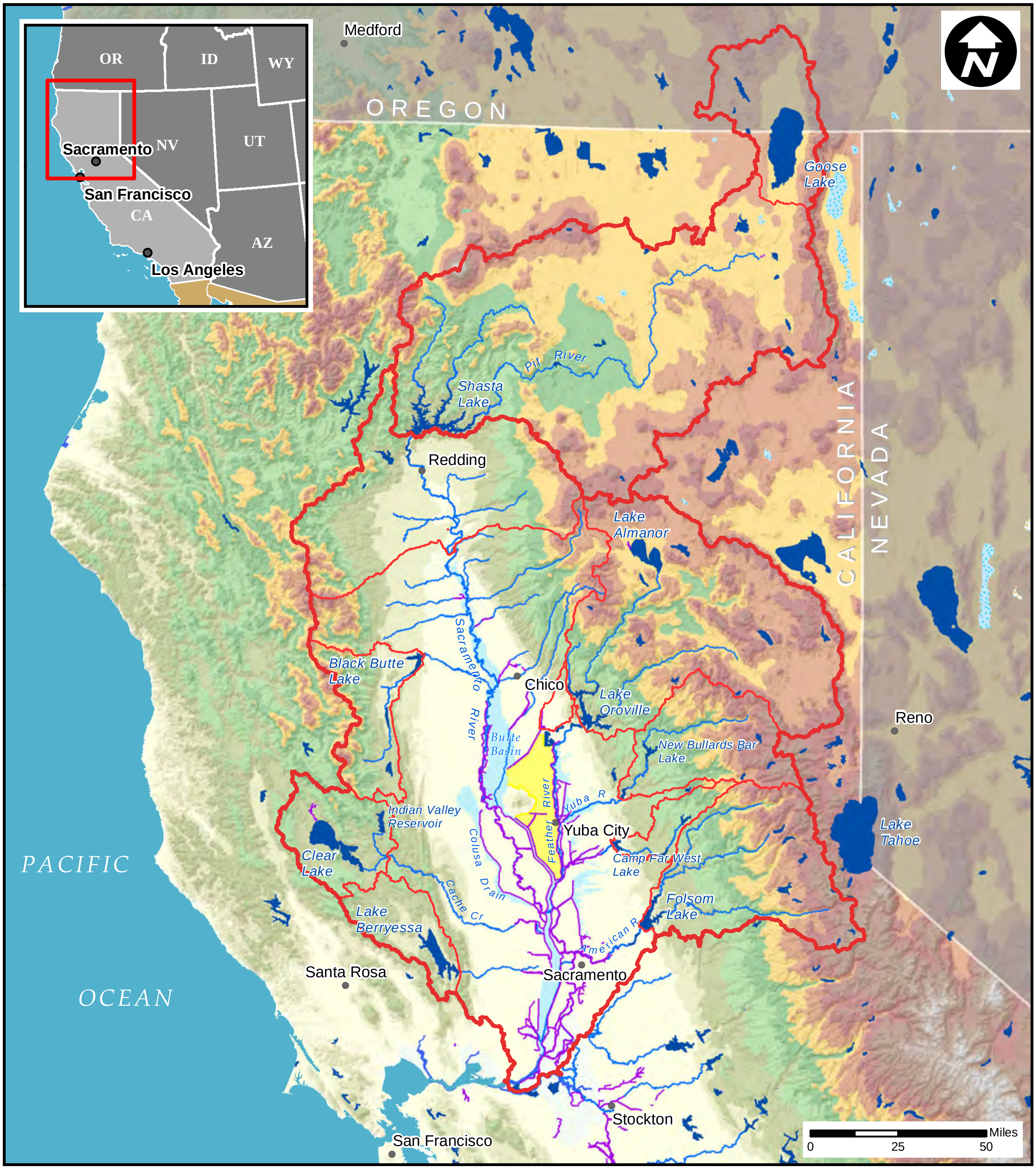
Sacramento District,
U.S. Army Corps of Engineers



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

SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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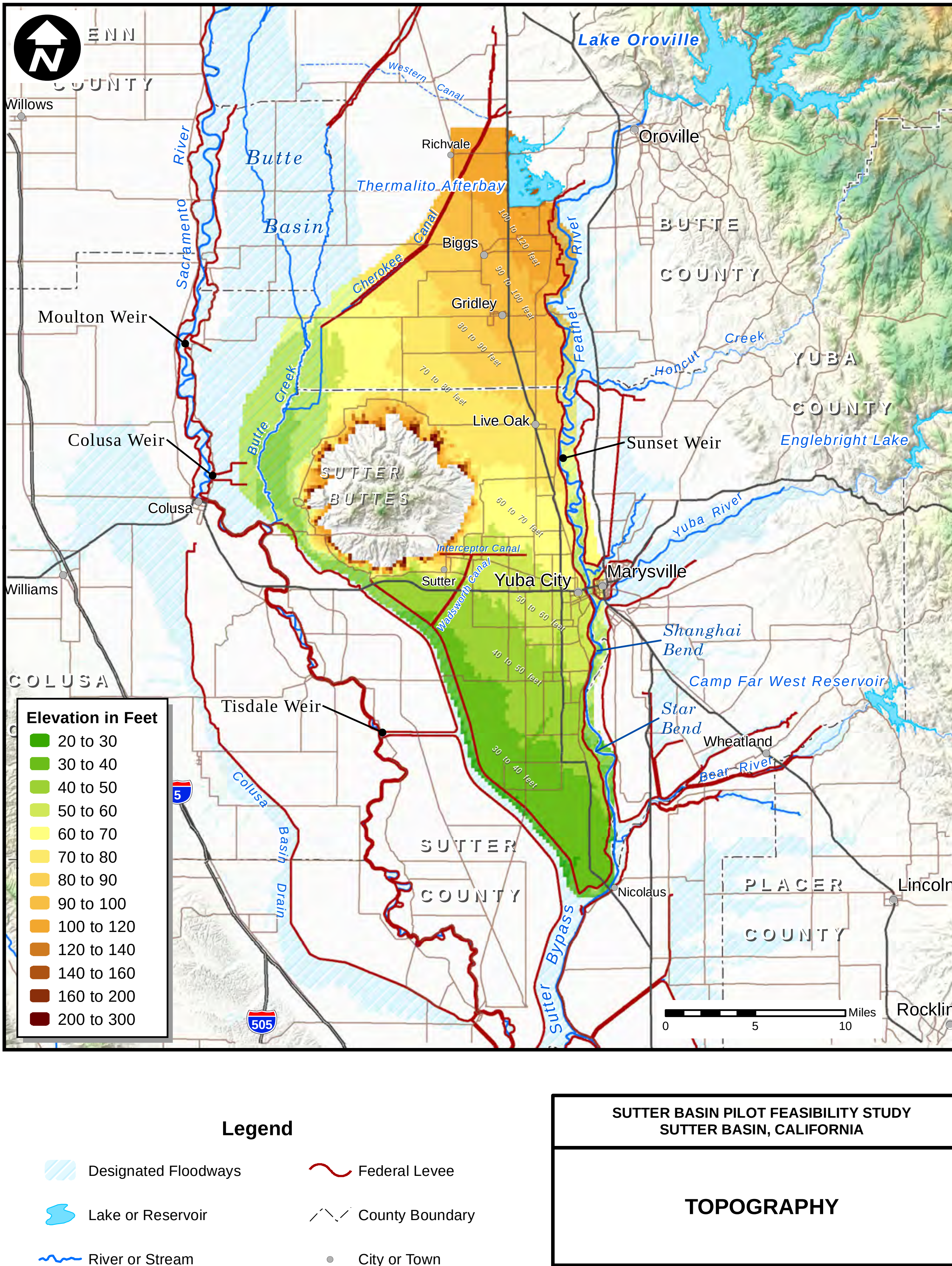
PLATE 1



SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

TOPOGRAPHY

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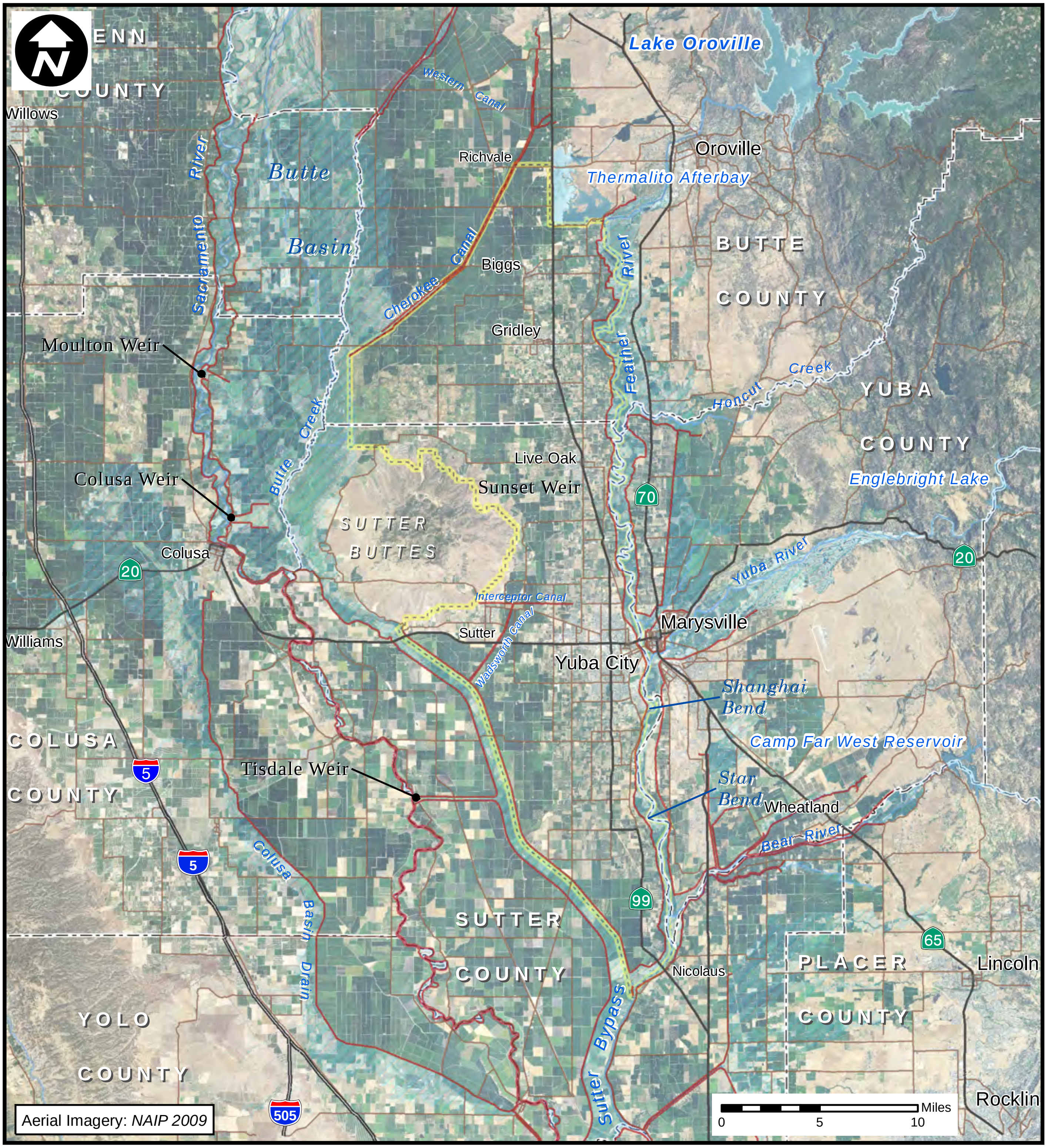
PLATE 2



Legend

Study Area Extent

Federal Levee

Designated Floodways

County Boundary

Lake or Reservoir

City or Town

River or Stream

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

AERIAL IMAGERY

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SACRAMENTO DISTRICT

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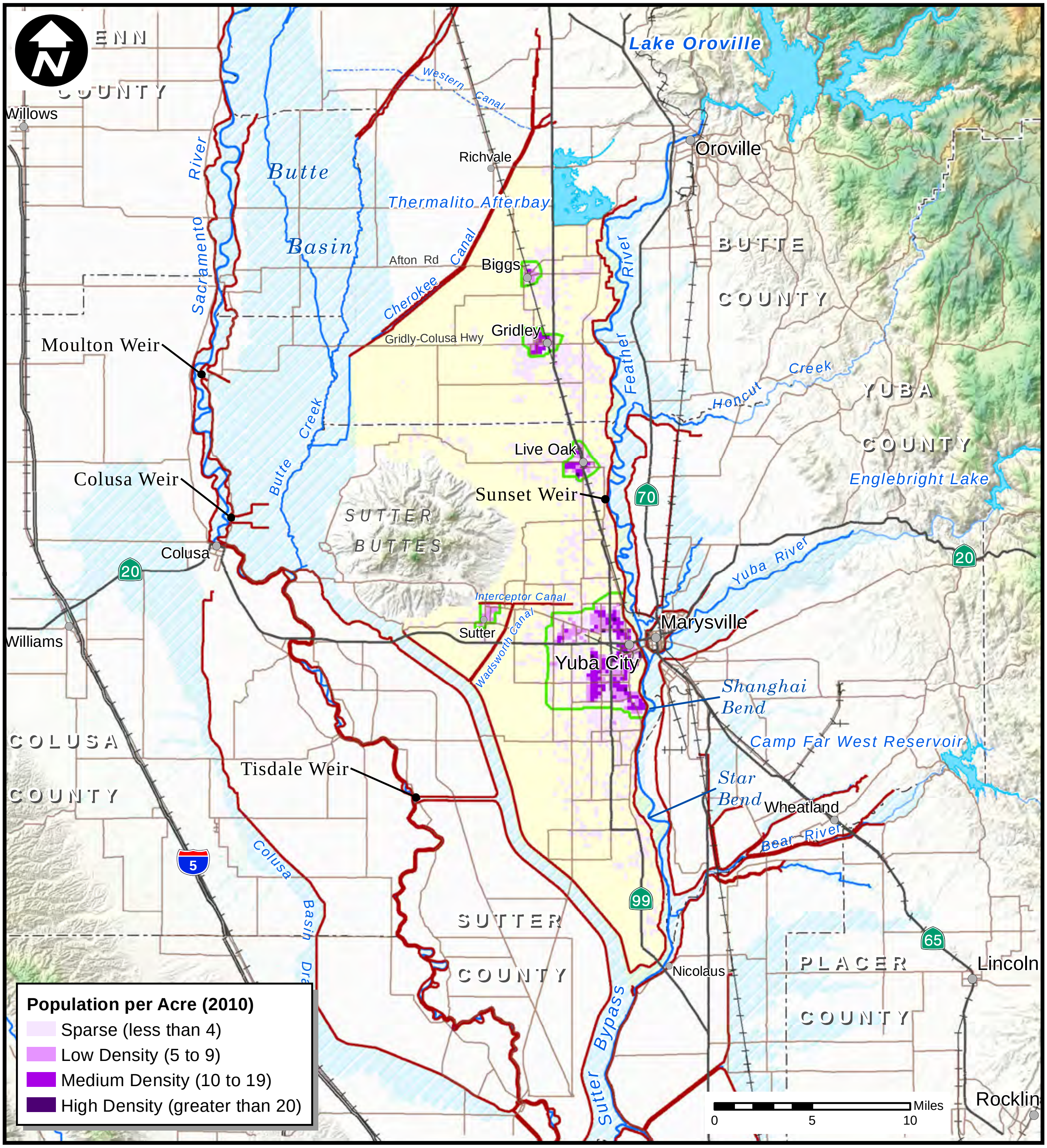
PLATE 3



Legend

- Economic Evaluation Area
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- Railroad
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

POPULATION DENSITY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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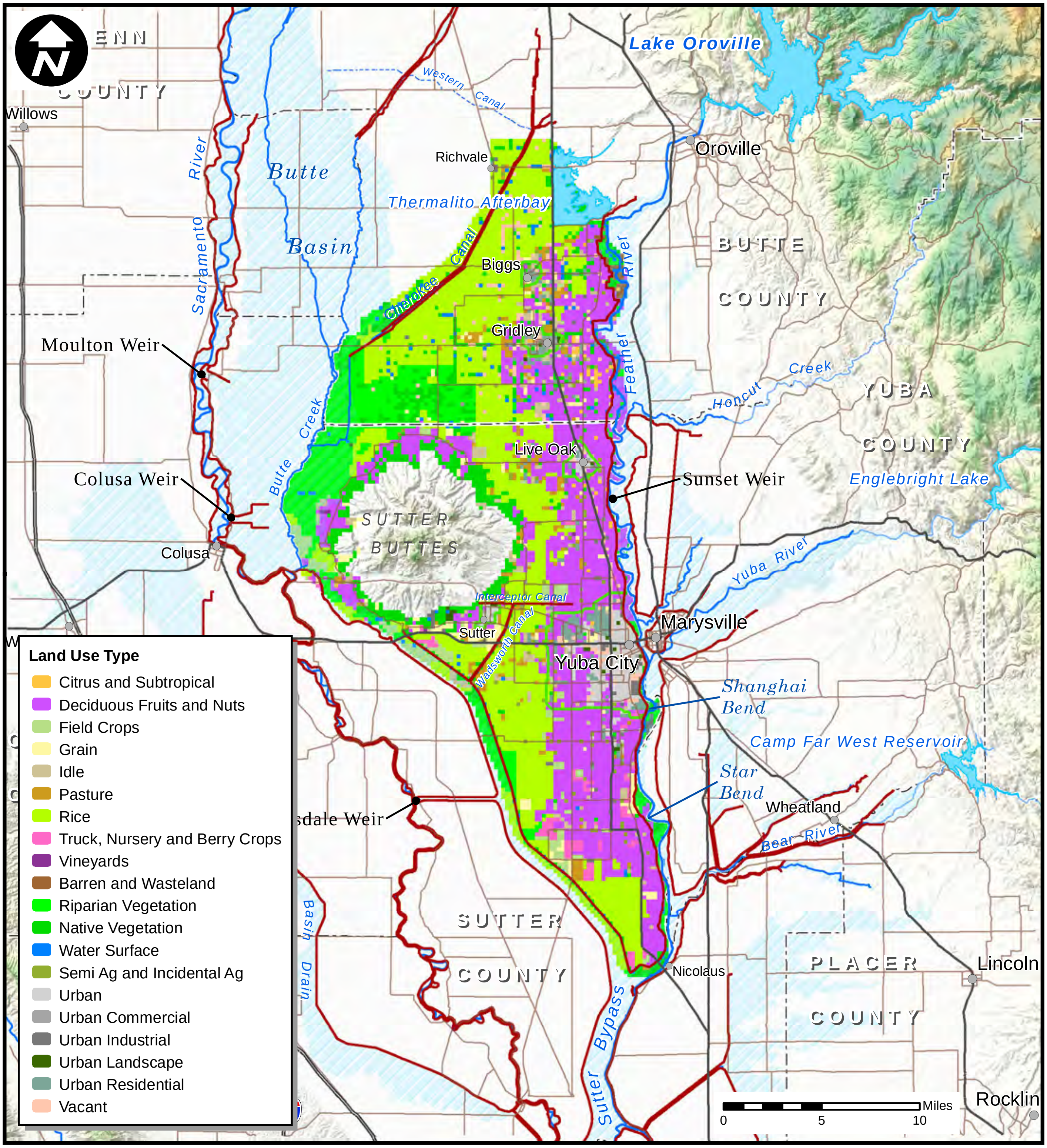
PLATE 4



Legend

Designated Floodways

Lake or Reservoir

River or Stream

Federal Levee

County Boundary

City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

LAND USE

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SACRAMENTO DISTRICT

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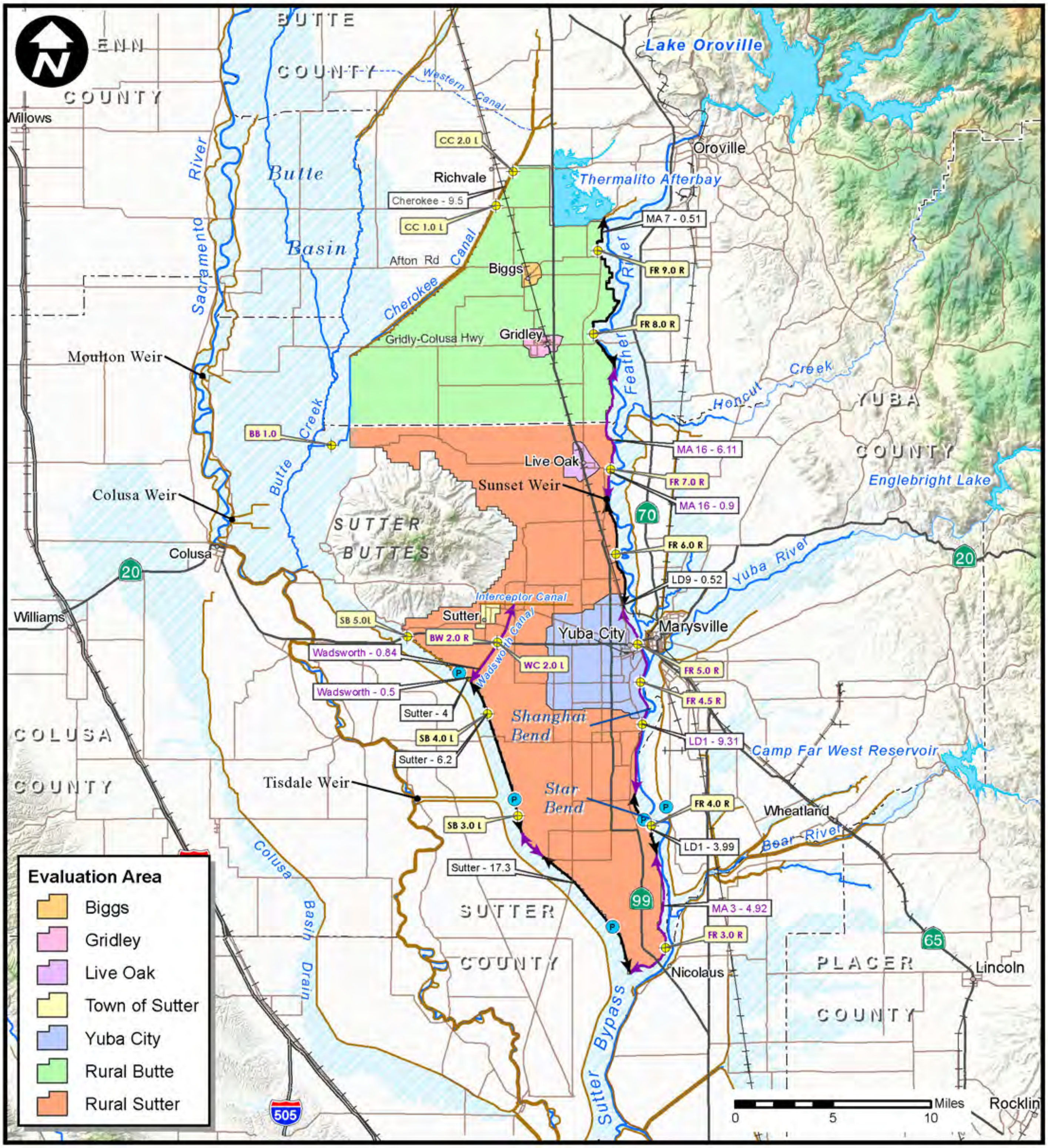

Legend

- Geotechnical Levee Reach
- Federal Levee
- Breach Simulation Site
- Geotechnical Index Point
- Pump Station
- City or Town
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

ECONOMIC IMPACT AREAS

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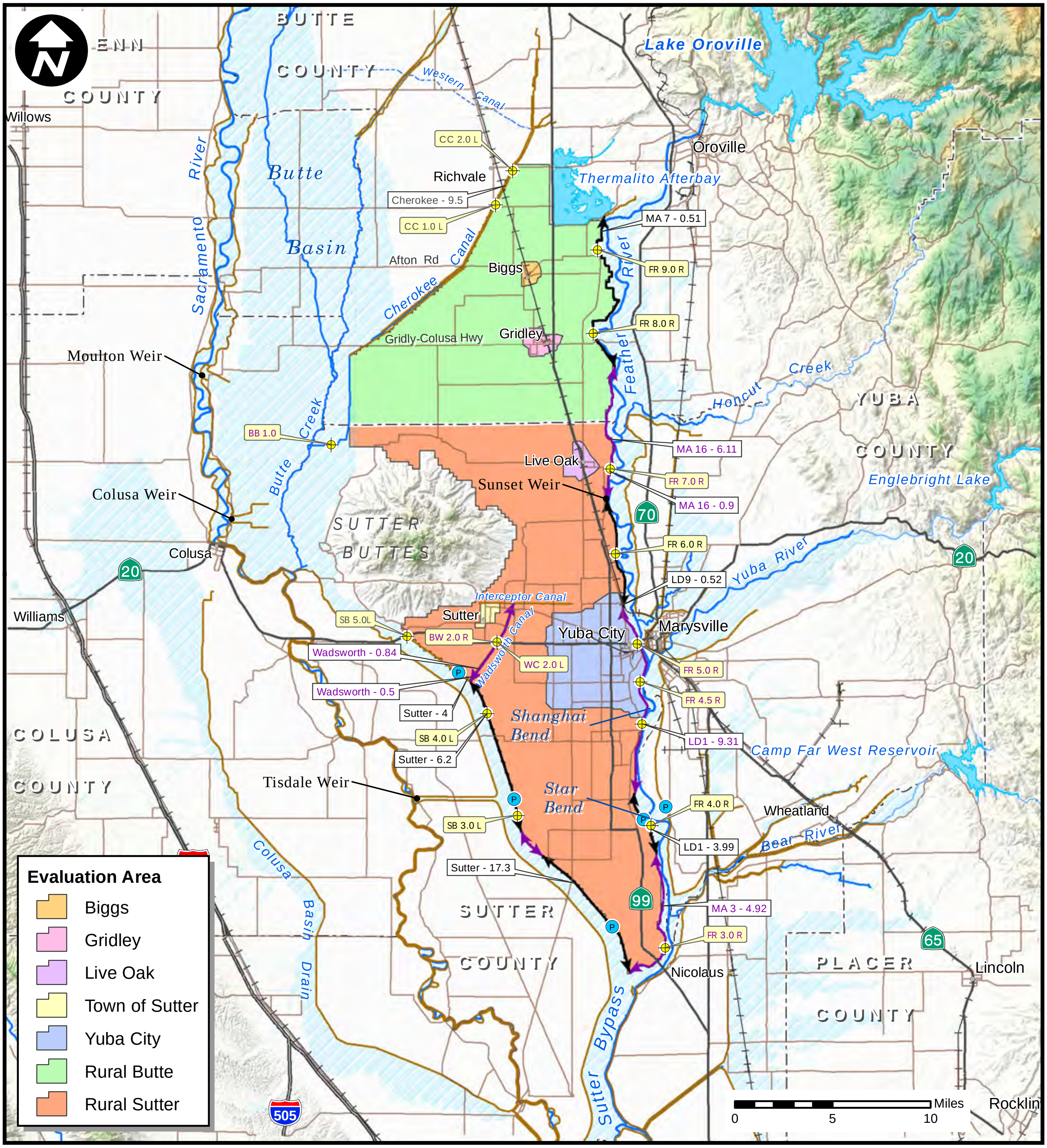

Legend

Geotechnical Levee Reach	Designated Floodways
Federal Levee	Lake or Reservoir
Breach Simulation Site	River or Stream
Geotechnical Index Point	Railroad
Pump Station	County Boundary
City or Town	

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

ECONOMIC IMPACT AREAS

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SACRAMENTO DISTRICT

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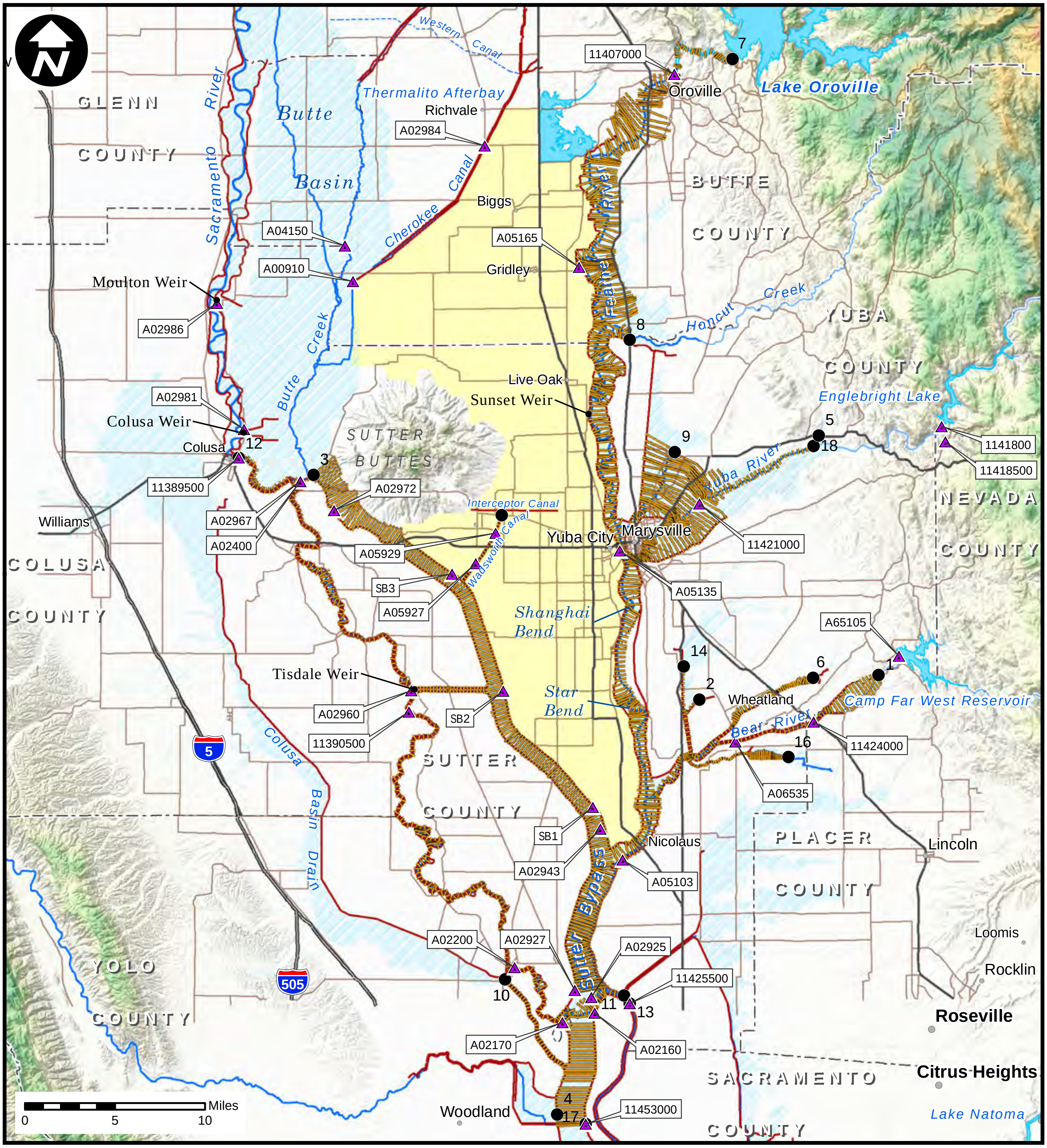

Legend

- Stream Gage
- Model Boundaries
- Model Cross Sectios
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: See Table 1 and 2 for Model Boundary Name

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

HEC-RAS HYDRAULIC MODEL BOUNDARY CONDITIONS AND STREAM GAGES

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SACRAMENTO DISTRICT

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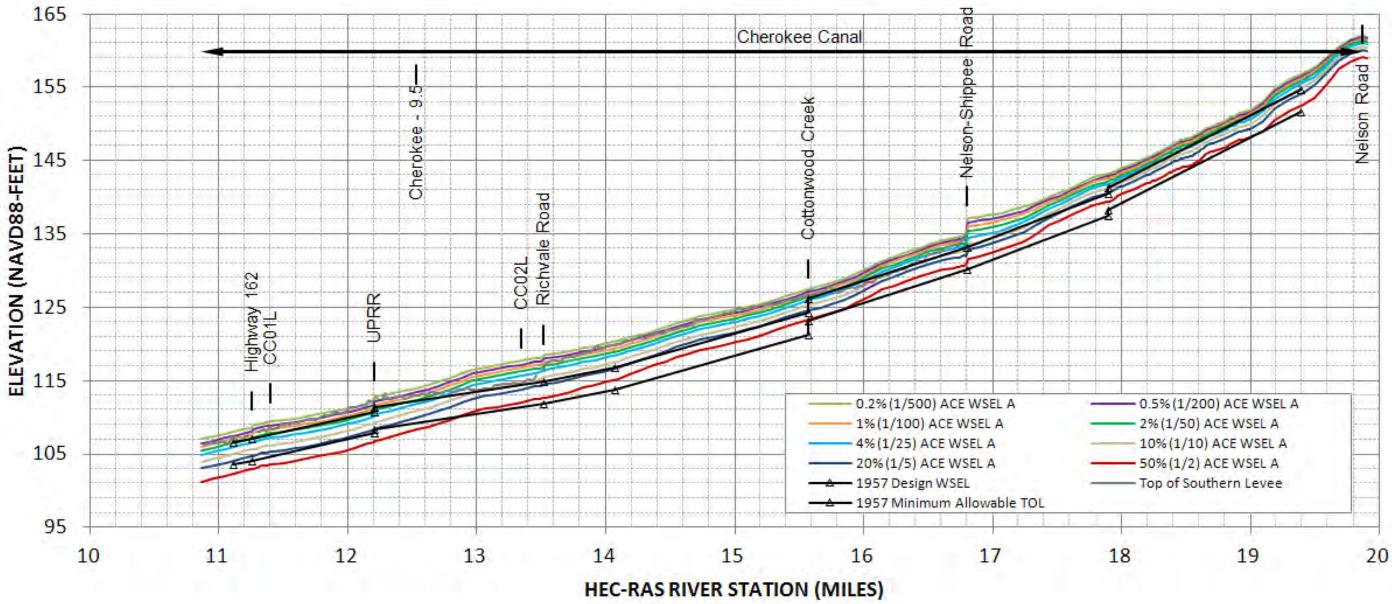
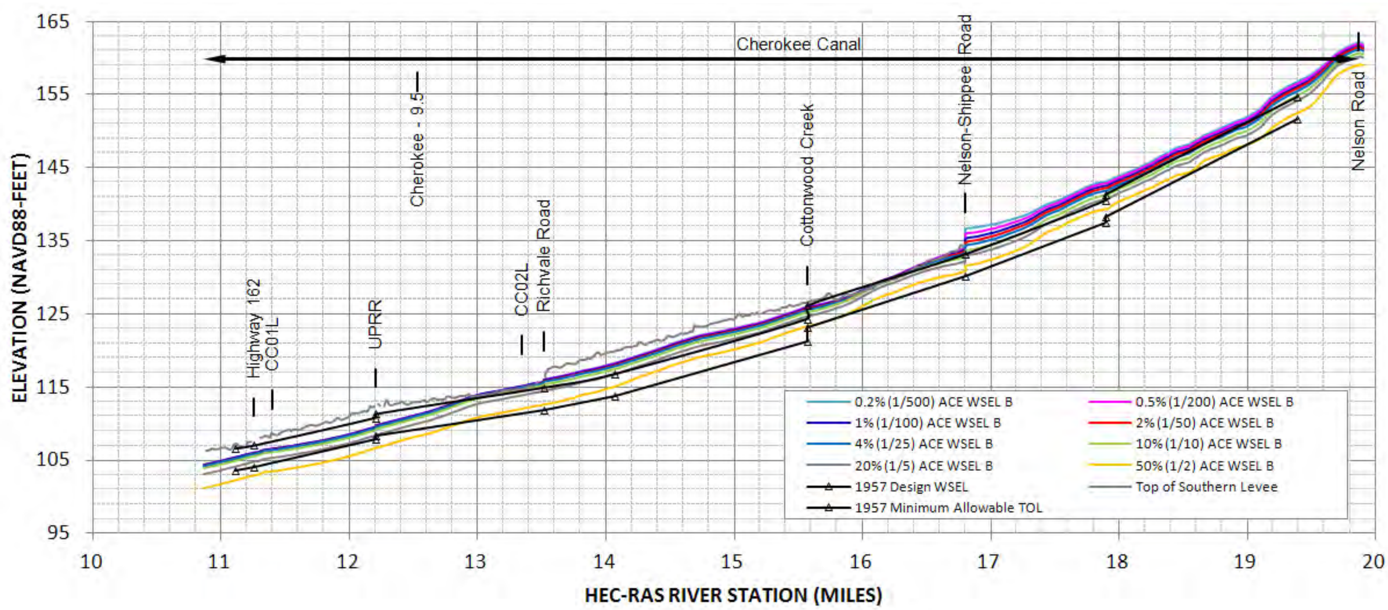
Water Surface Profile A



Water Surface Profile B



Notes:

Water Surface Profile A assumes infinite levee height, no overtopping.

Water Surface Profile B assumes overtopping only, no failure.

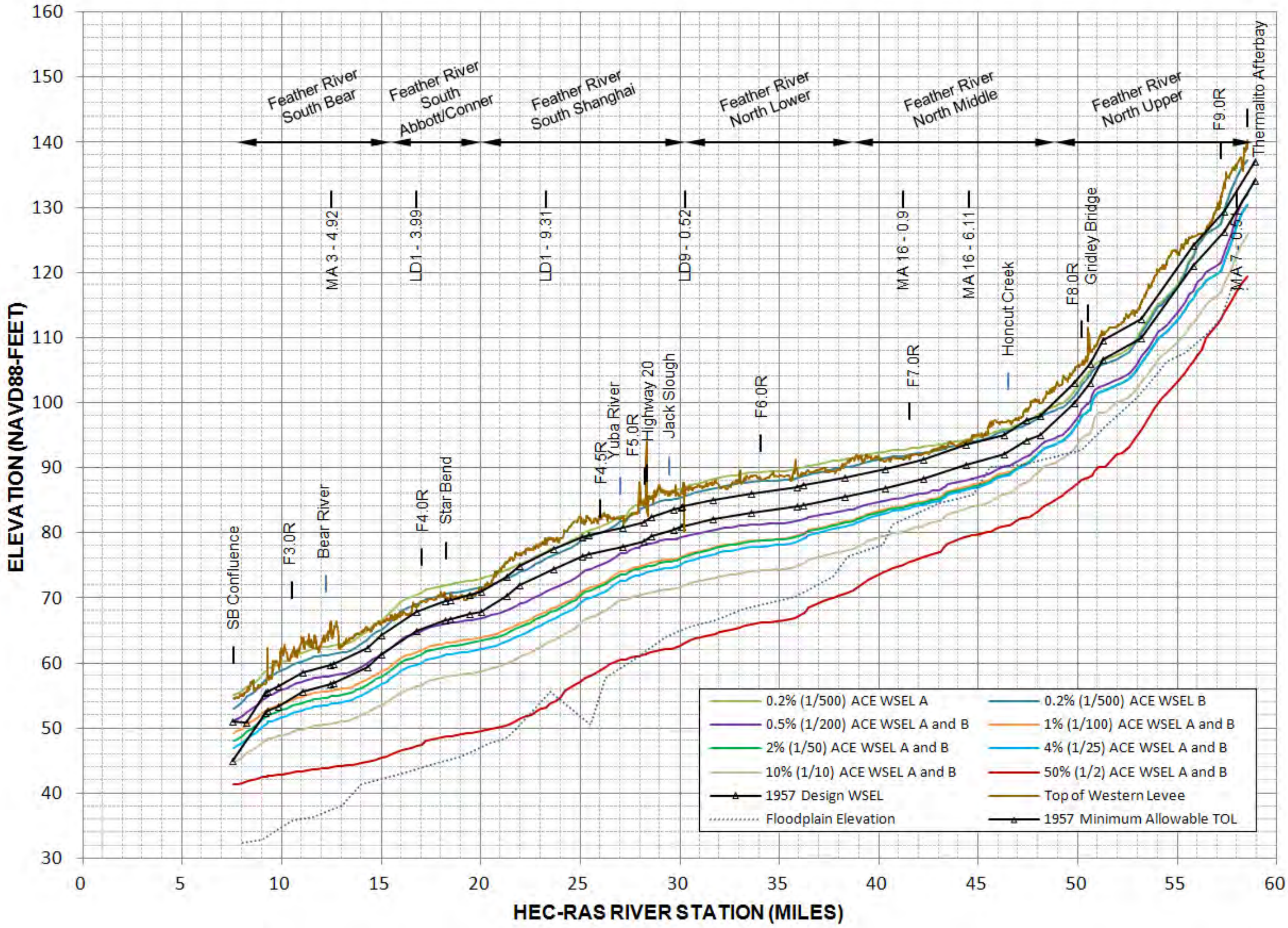
WSEL = Water Surface Elevation

Source:

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Notes:

Water Surface Profile A assumes infinite height levee, no overtopping.

Water Surface Profile B assumes overtopping, no failure

WSEL = Water Surface Elevation

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

FEATHER RIVER WATER SURFACE PROFILES

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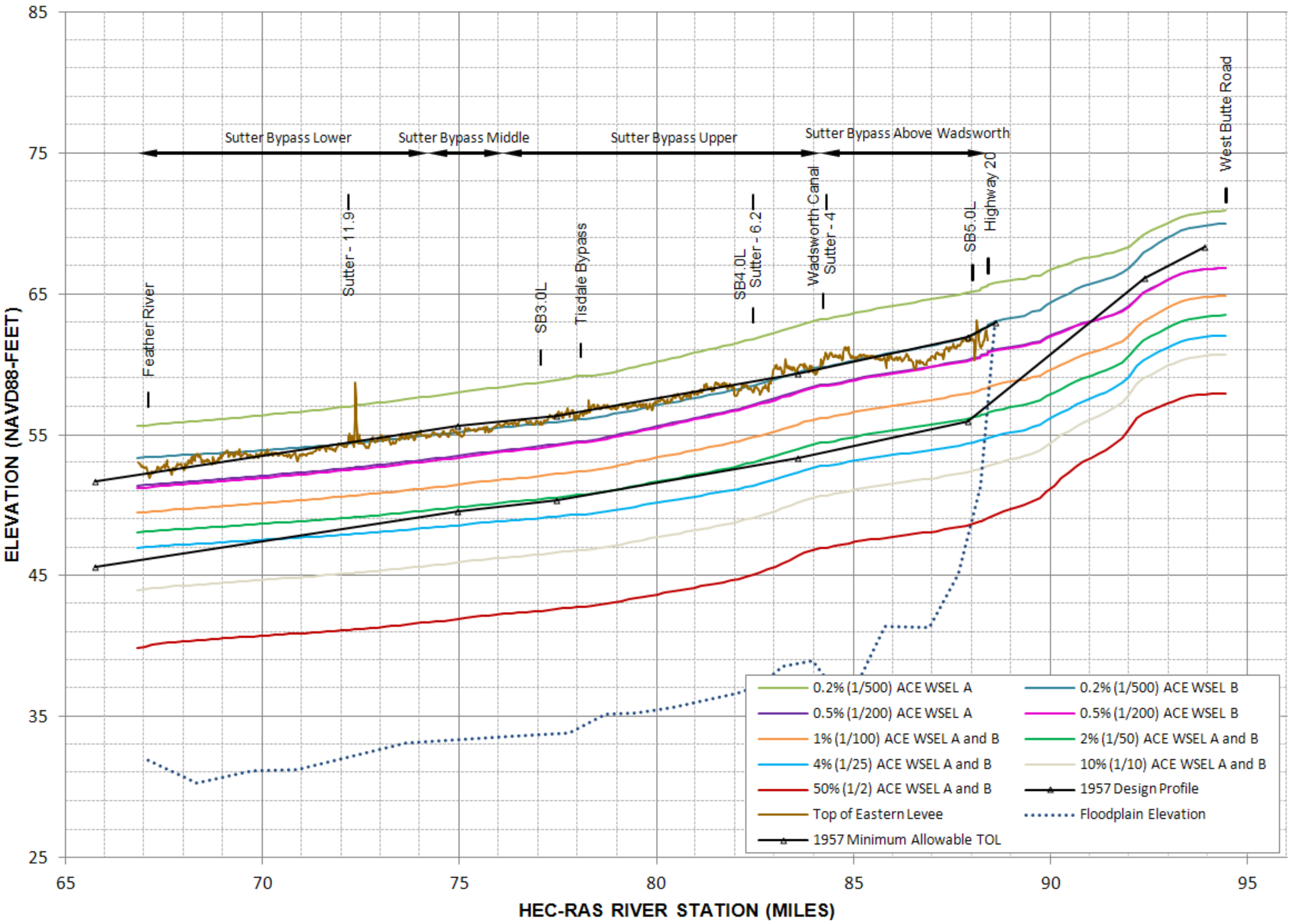
SACRAMENTO DISTRICT



Note:

Water Surface Profile A assumes infinite levee height, no overtopping.

Water Surface Elevation B assumes overtopping only, no failure

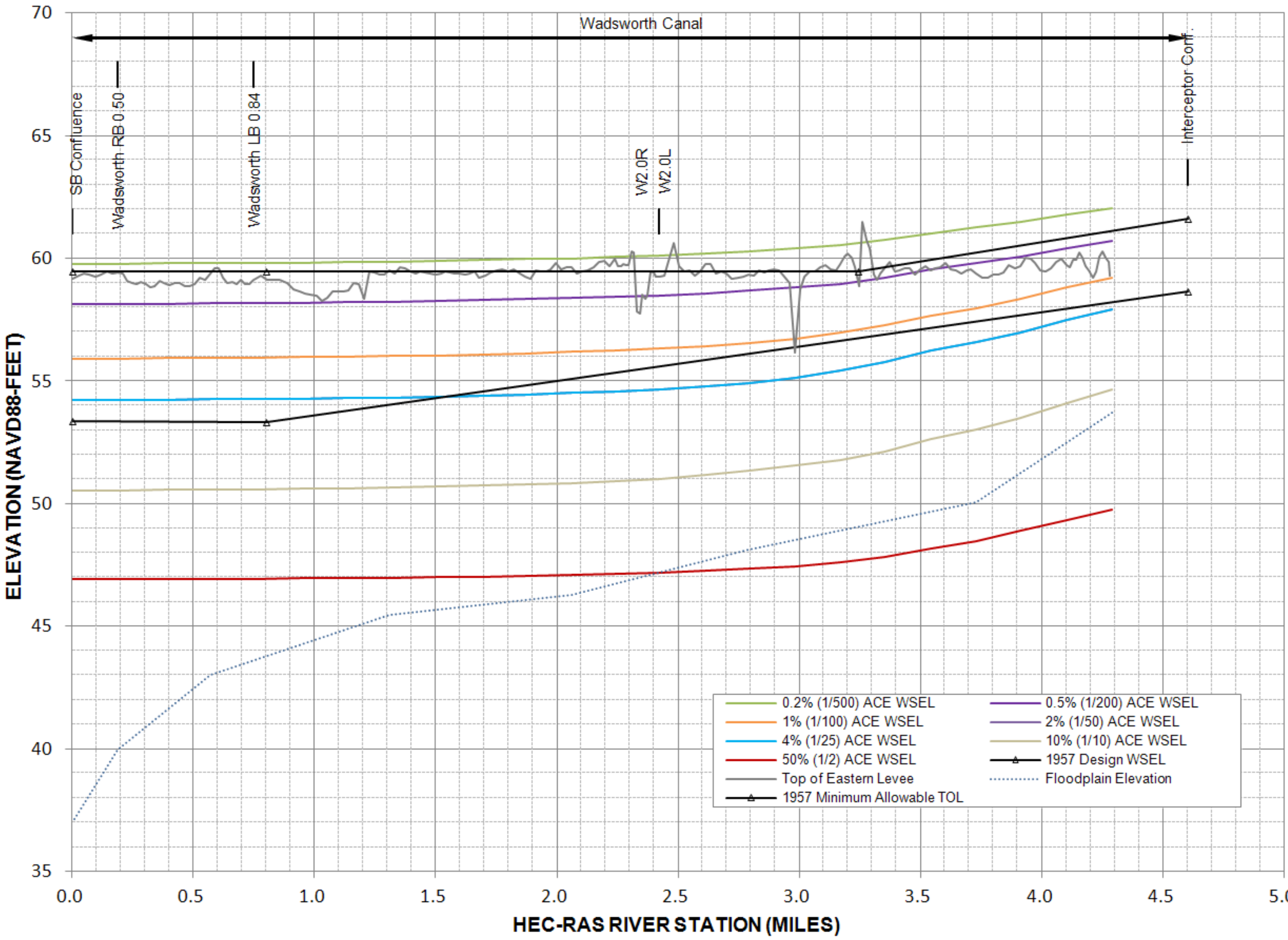
WSEL = Water Surface Elevation

Source:

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

SUTTER BYPASS
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Notes:

Water Surface Profiles assume infinite height levee, no overtopping.

Overtopping, no failure was not created for Wadsworth Canal.

WSEL = Water Surface Elevation

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

WADSWORTH CANAL
WATER SURFACE PROFILES

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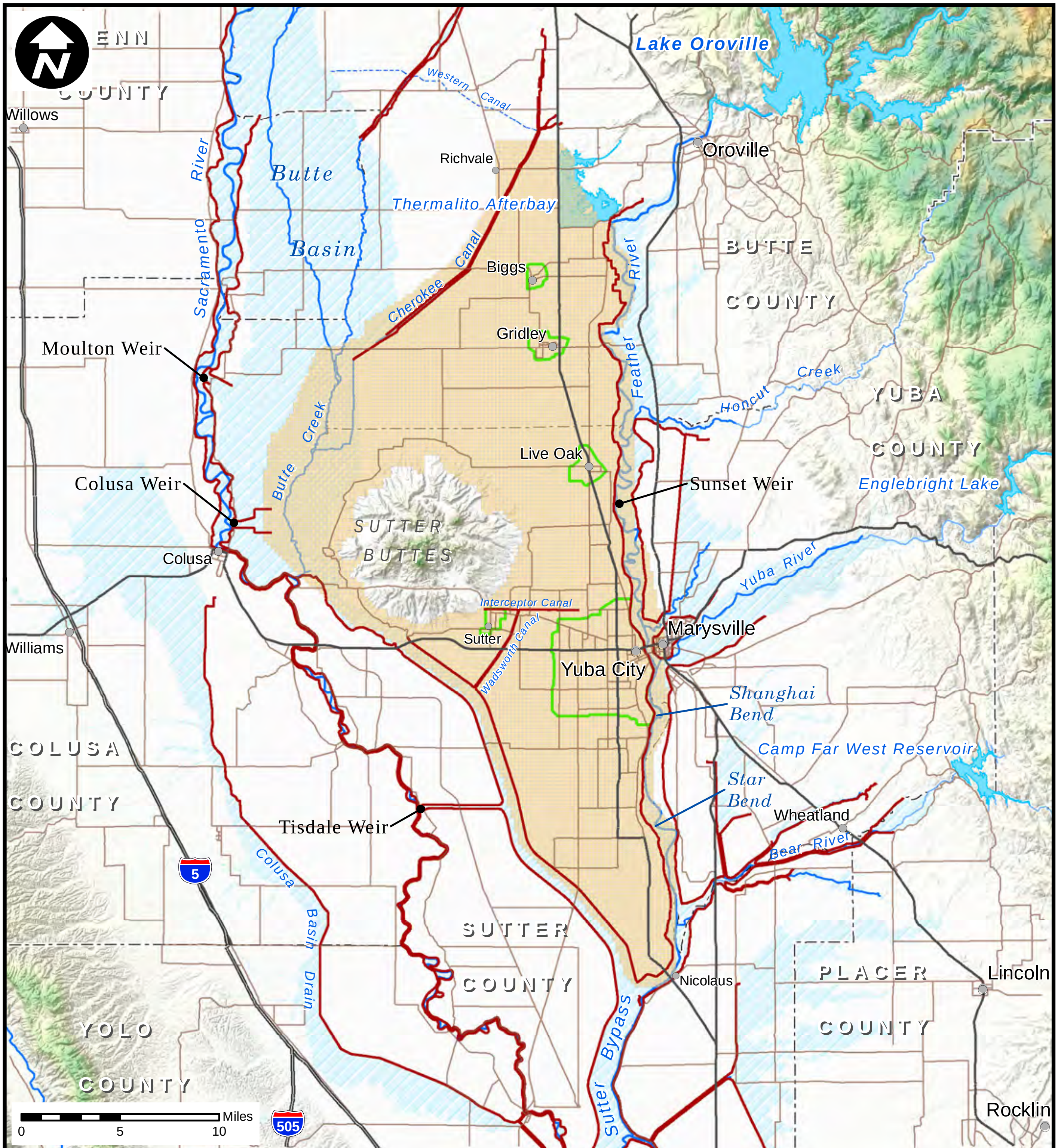

Legend

- FLO2D Grid
- Designated Floodways
- Lake or Reservoir
- Economic Evaluation Area
- River or Stream
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

FLO2D MODEL GRID

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SACRAMENTO DISTRICT

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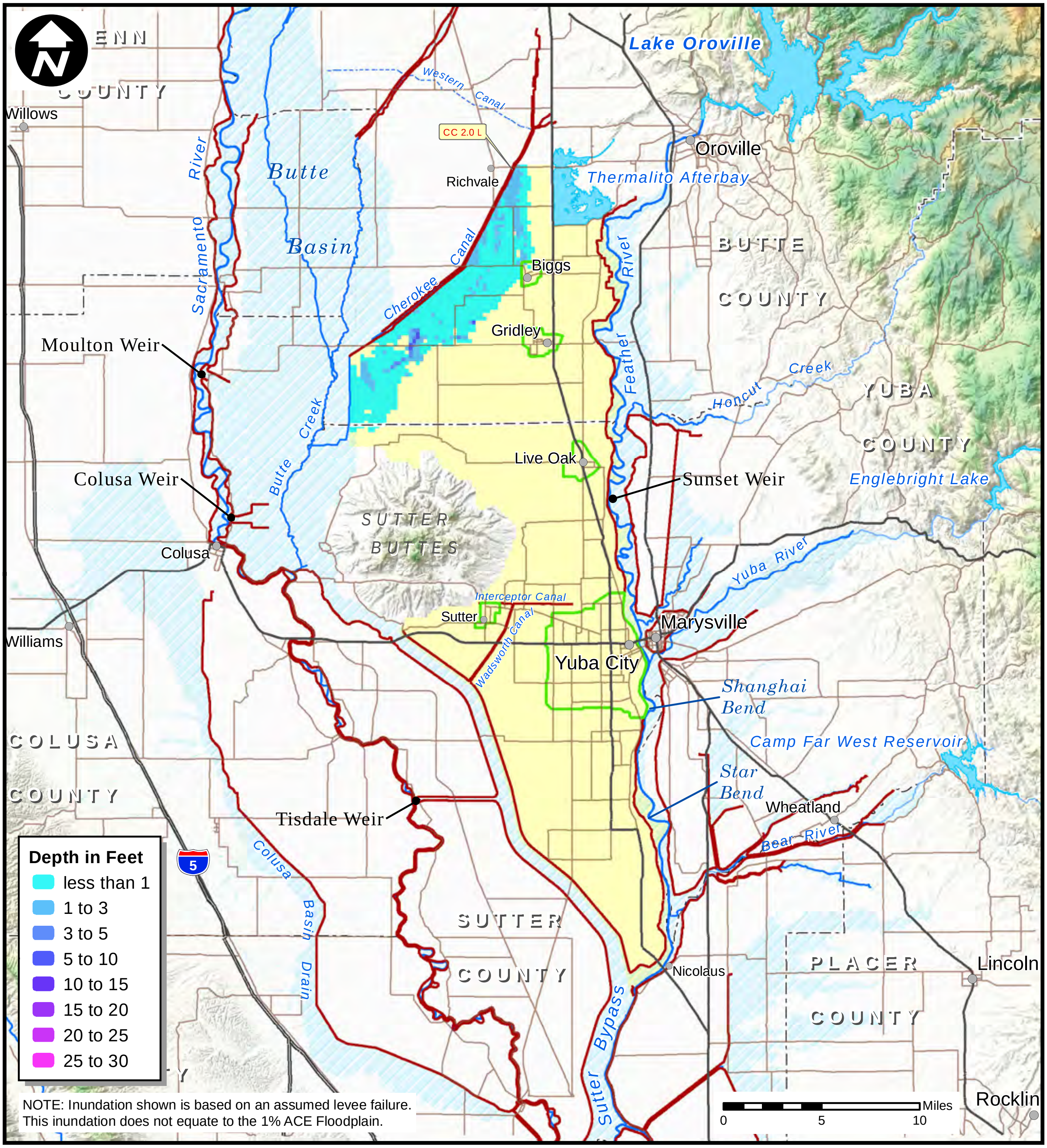
OCT 2012

PLATE 12



Legend

	Breach Index Point		Study Area Extent
	Designated Floodways		Federal Levee
	Lake or Reservoir		County Boundary
	River or Stream		City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION CC 2.0 L INDEX POINT 1% ACE EVENT

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SACRAMENTO DISTRICT

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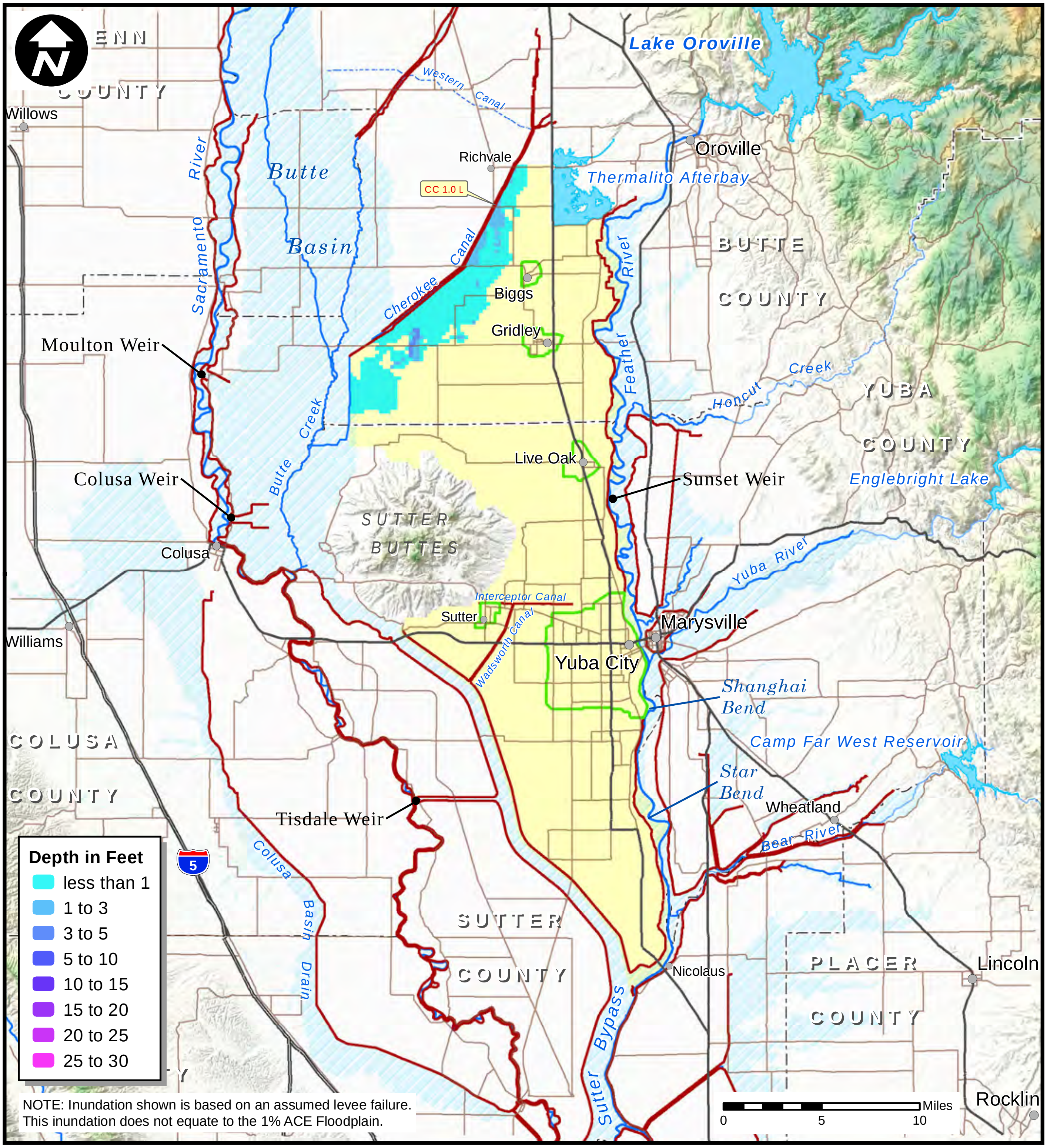

Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
CC 1.0 L INDEX POINT
1% ACE EVENT

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SACRAMENTO DISTRICT

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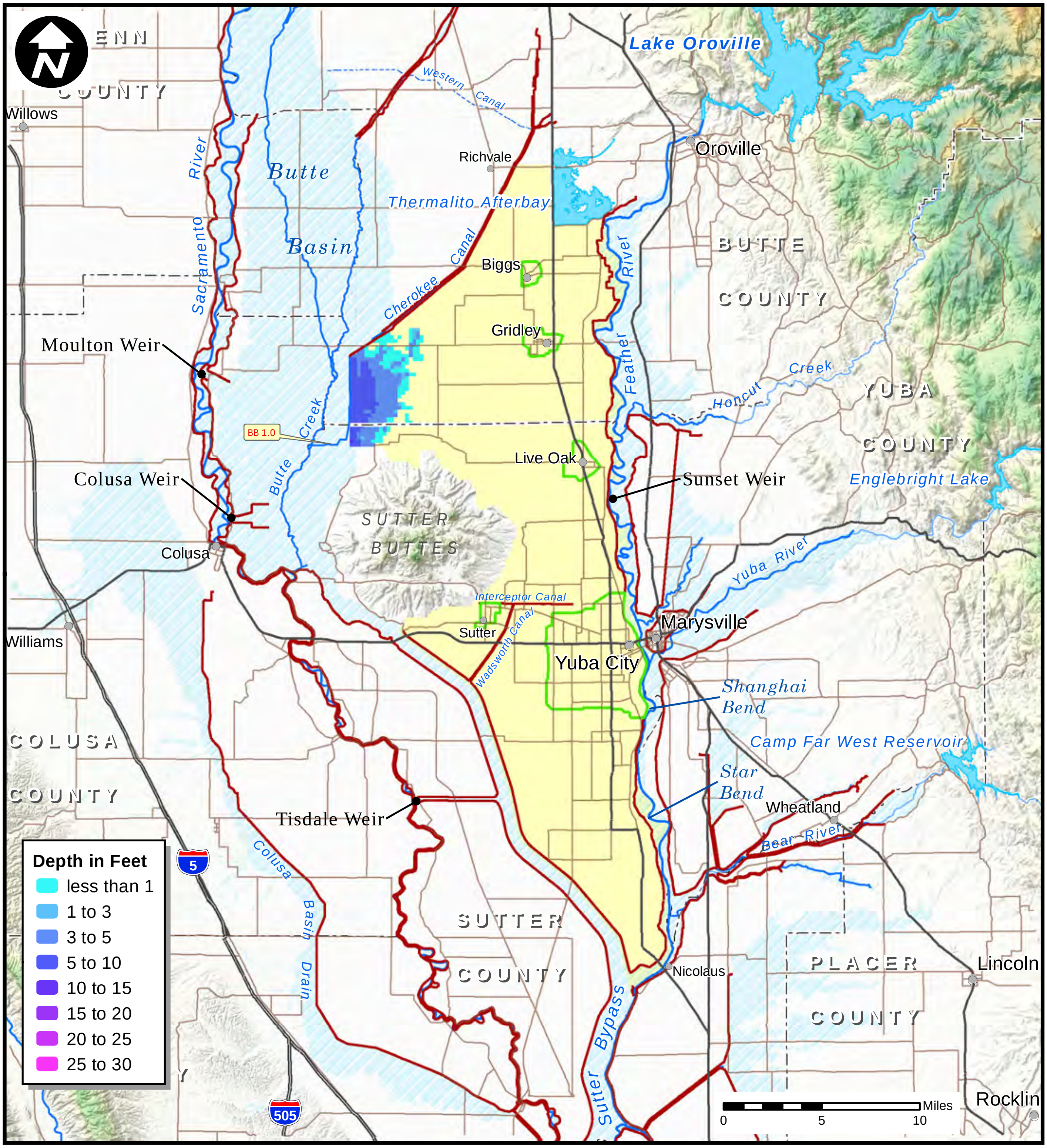

Legend

Flood Source Point	Study Area Extent
Designated Floodways	Federal Levee
Lake or Reservoir	County Boundary
River or Stream	City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED INUNDATION
BB 1.0 INDEX POINT
1% ACE EVENT

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SACRAMENTO DISTRICT

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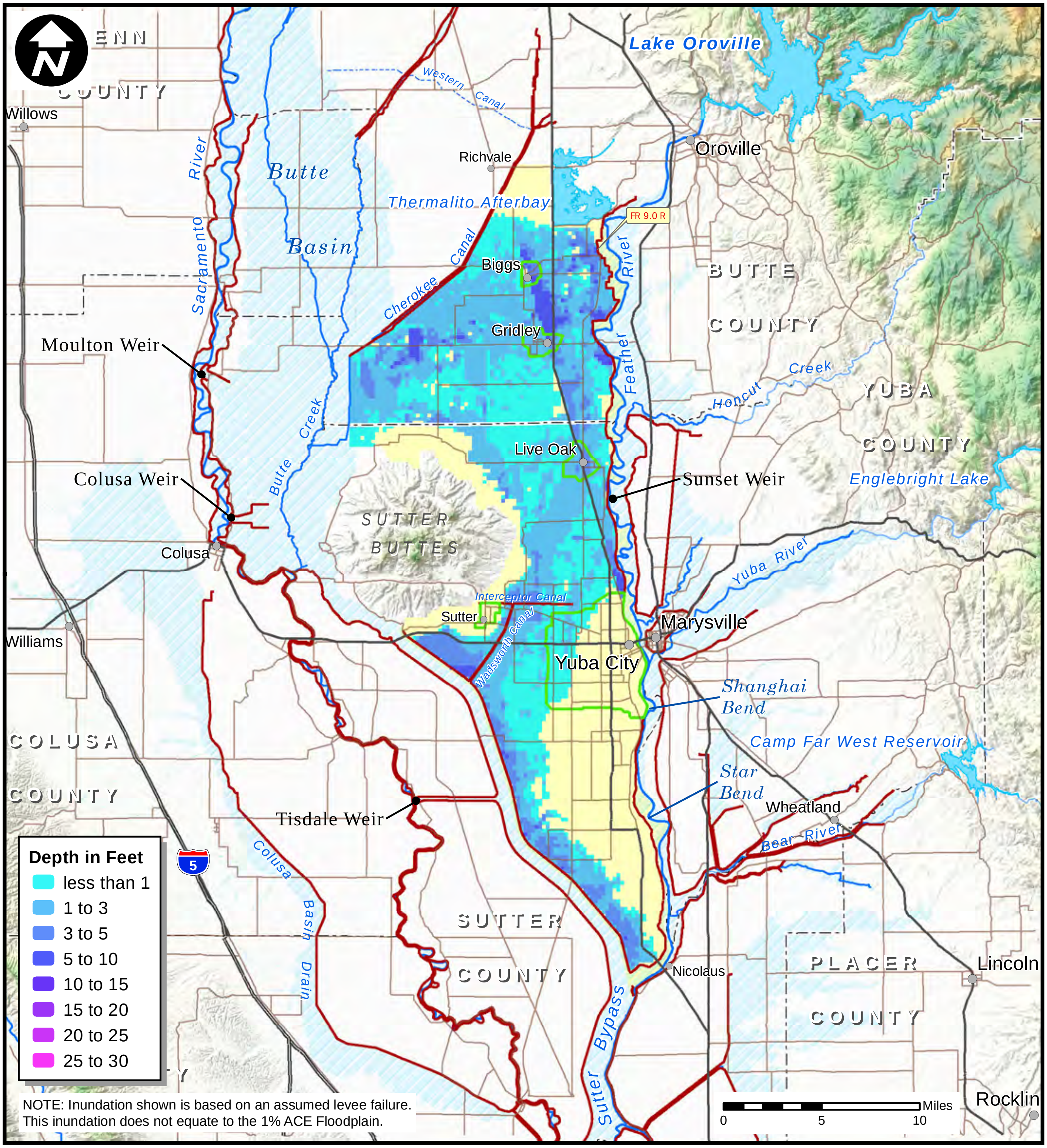
PLATE 15



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION FR 9.0 R INDEX POINT 1% ACE EVENT

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SACRAMENTO DISTRICT

Prepared by Jim Mars

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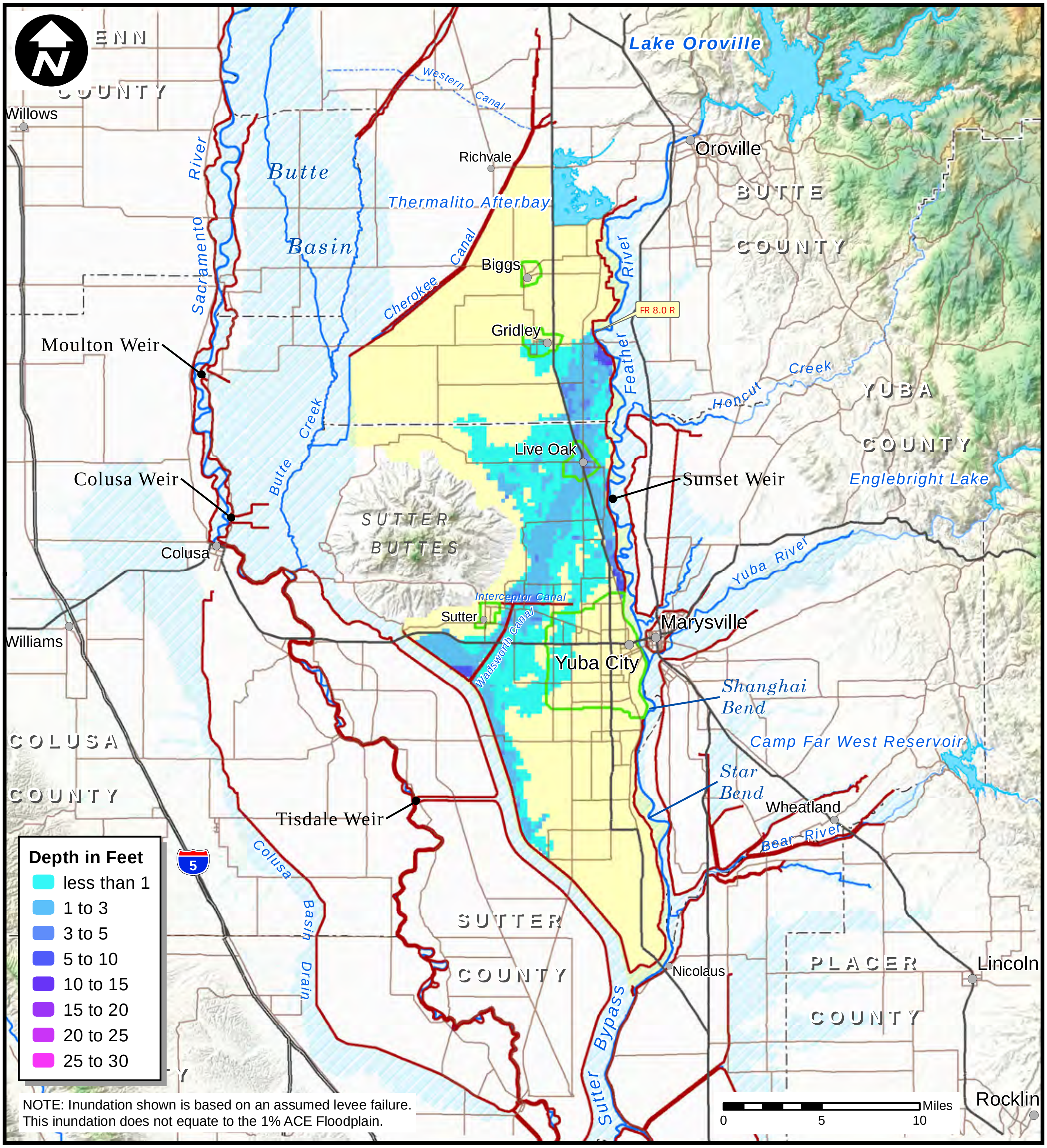

Legend

Breach Index Point	Study Area Extent
Designated Floodways	Federal Levee
Lake or Reservoir	County Boundary
River or Stream	City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION FR 8.0 R INDEX POINT 1% ACE EVENT

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SACRAMENTO DISTRICT

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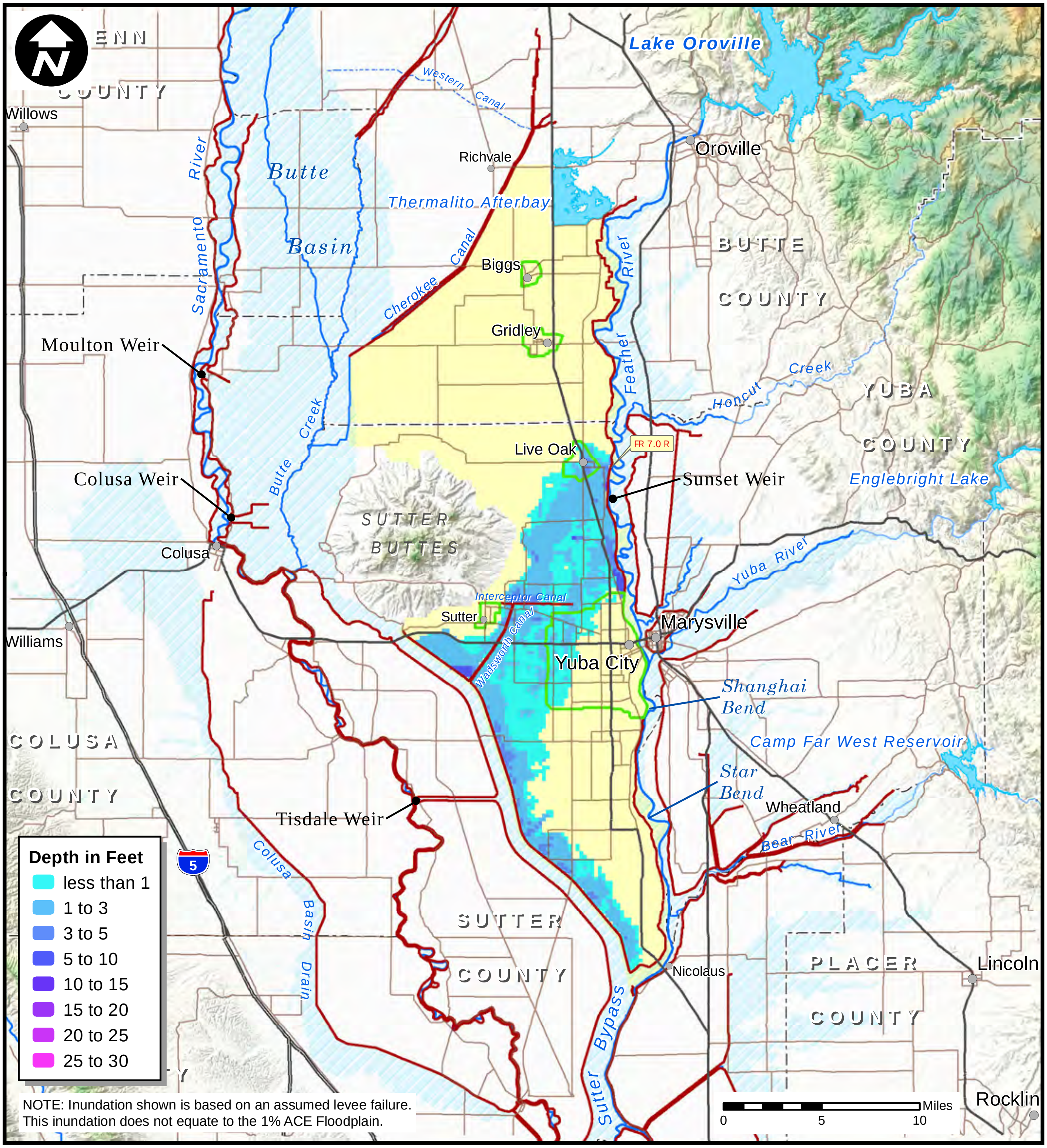
PLATE 17



Legend

Breach Index Point	Study Area Extent
Designated Floodways	Federal Levee
Lake or Reservoir	County Boundary
River or Stream	City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION FR 7.0 R INDEX POINT 1% ACE EVENT

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SACRAMENTO DISTRICT

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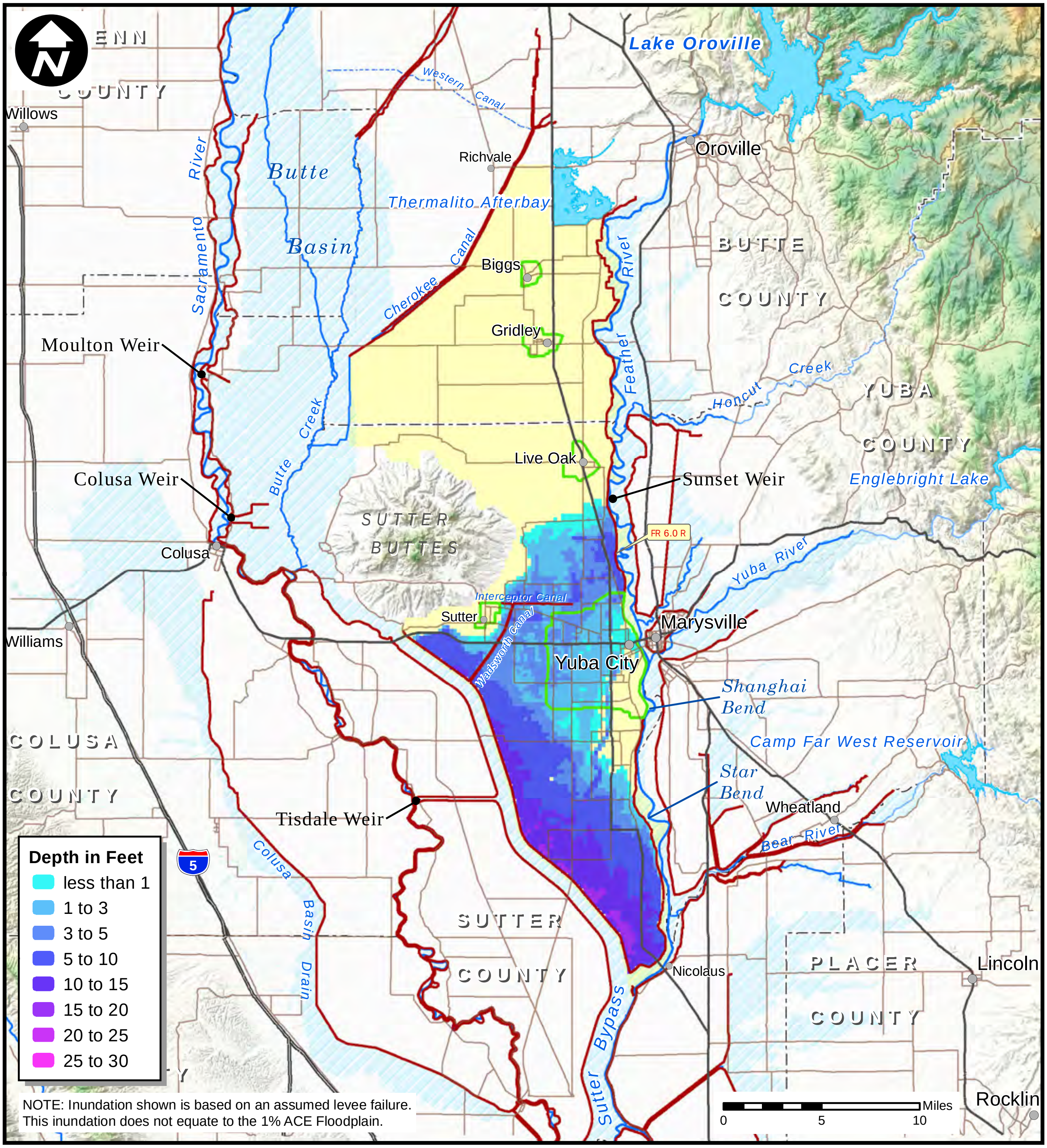

Legend

Breach Index Point	Study Area Extent
Designated Floodways	Federal Levee
Lake or Reservoir	County Boundary
River or Stream	City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION FR 6.0 R INDEX POINT 1% ACE EVENT

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SACRAMENTO DISTRICT

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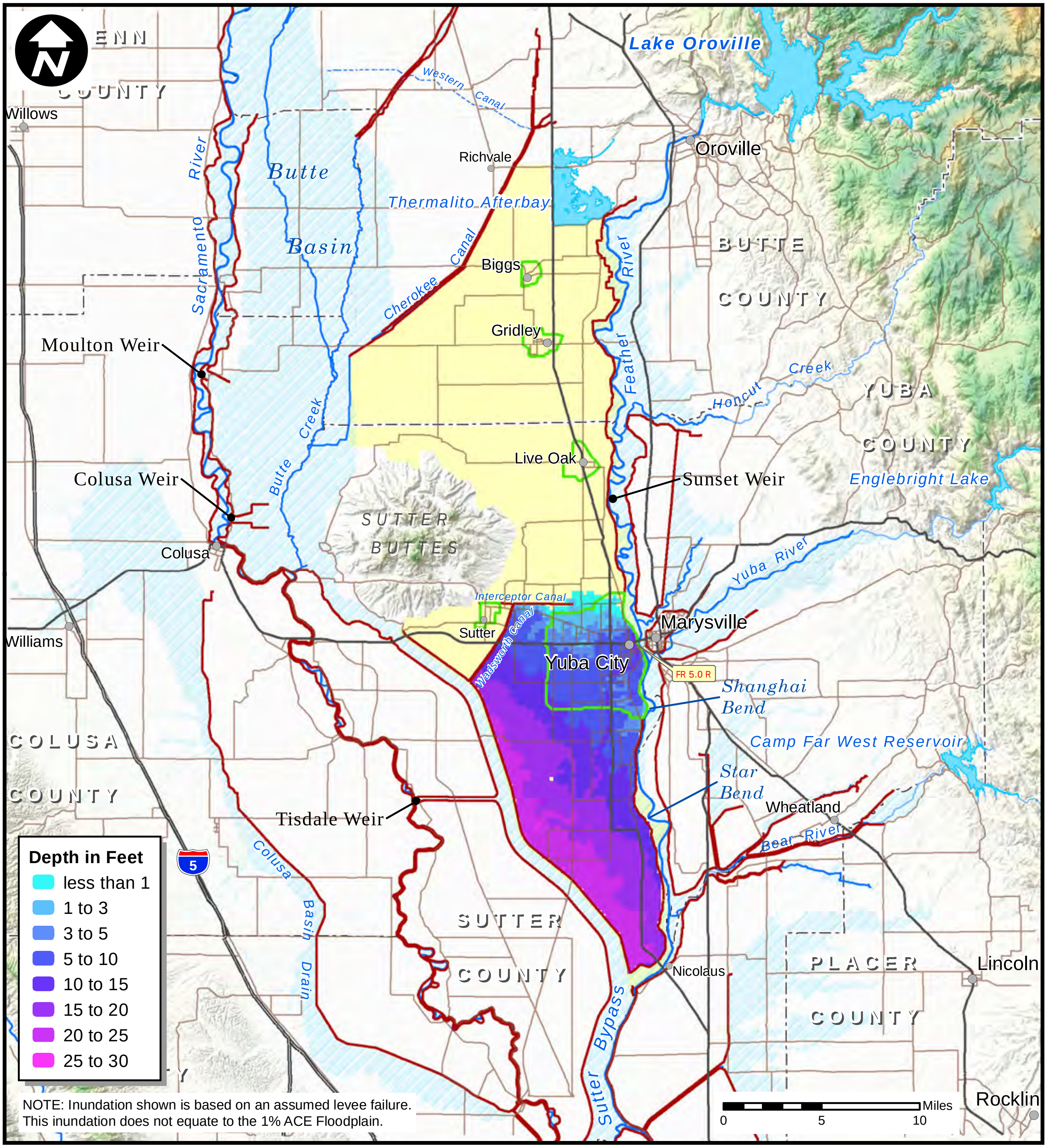


Legend

Breach Index Point	Study Area Extent
Designated Floodways	Federal Levee
Lake or Reservoir	County Boundary
River or Stream	City or Town

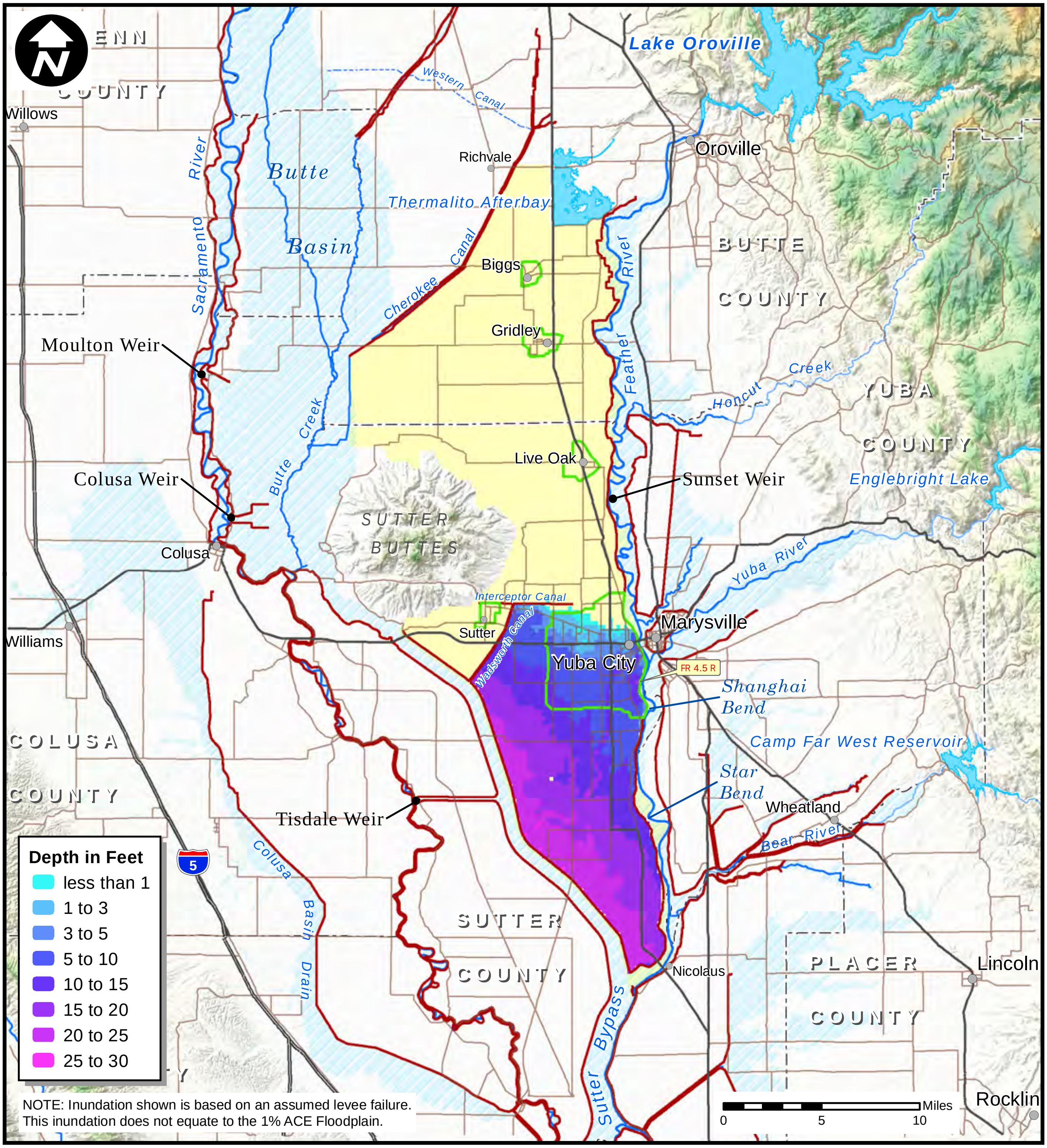
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION FR 5.0 R INDEX POINT 1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

Breach Index Point	Study Area Extent
Designated Floodways	Federal Levee
Lake or Reservoir	County Boundary
River or Stream	City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

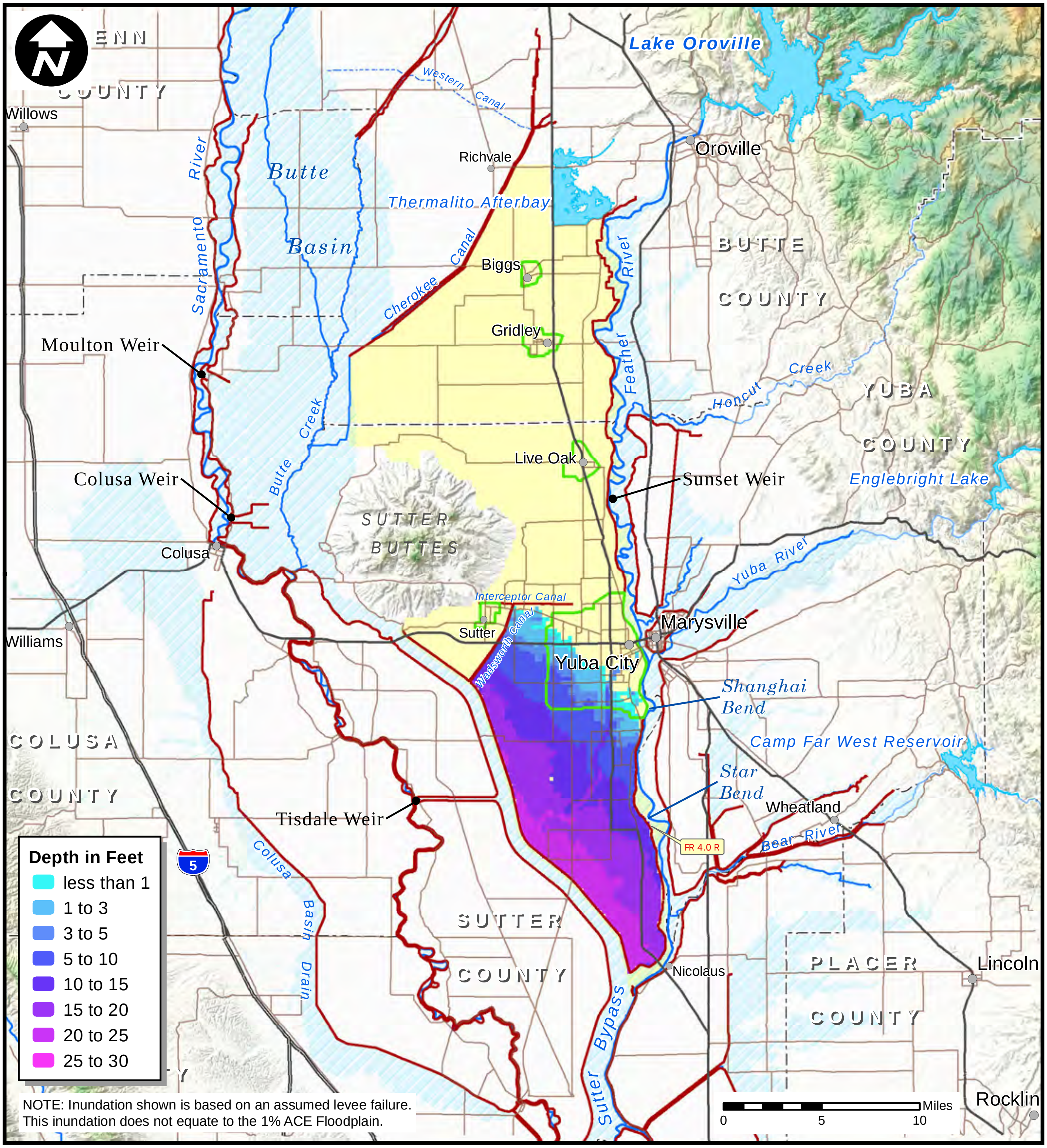
MODELED BREACH INUNDATION
FR 4.5 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 21



Legend

Breach Index Point	Study Area Extent
Designated Floodways	Federal Levee
Lake or Reservoir	County Boundary
River or Stream	City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION FR 4.0 R INDEX POINT 1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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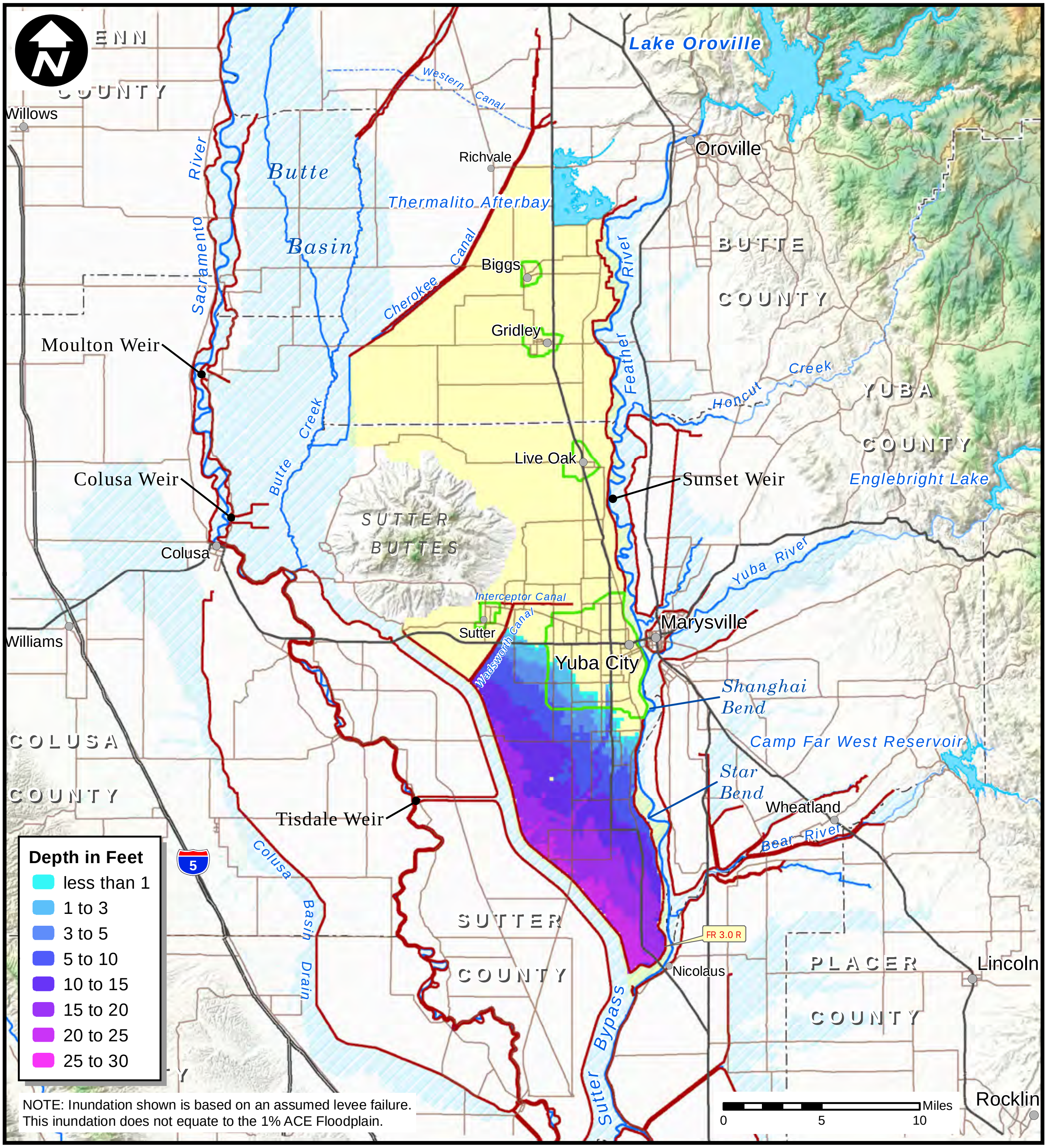


Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

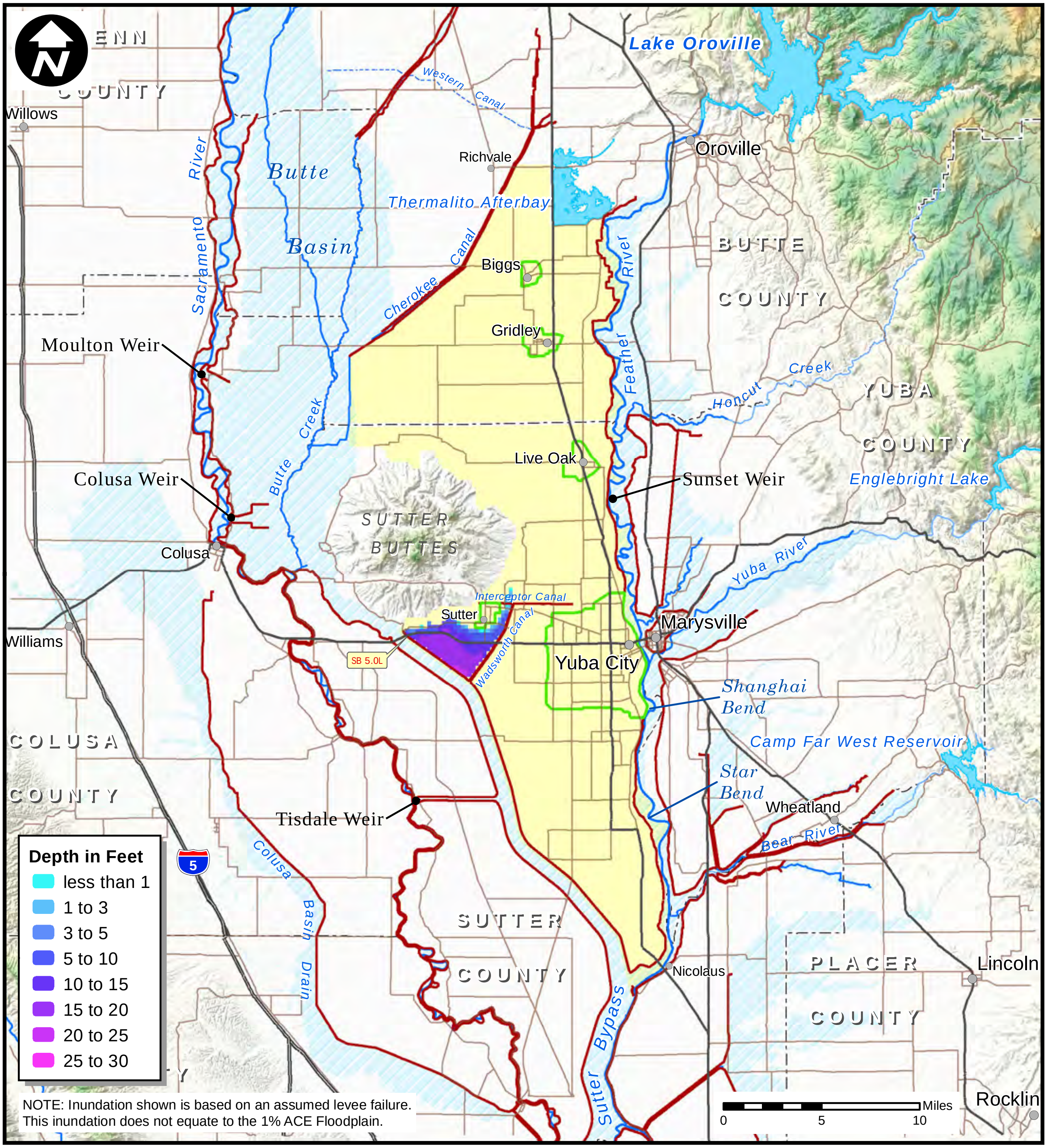
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 3.0 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

Breach Index Point	Study Area Extent
Designated Floodways	Federal Levee
Lake or Reservoir	County Boundary
River or Stream	City or Town

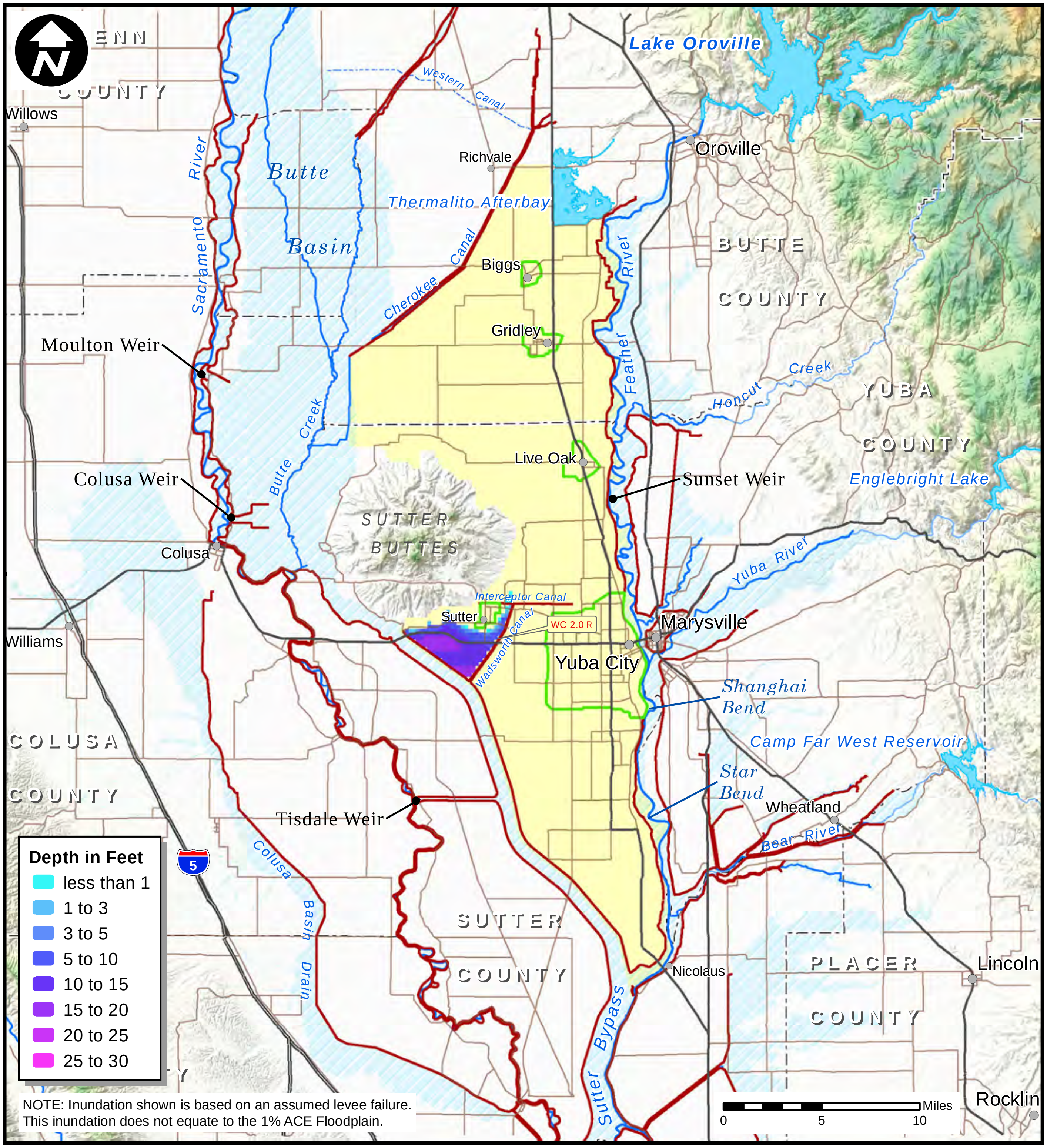
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION SB 5.0 L INDEX POINT 1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

	Breach Index Point		Study Area Extent
	Designated Floodways		Federal Levee
	Lake or Reservoir		County Boundary
	River or Stream		City or Town

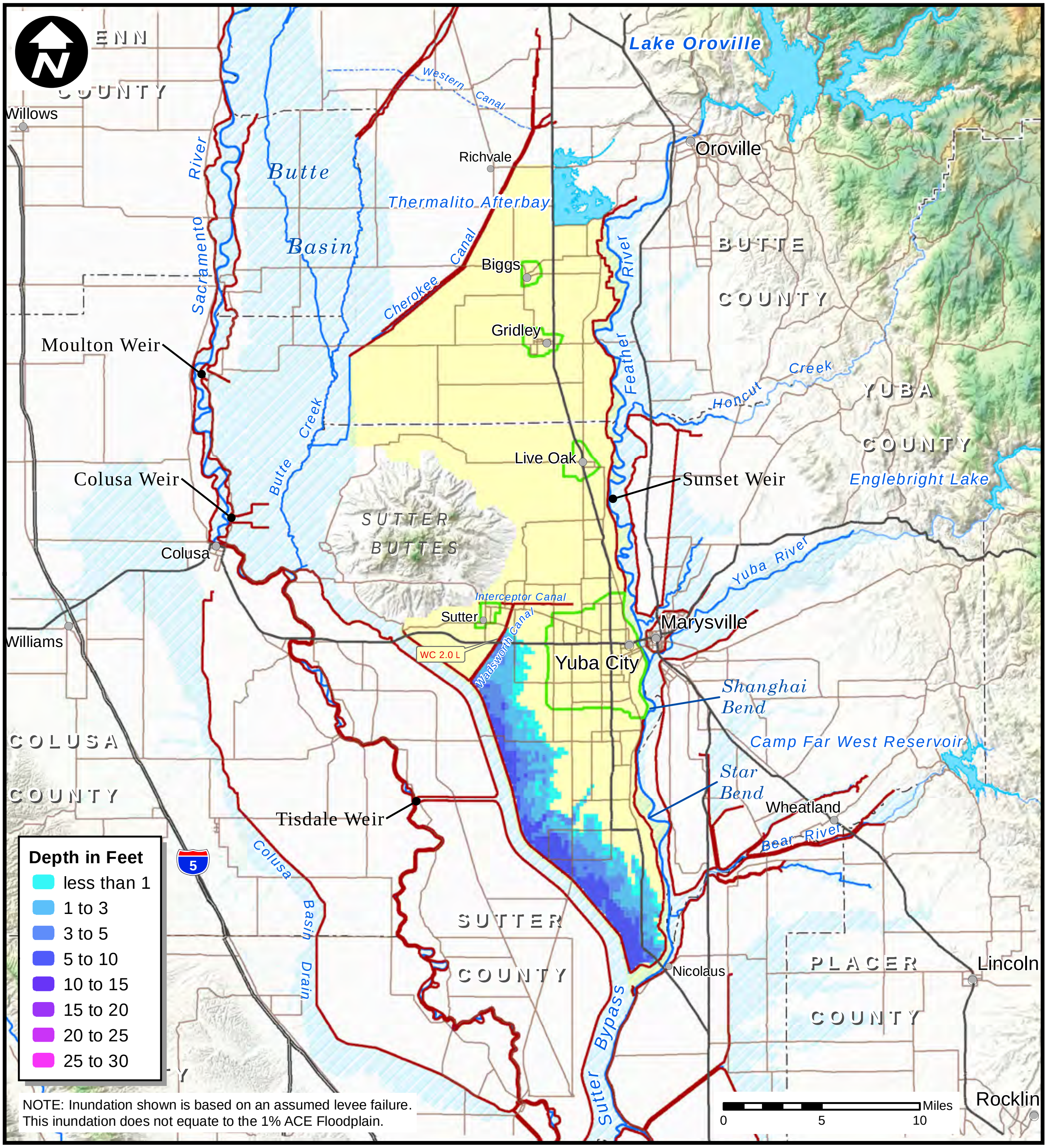
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
WC 2.0 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

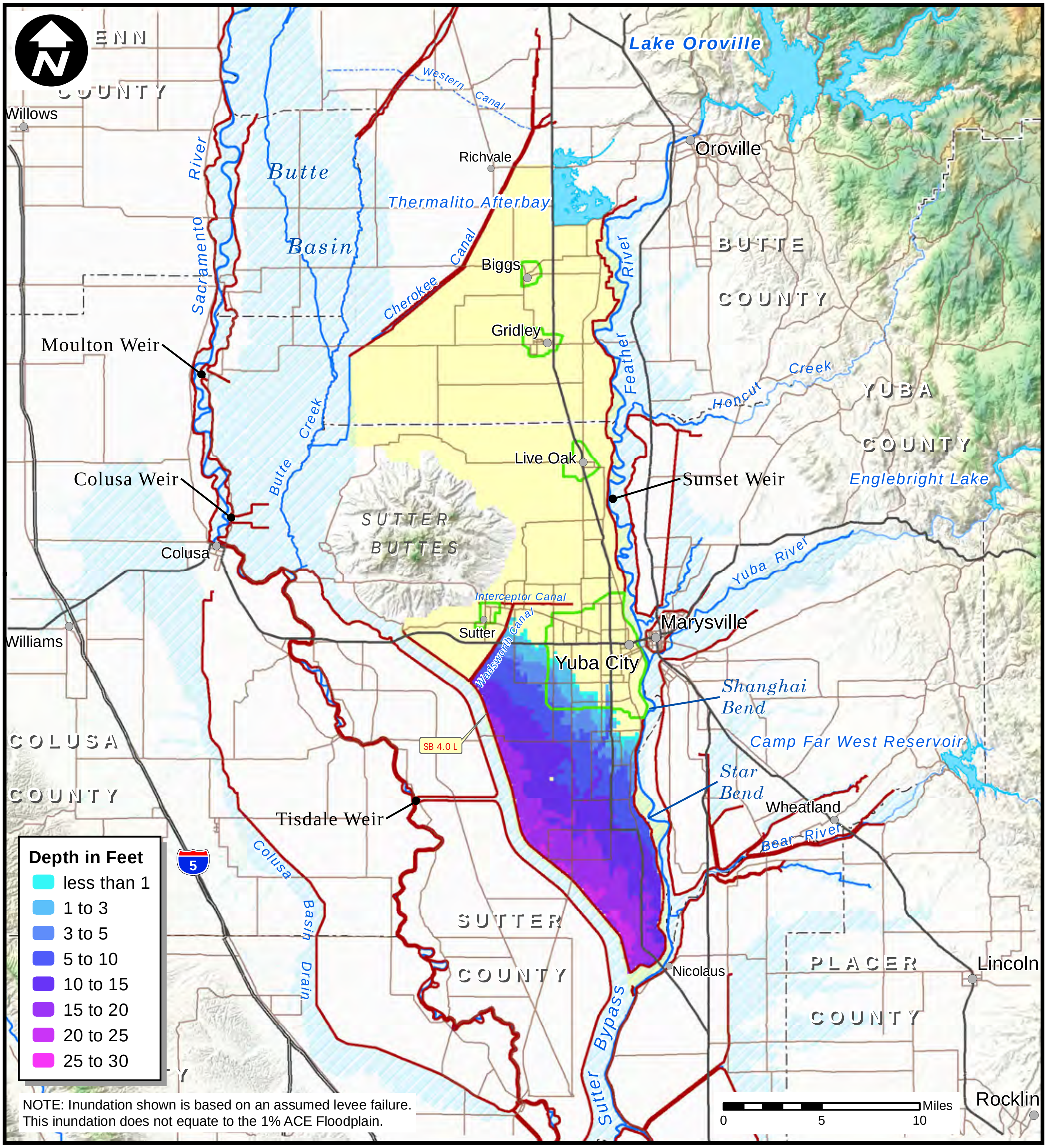
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
WC 2.0 L INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

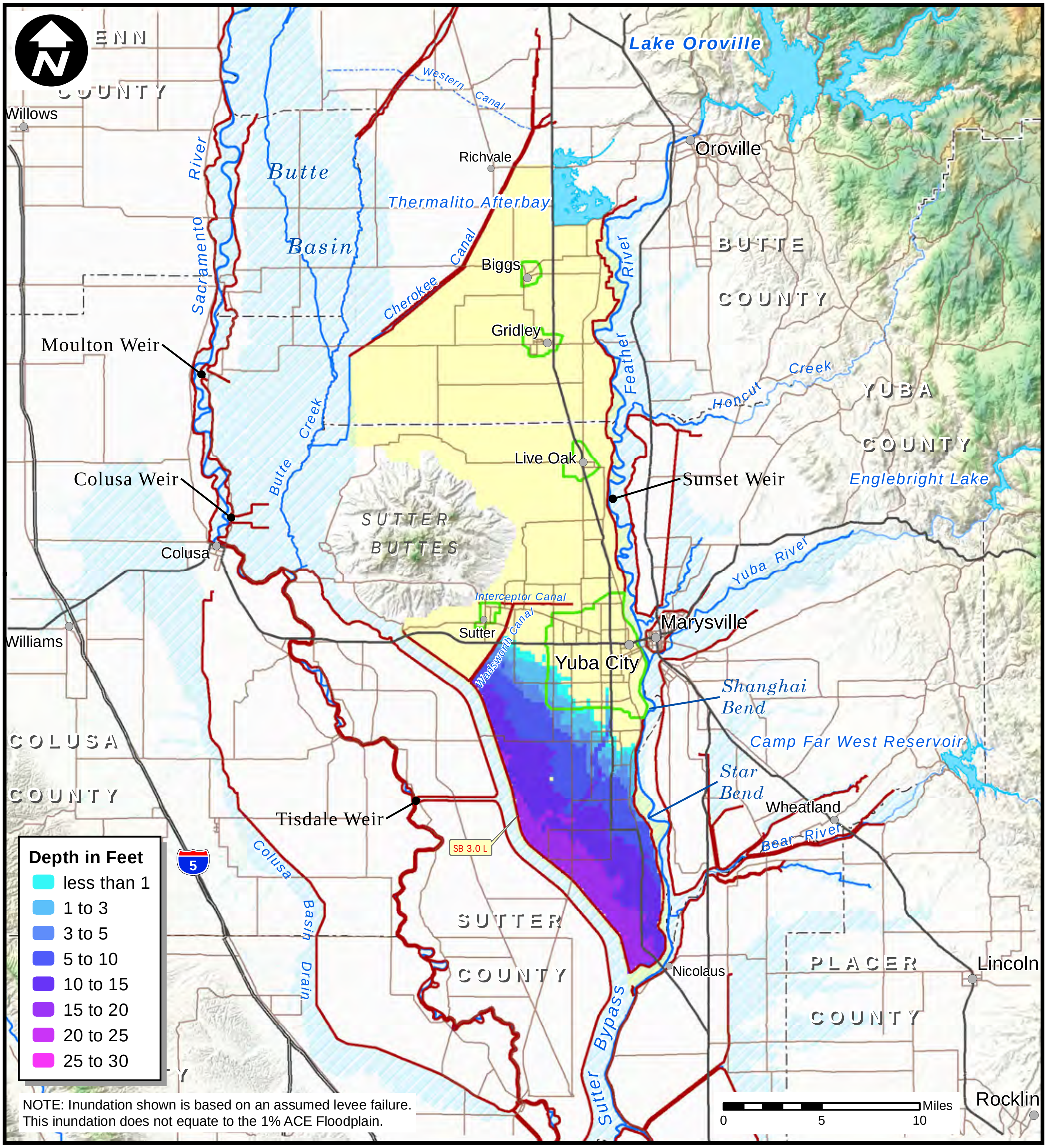
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
SB 4.0 L INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

Breach Index Point	Study Area Extent
Designated Floodways	Federal Levee
Lake or Reservoir	County Boundary
River or Stream	City or Town

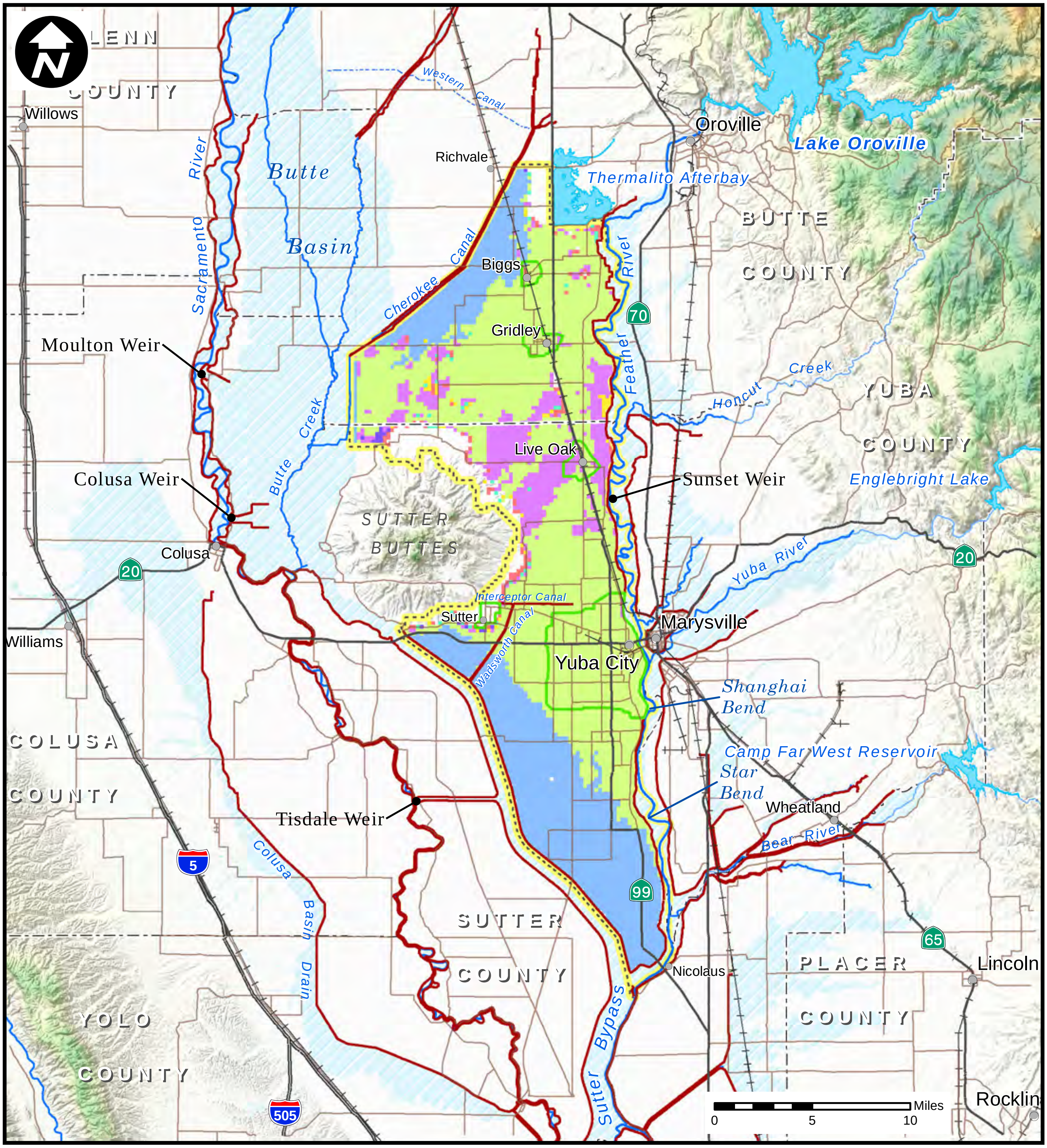
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
SB 3.0 L INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

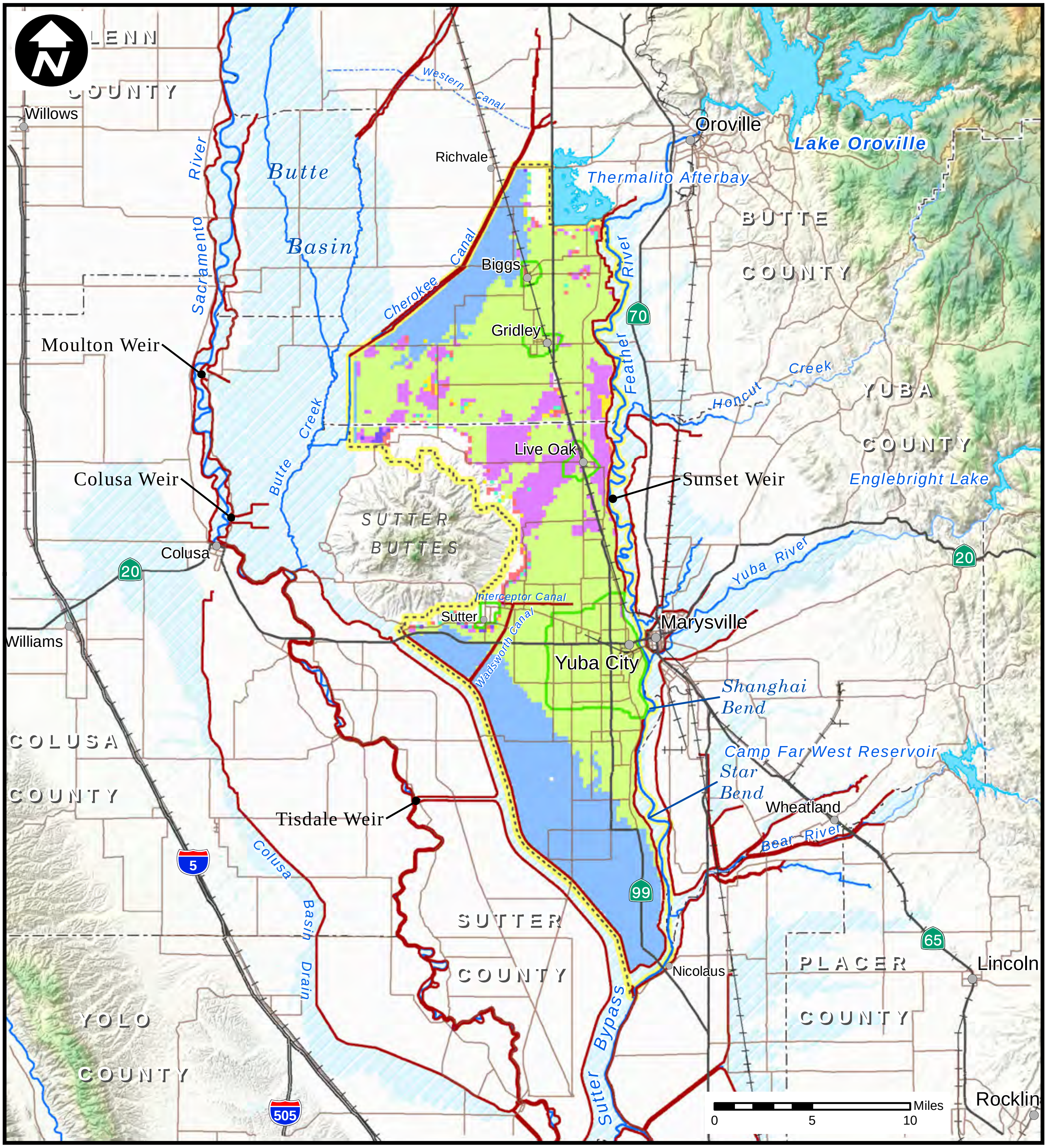
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual flooplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

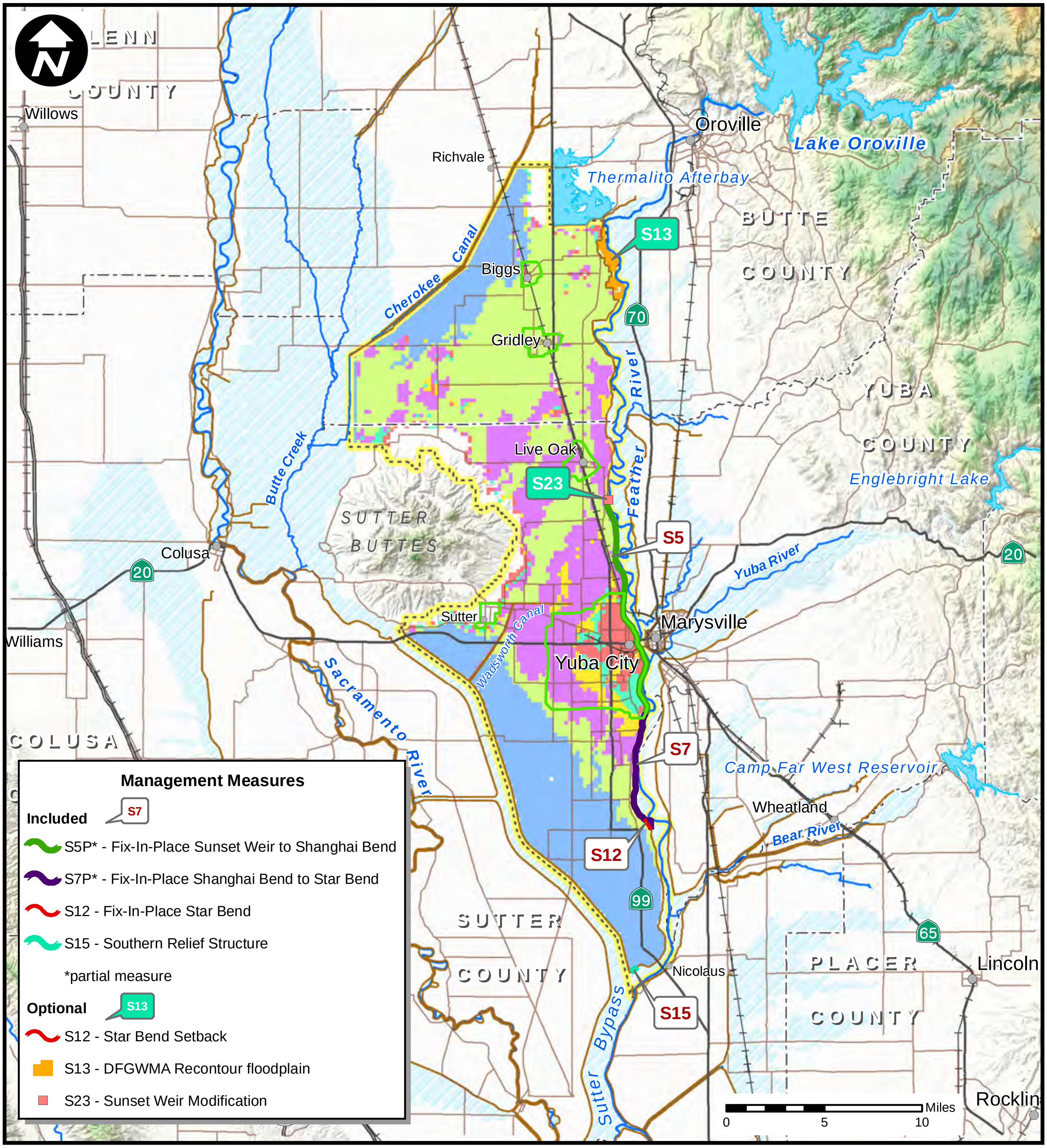
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

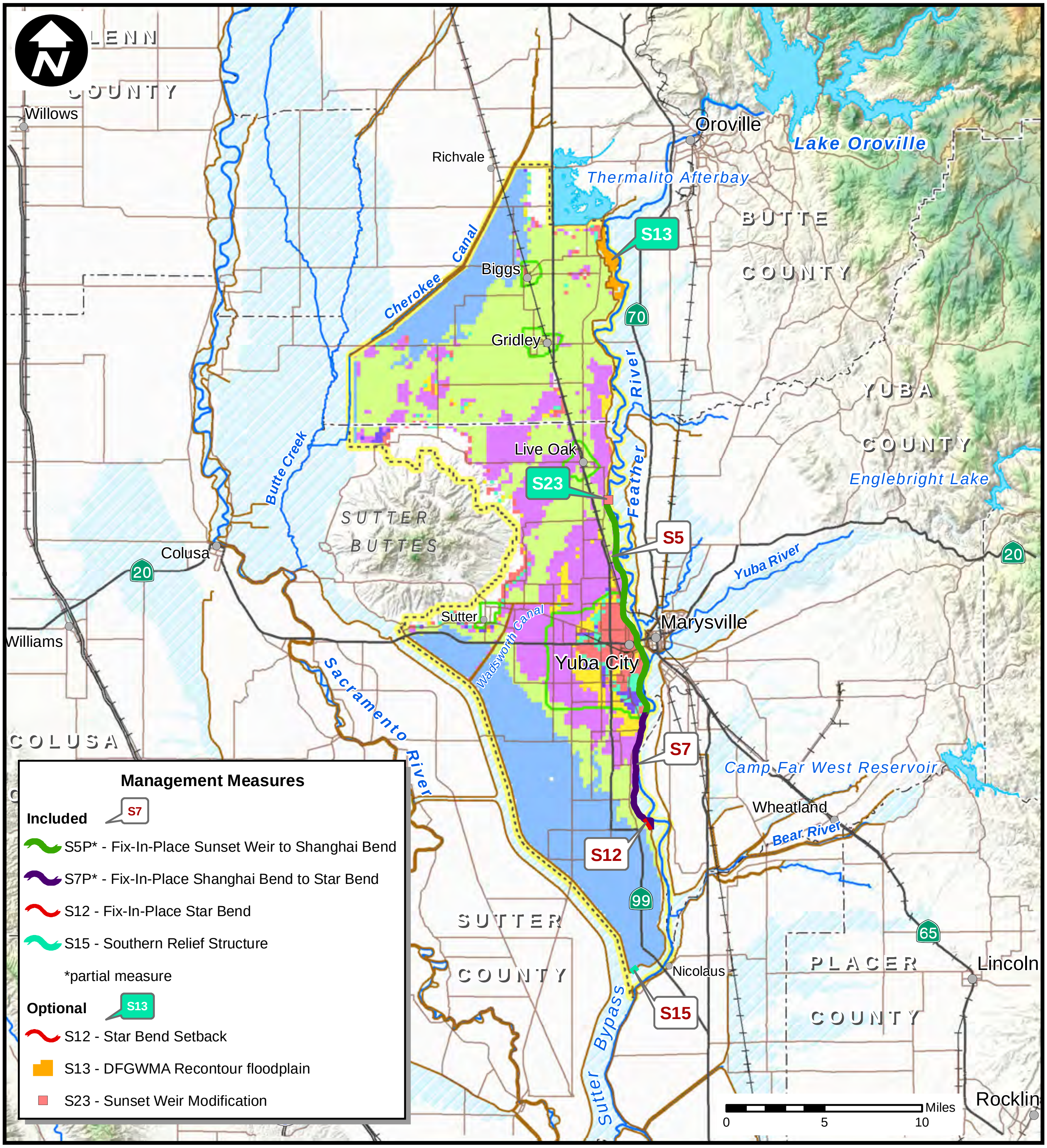
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-2 MINIMAL FIX-IN-PLACE PLUS NONSTRUCTURAL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual flooplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

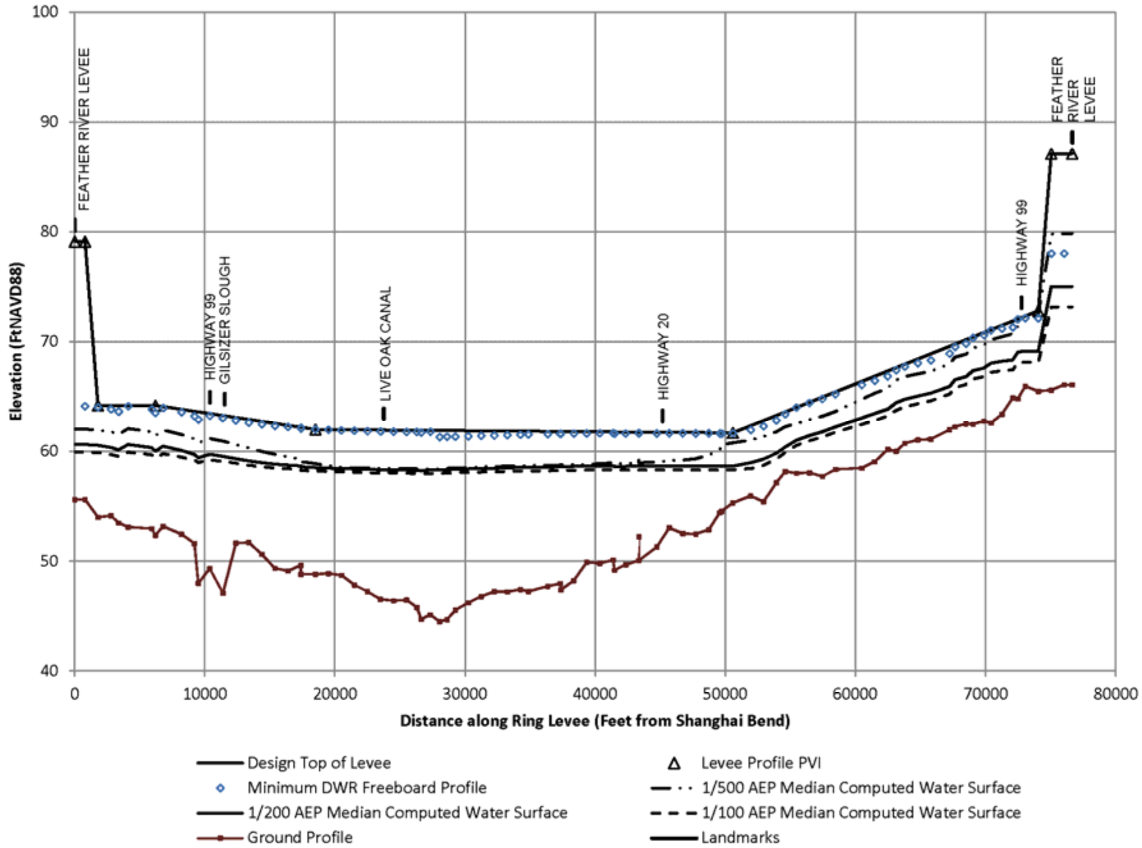
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-2 MINIMAL FIX-IN-PLACE PLUS NONSTRUCTURAL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Notes:

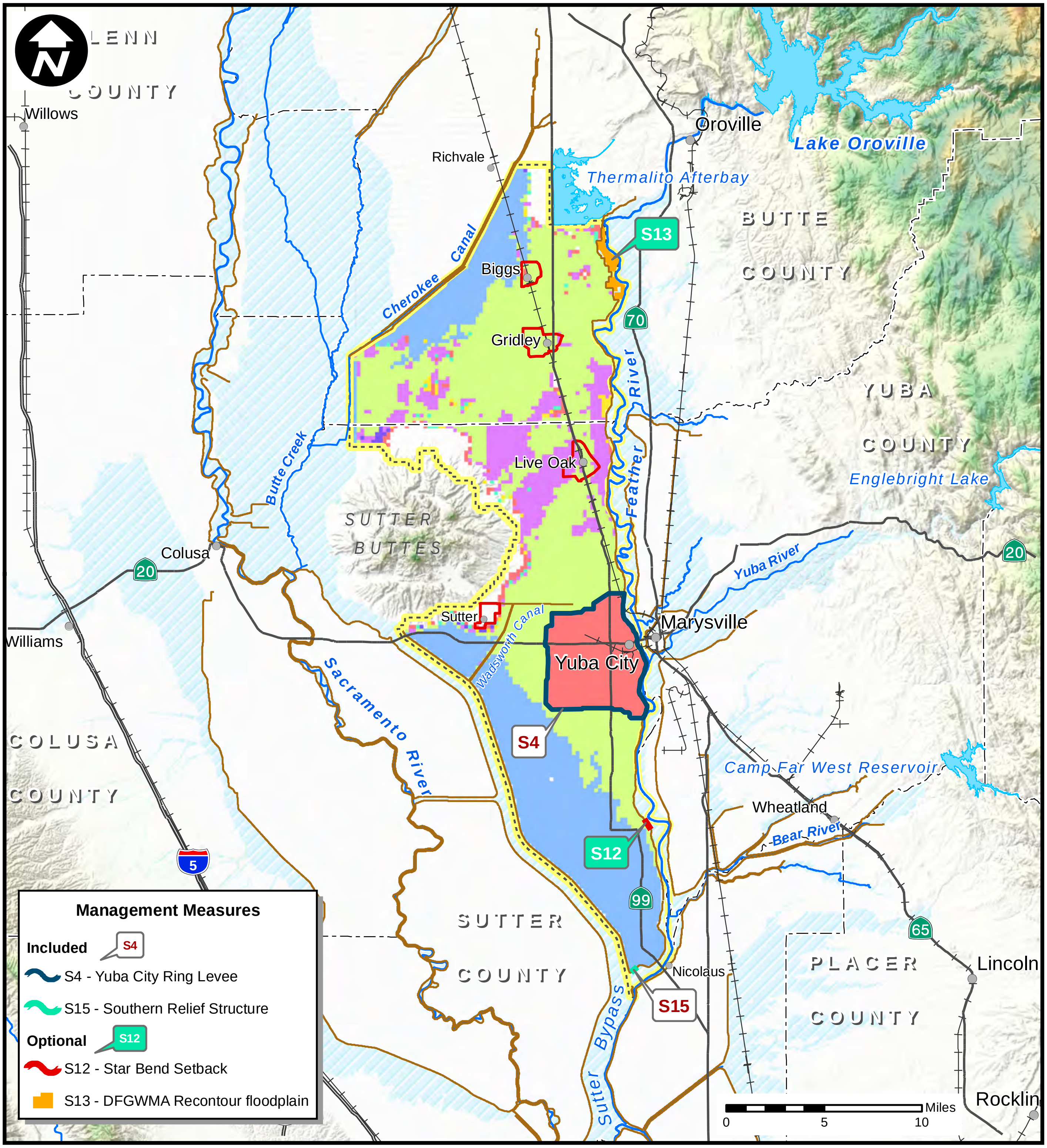
1) WSEL = Water Surface Elevation

2) Water surface elevations based on maximum water surface from assumed levee breaches outside the ring levee.

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

LEVEE DESIGN PROFILE
ALTERNATIVE SB-3
YUBA CITY RING LEVEE

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

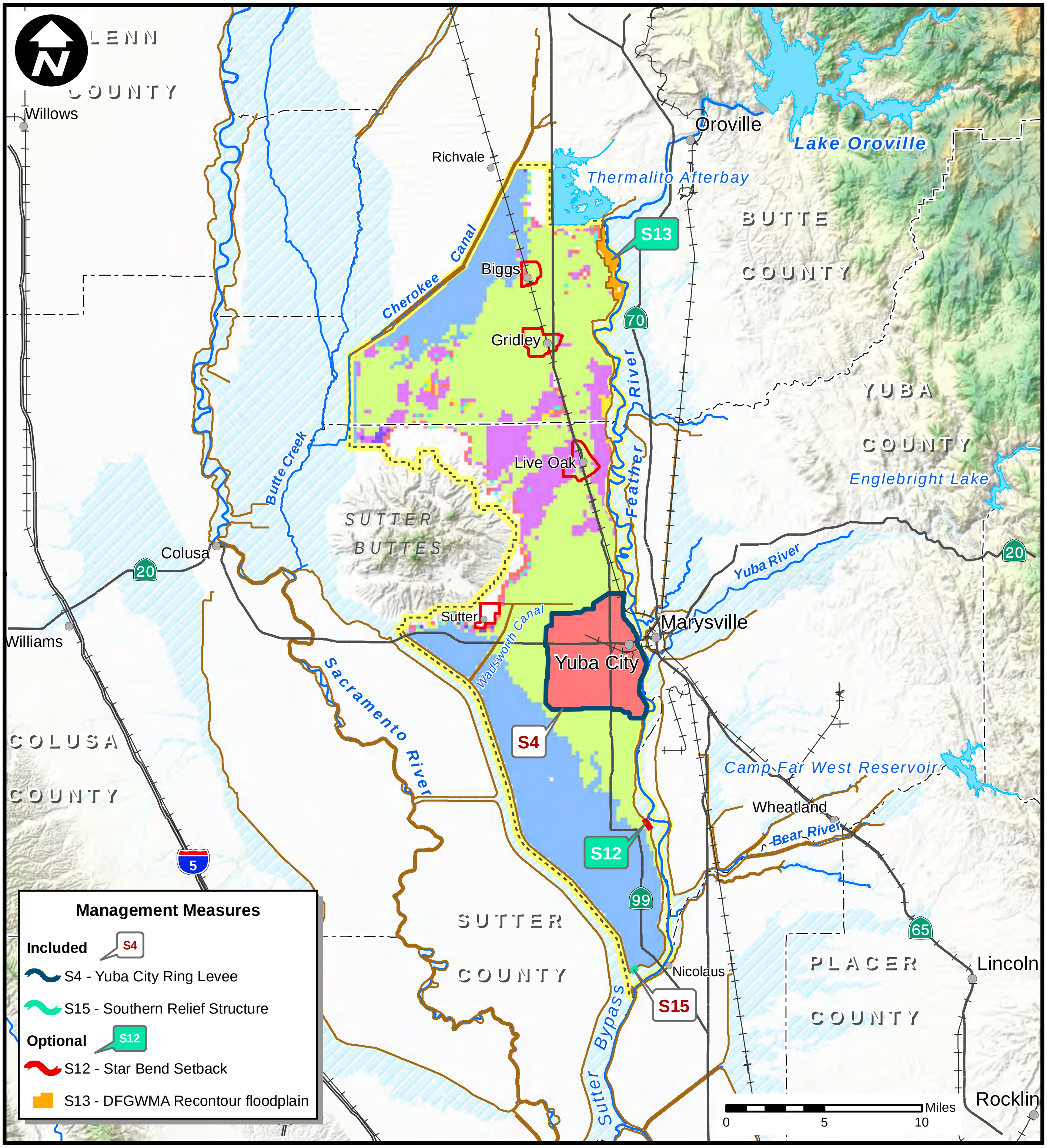
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-3 YUBA CITY RING LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

0.2% (1/500) ACE Floodplain
0.5% (1/200) ACE Floodplain
1% (1/100) AEP Floodplain
2% (1/50) ACE Floodplain
4% (1/25) ACE Floodplain
10% (1/10) ACE Floodplain
50% (1/2) ACE Floodplain

Federal Levee
Study Area Extent
Designated Floodways
Lake or Reservoir
River or Stream
Railroad

Criteria 2 Residual flooplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

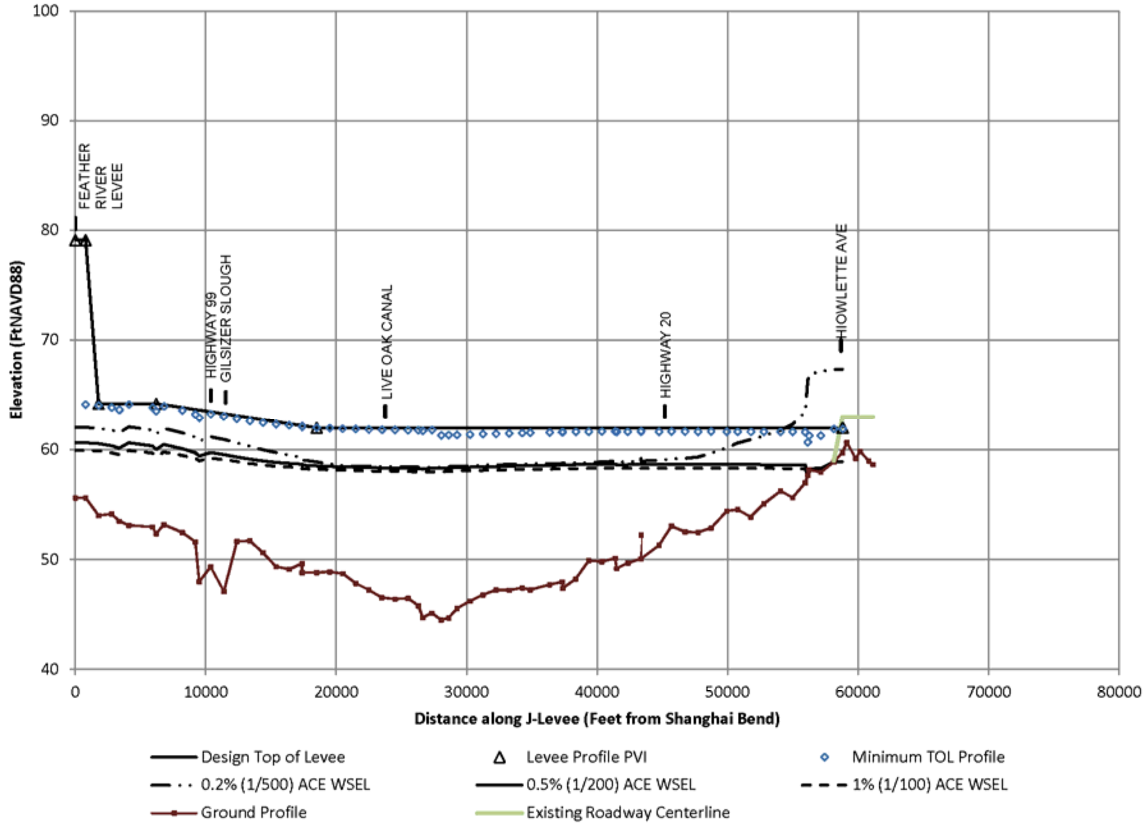
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-3 YUBA CITY RING LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Notes:

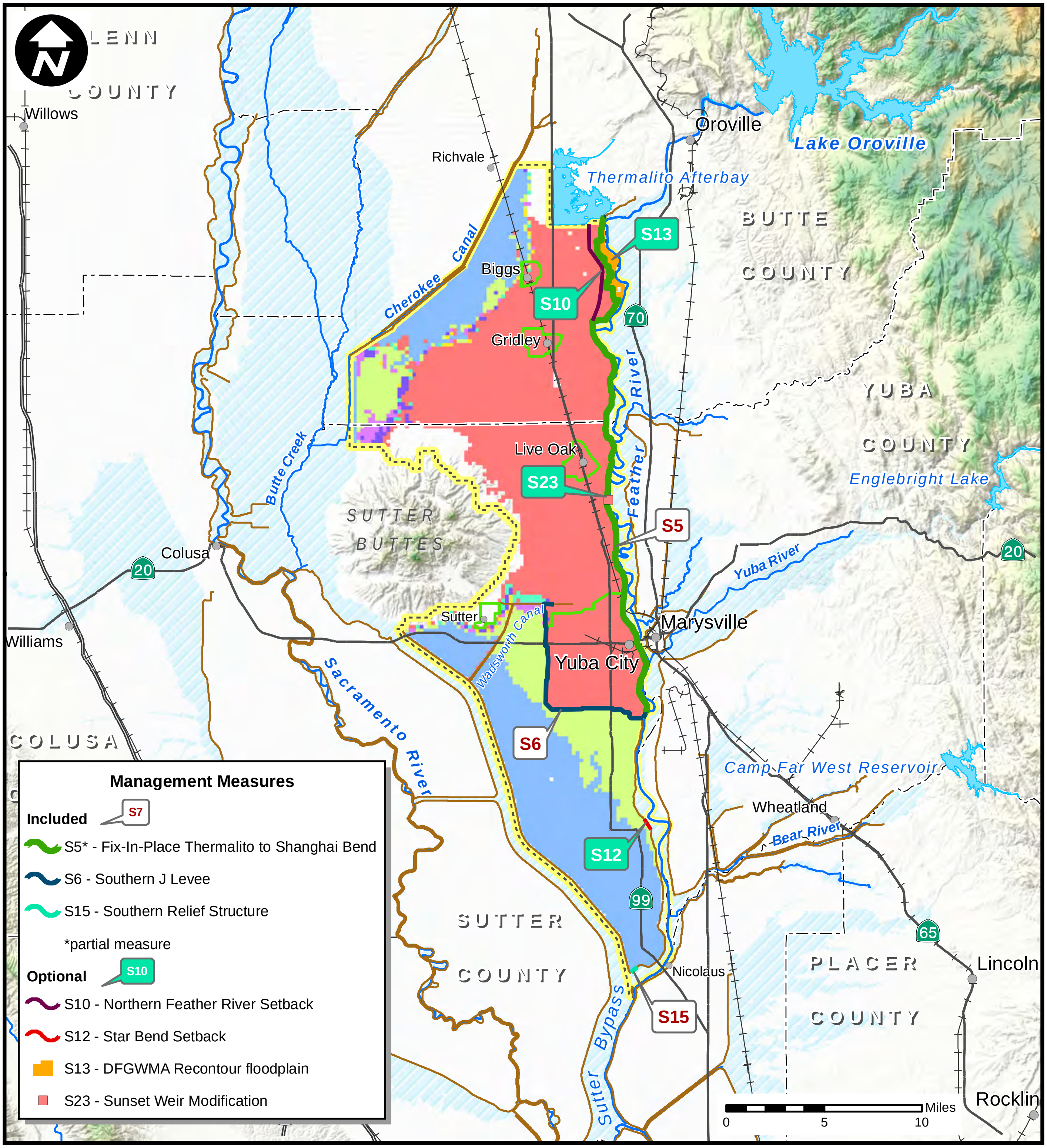
1) WSEL = Water Surface Elevation

2) Water surface elevations based on maximum water surface from assumed levee breaches outside the ring levee.

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

LEVEE DESIGN PROFILE
ALTERNATIVE SB-4
LITTLE "J" LEVEE

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

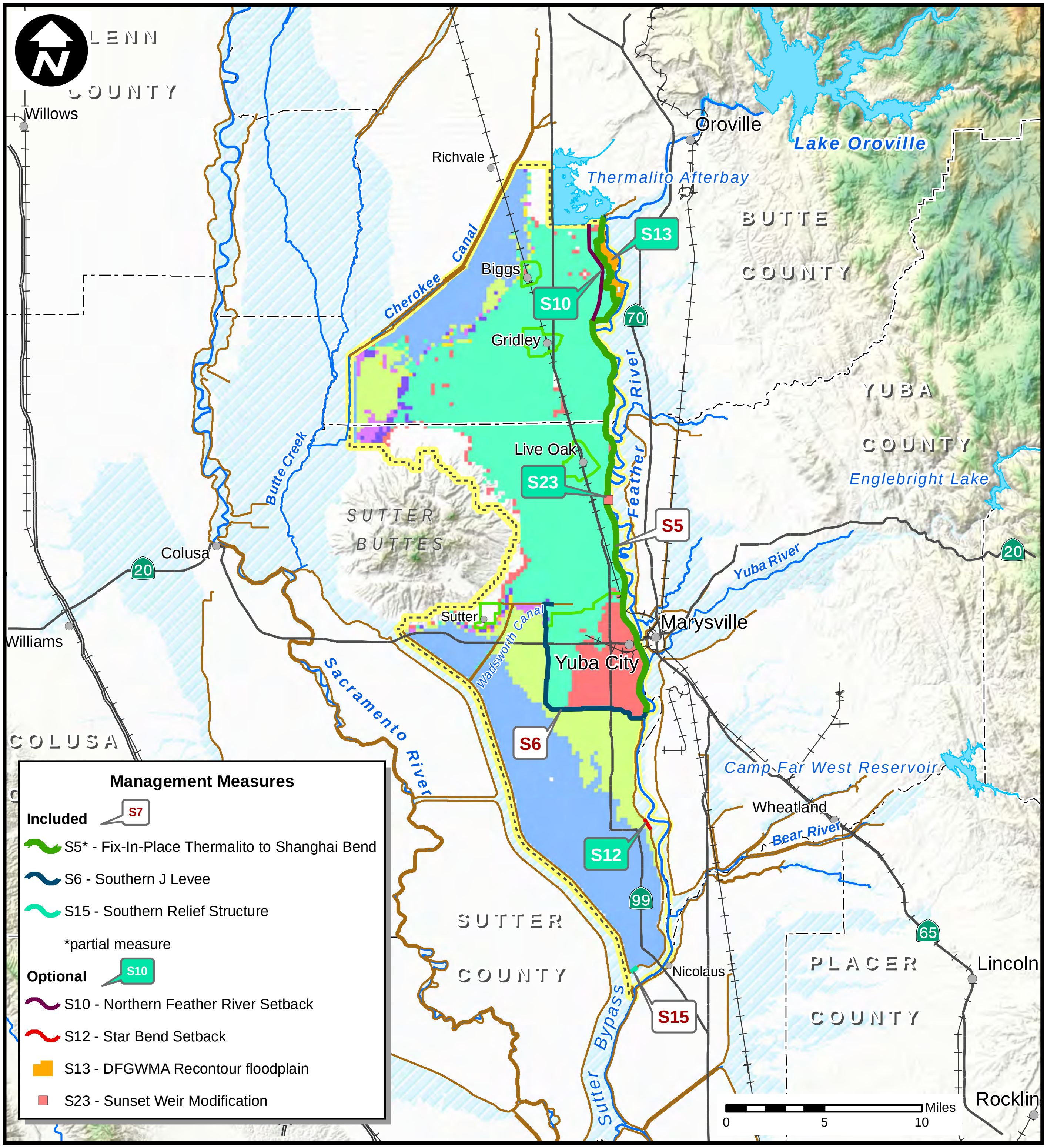
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-4 LITTLE "J" LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual flooplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

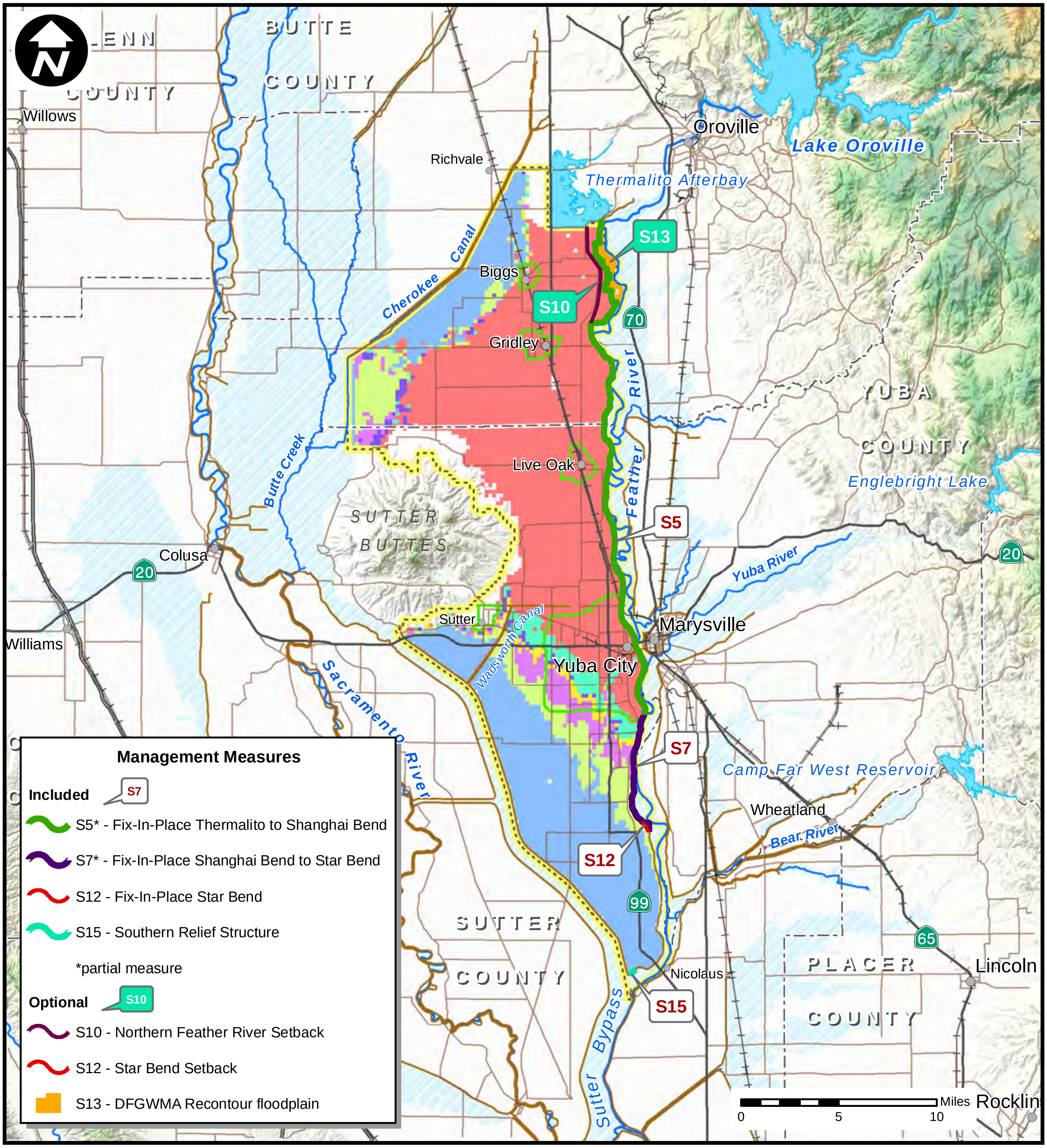
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-4 LITTLE "J" LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

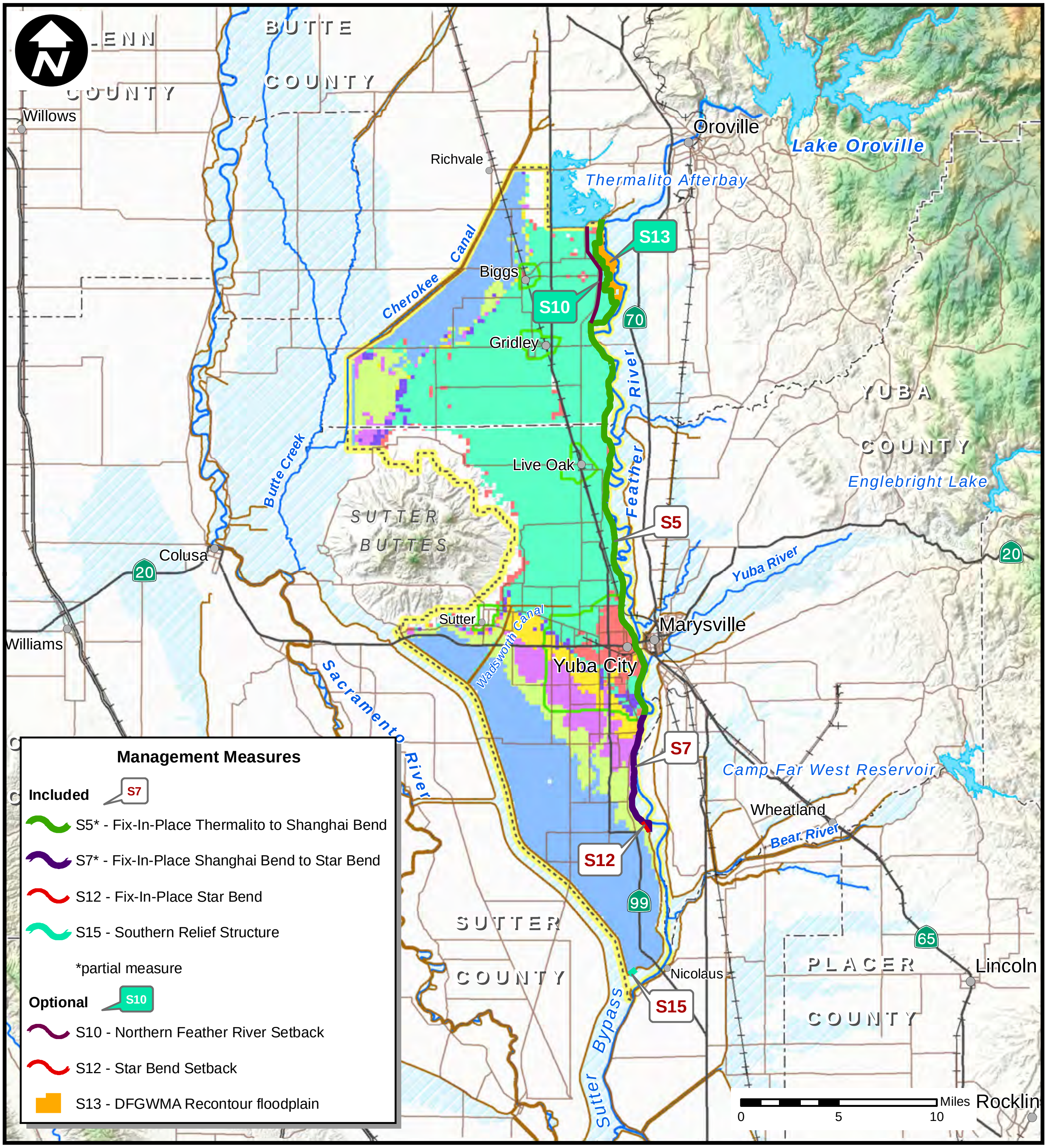
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-5 FIX IN PLACE FEATHER RIVER, THERMALITO TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

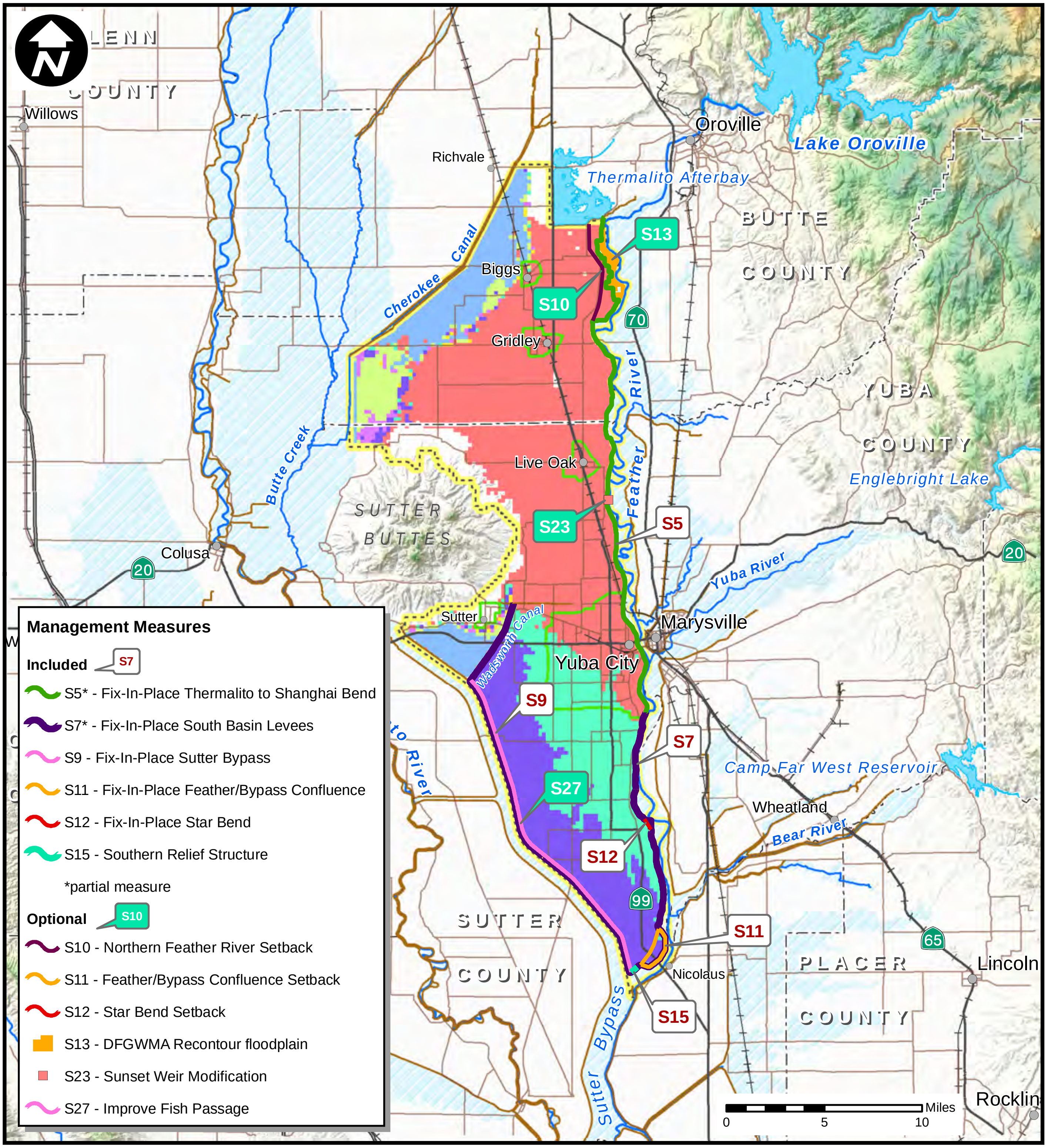
0.2% (1/500) ACE Floodplain	Federal Levee
0.5% (1/200) ACE Floodplain	Study Area Extent
1% (1/100) AEP Floodplain	Designated Floodways
2% (1/50) ACE Floodplain	Lake or Reservoir
4% (1/25) ACE Floodplain	River or Stream
10% (1/10) ACE Floodplain	Railroad
50% (1/2) ACE Floodplain	

Criteria 2 Residual flooplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-5 FIX IN PLACE FEATHER RIVER, THERMALITO TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

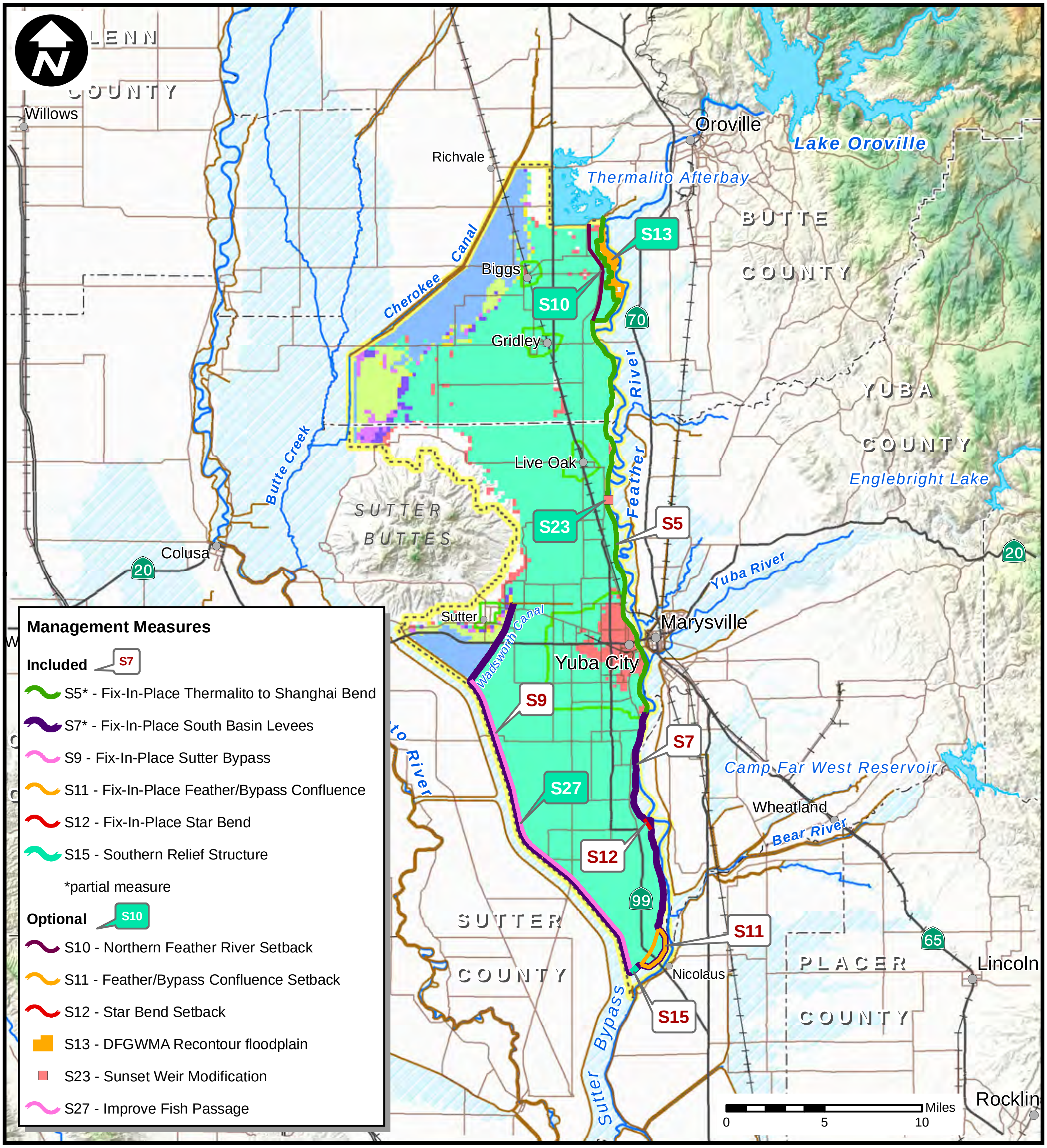
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-6 FIX IN PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual flooplain shown if levee does not pass criteria.
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2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

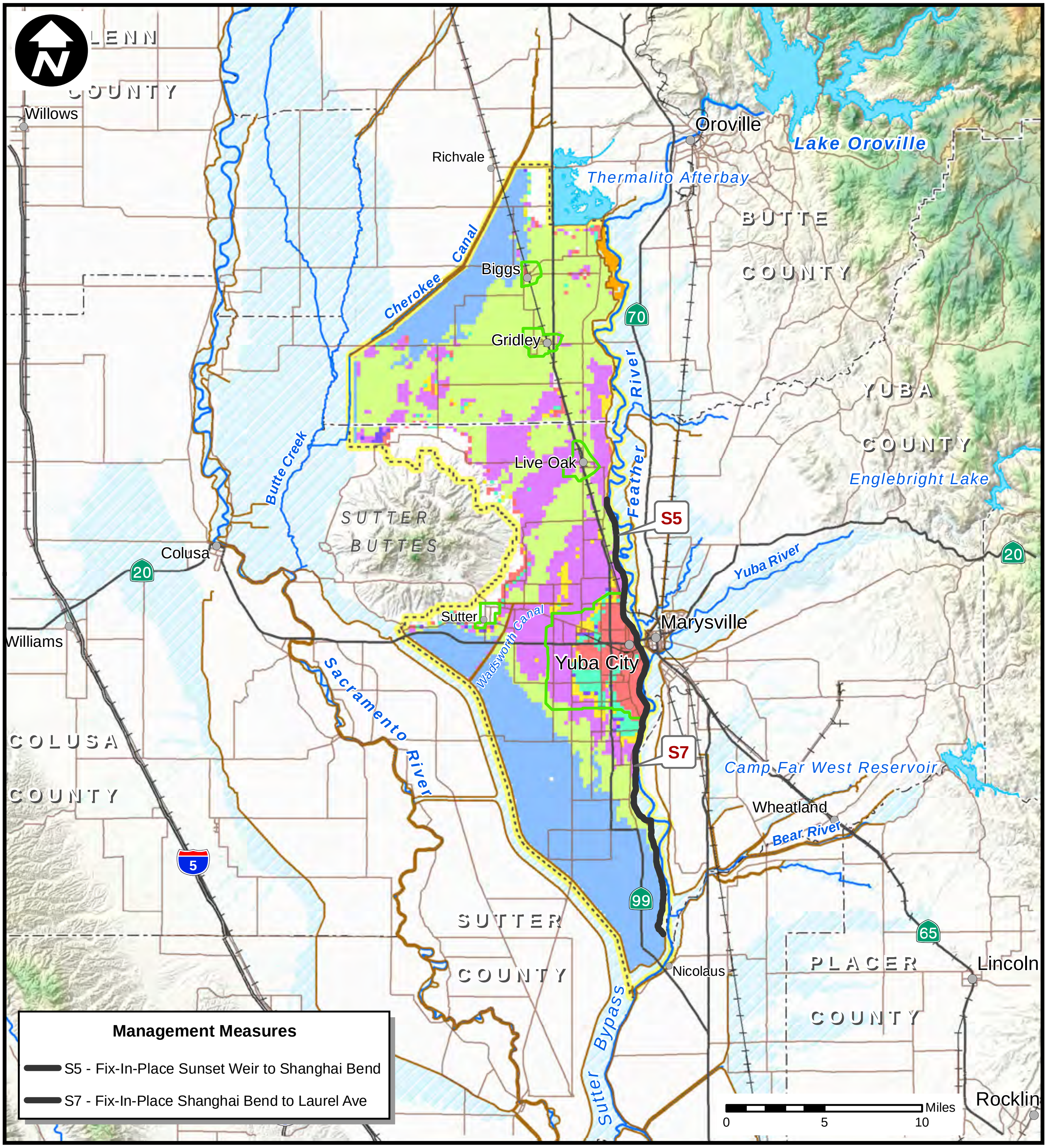
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-6 FIX IN PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

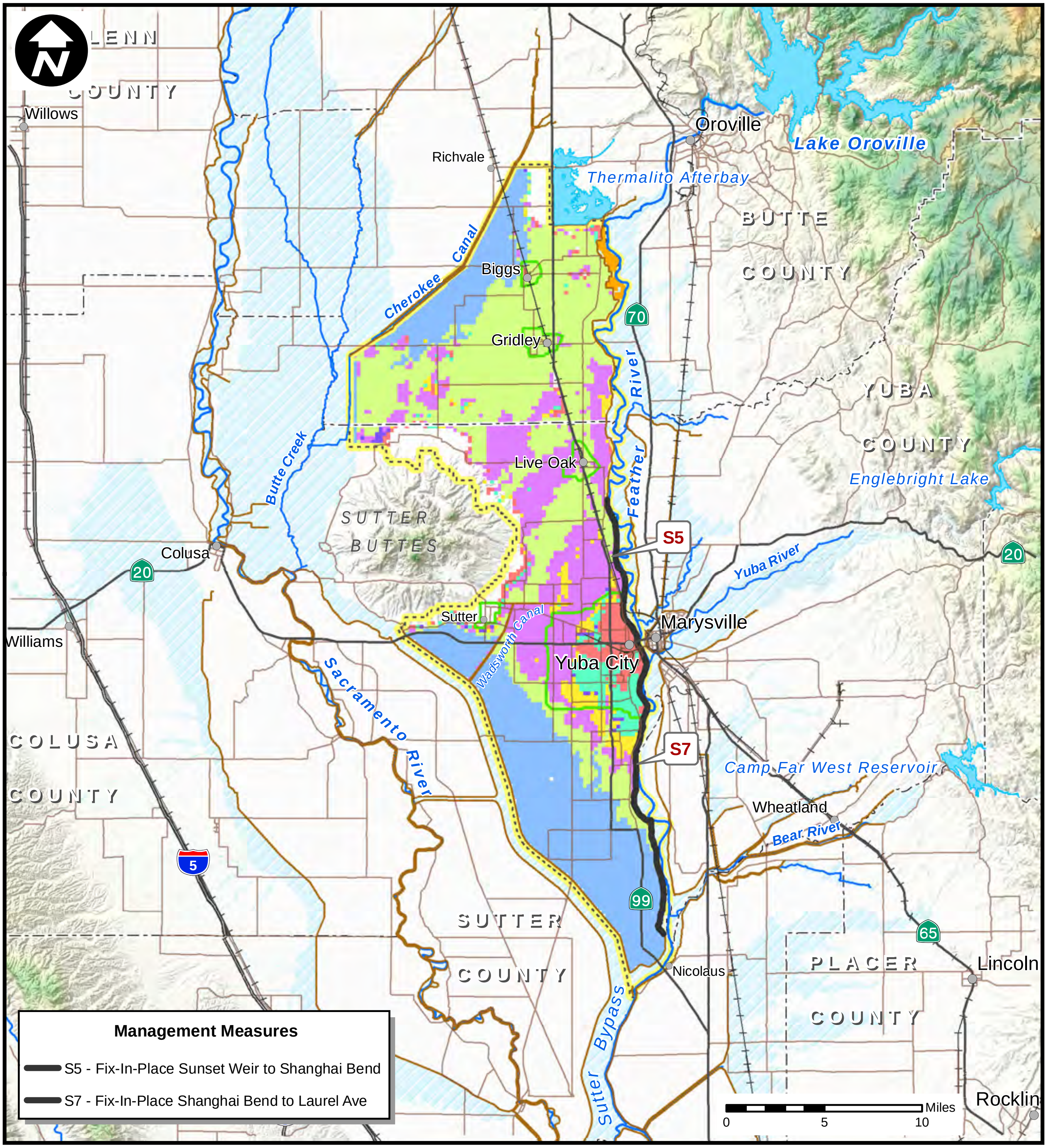
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 1 RESIDUAL FLOODPLAIN 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

OCT 2012



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

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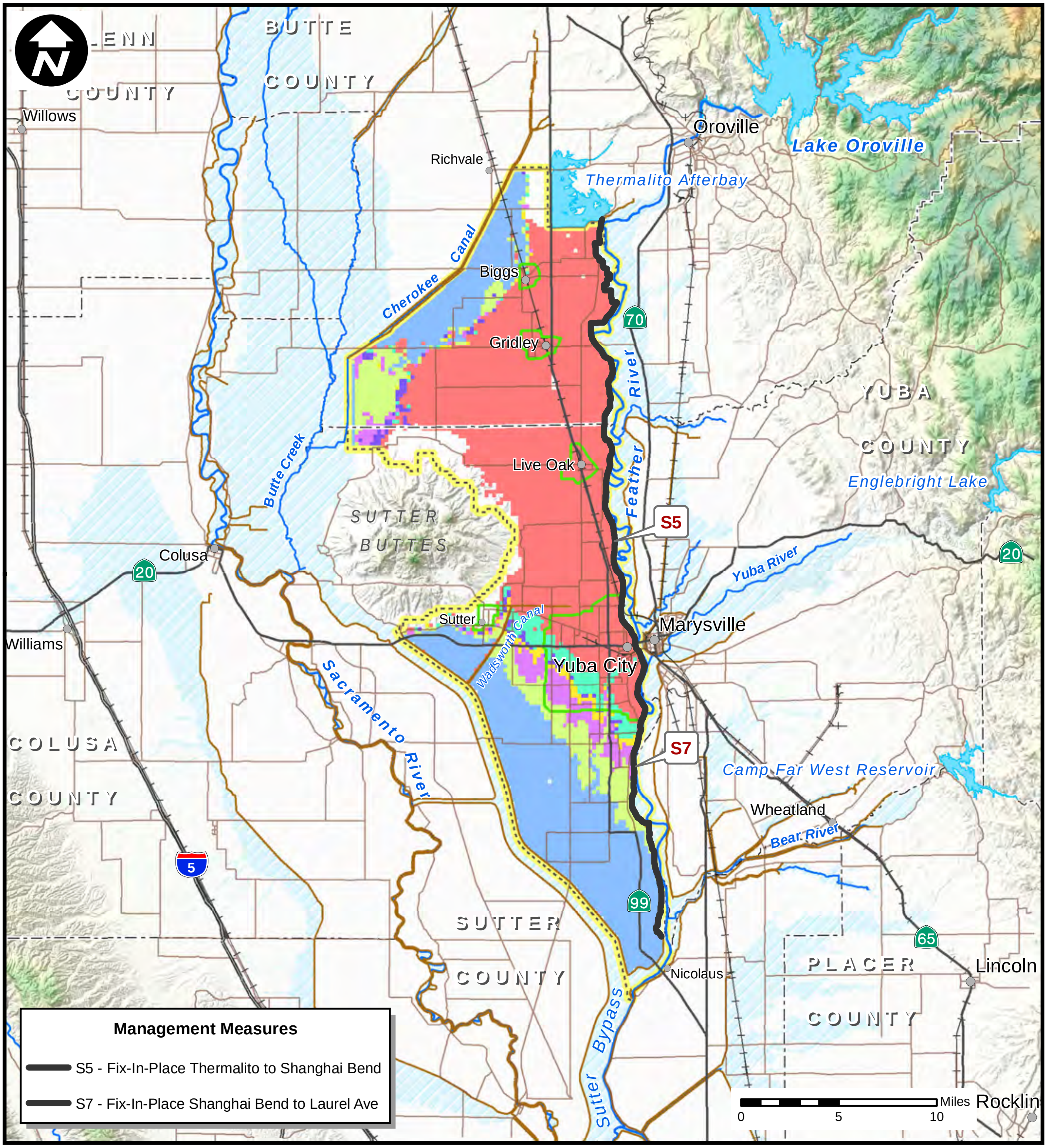
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 2 RESIDUAL FLOODPLAIN 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

OCT 2012



Legend

- 0.2% (1/500) ACE Floodplain
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- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

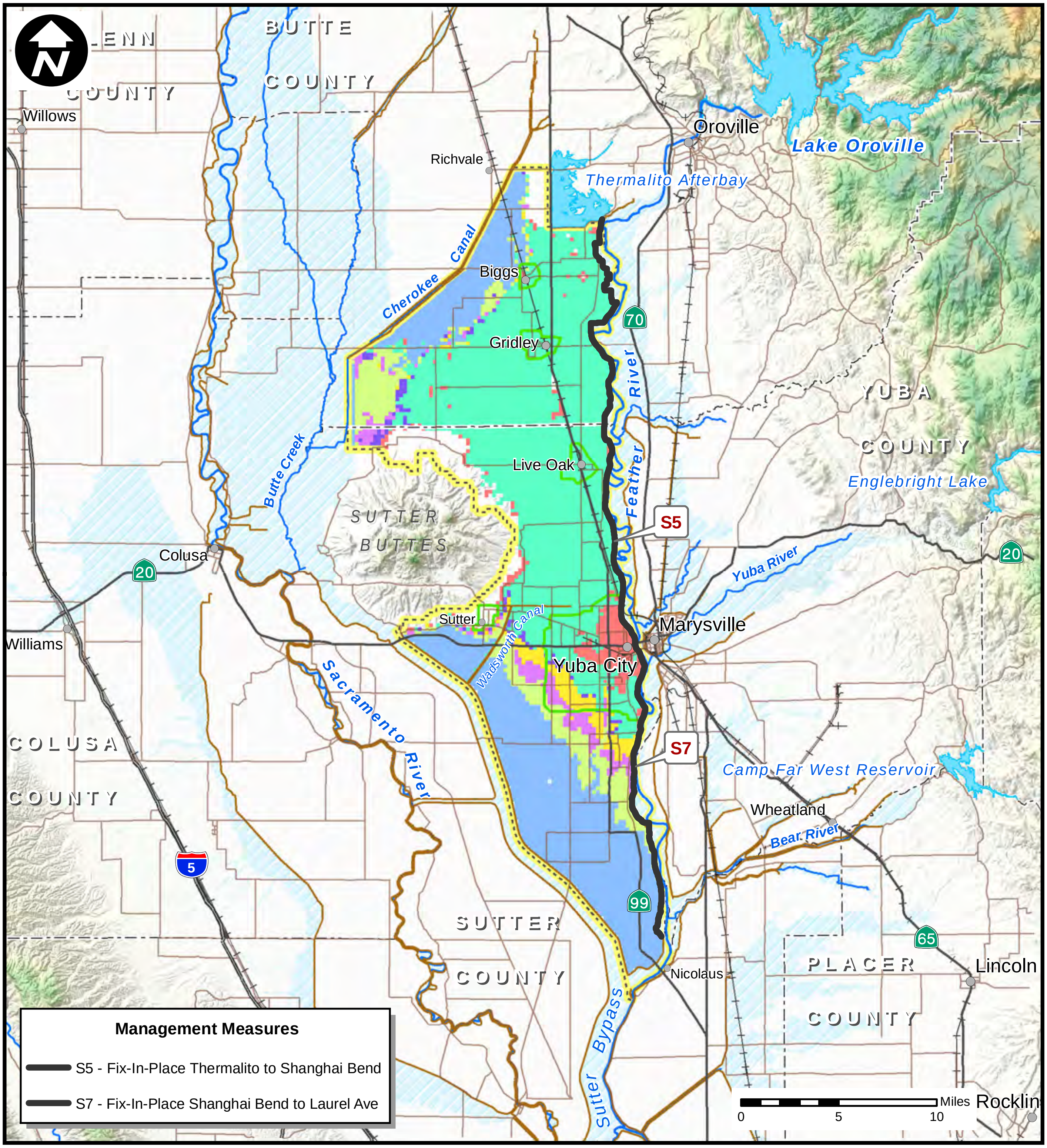
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual flooplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 46

QUALITY CONTROL CERTIFICATE

Hydraulic Analysis Section, Engineering Division

PROJECT NAME: SUTTER BASIN, CALIFORNIA – PILOT FEASIBILITY STUDY
PRODUCT: MEMORANDUM FOR FILE: HYDRAULIC ANALYSIS OF REFINED ALTERNATIVES.
Actual Completion Date: 23-Oct-12

PROJECT MANAGER: LAURA WHITNEY

Background: [Include project description, technical products, and review methodology]

District Quality Control was performed on the 23 October revision to the memorandum originally dated 8 June 2012. The purpose of the revision was to include two additional alternatives SB-7 and SB-8.

HYDRAULIC LEAD

I have ensured that the above products were prepared in accordance with standard quality control practices. I have also incorporated or resolved all issues identified during District Quality Control (DQC) review.

Hydraulic Lead: Peter Blodgett	Title: Senior Hydraulic Engineer PETER BLODGETT	10/26/2012
Print name	Signature	Date

REVIEWERS

I have reviewed the products noted above and find them to be in accordance with project requirements, standards of the profession, and USACE policies and standards.

DQC Reviewer: John Wiest JOHN C WIEST	Title: Hydraulic Engineer	10/26/12
Print name	Signature	Date

RESOURCE PROVIDER

I have reviewed and resolved all critical and technical issues. I agree that all project requirements, standards of the profession, and USACE policies and standards have been met.

Section Chief: Peter Blodgett Peter Blodgett		10/26/2012
Print name	Signature	Date

ATTACHMENT B

Final Geotechnical Fragility Curves

February 2013.

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

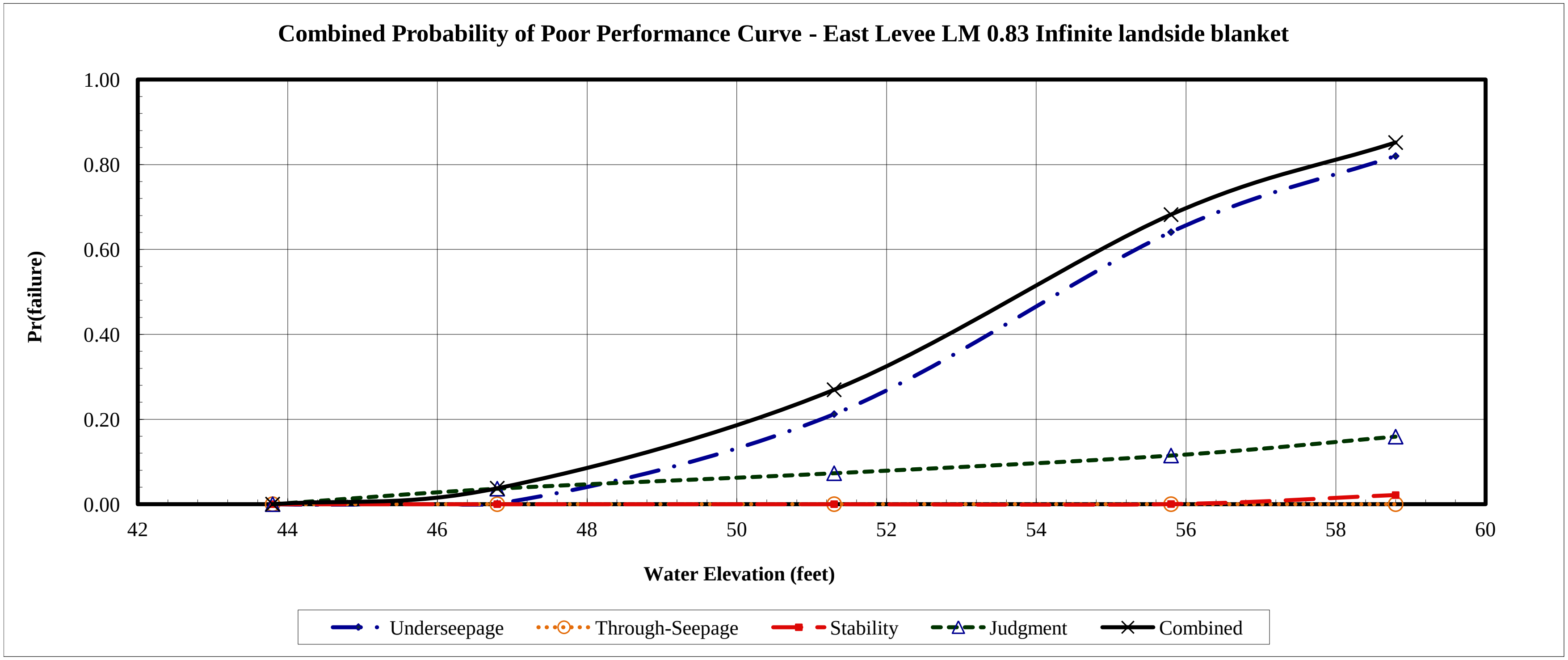
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal
River Section: East Levee

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
Combined Probability of Poor Performance Curve

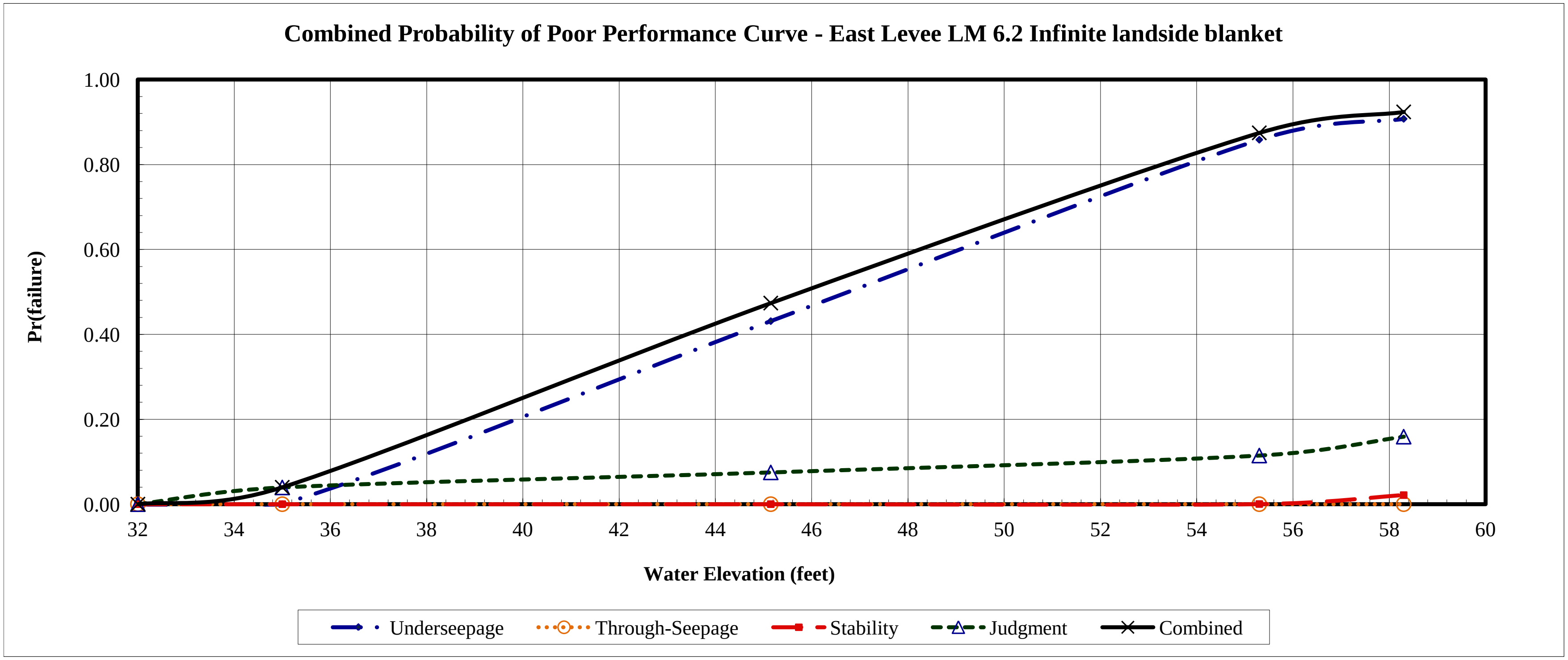
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

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



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

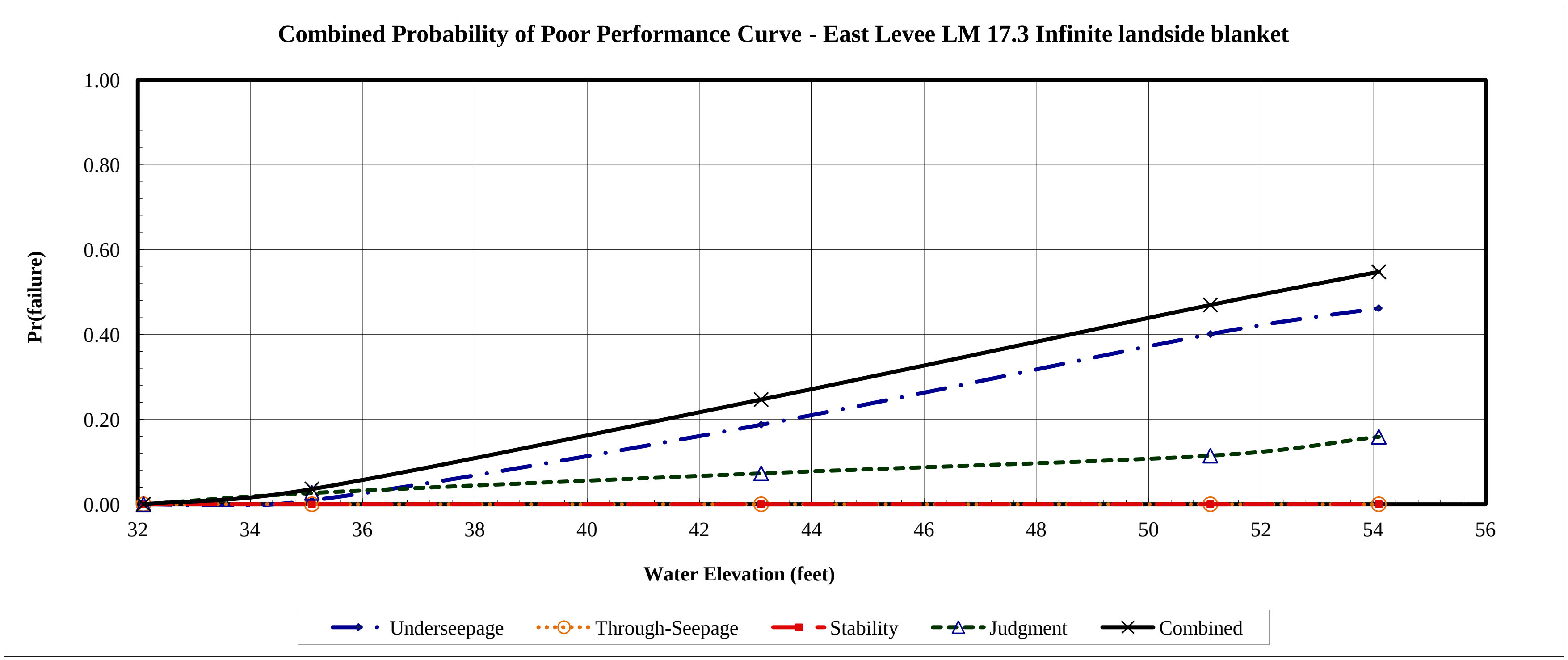
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

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



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

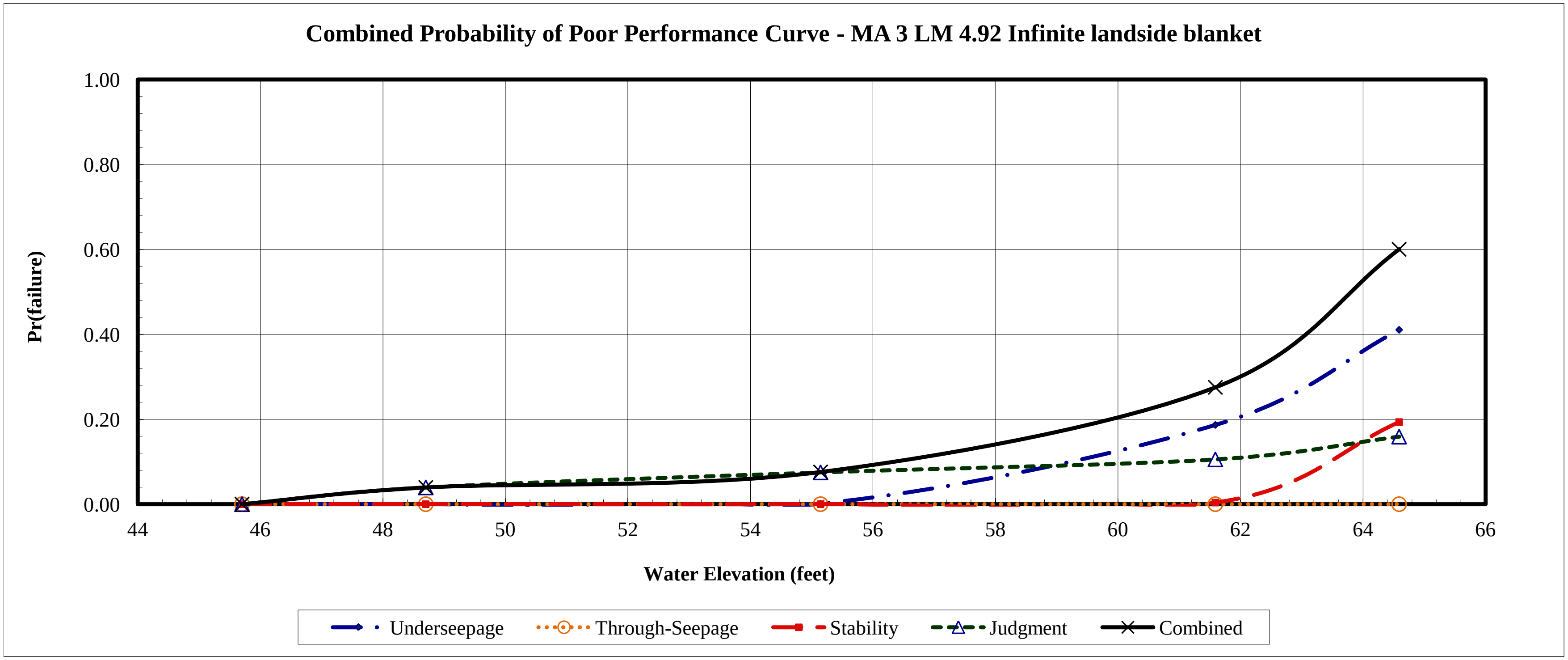
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

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



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

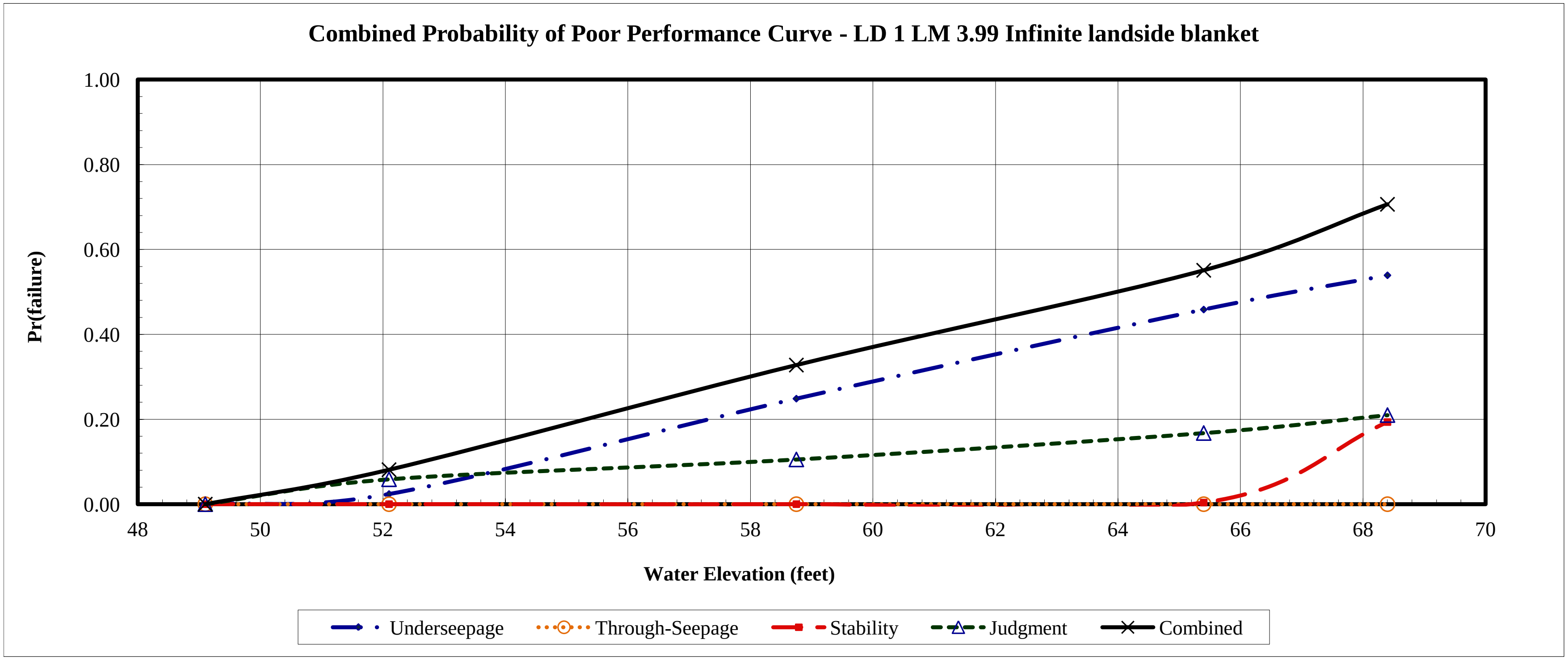
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

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 Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	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



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

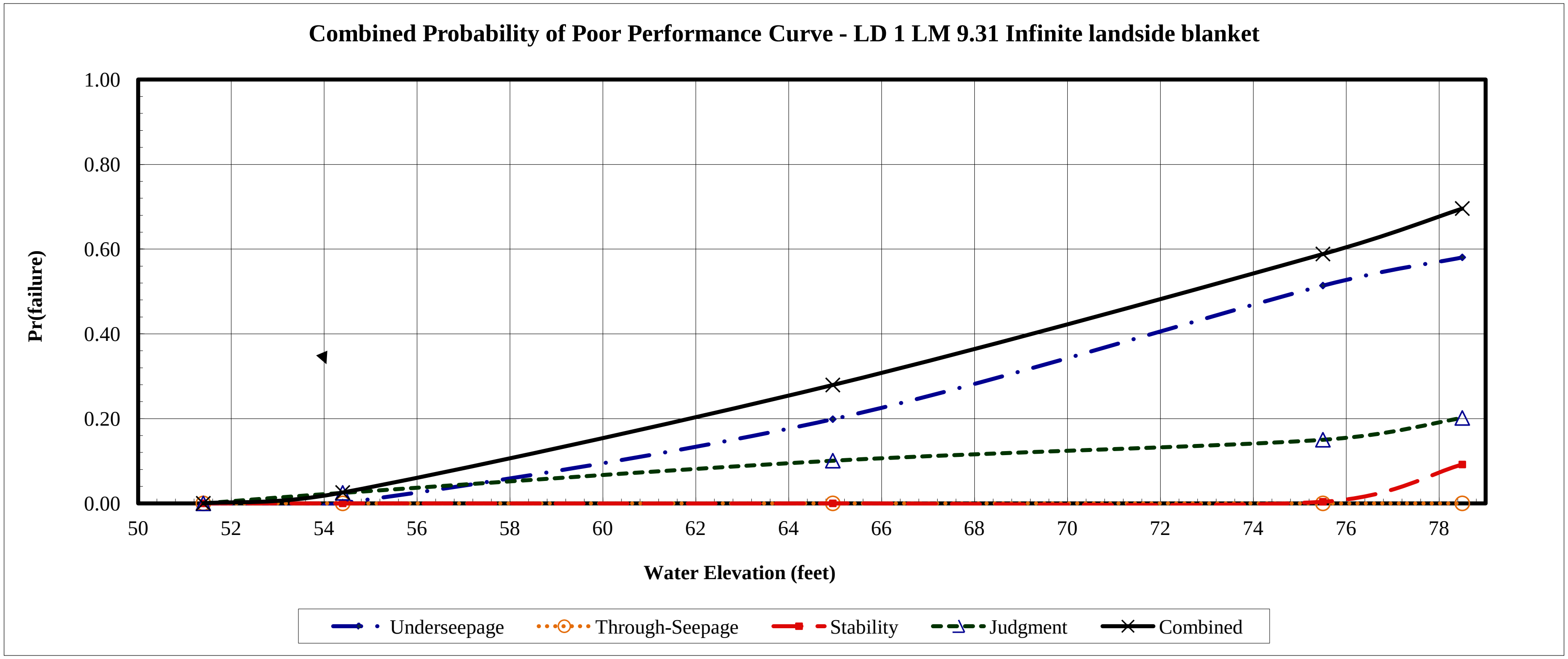
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

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 Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	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
Combined Probability of Poor Performance Curve

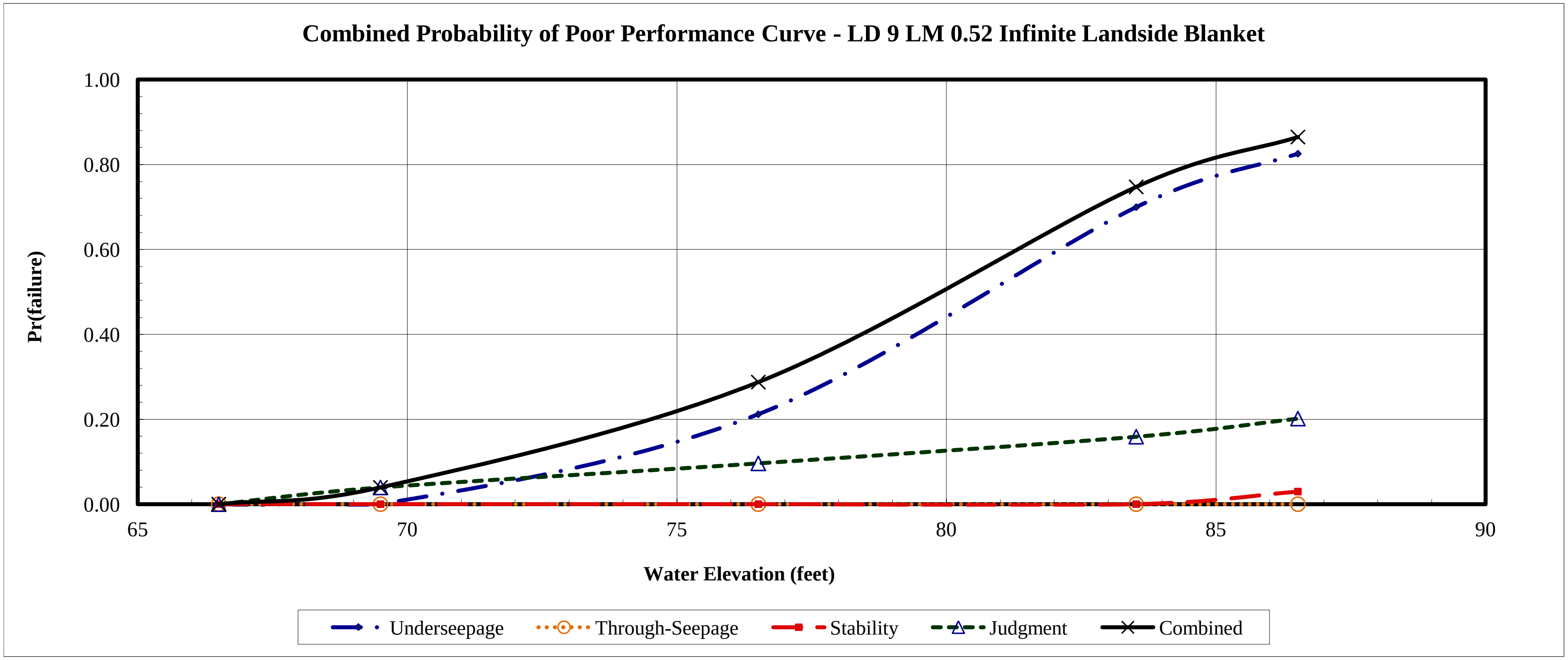
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 9

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 Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	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



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

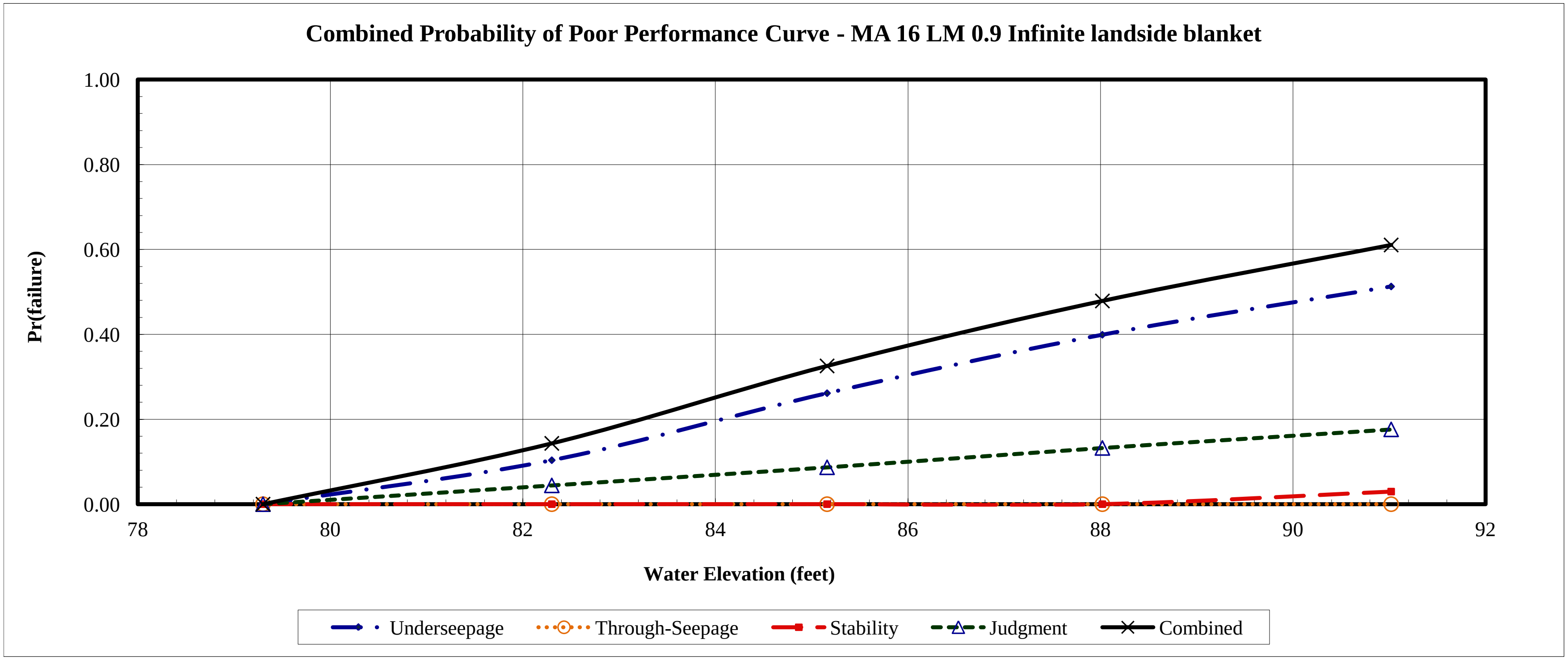
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

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 Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	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



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

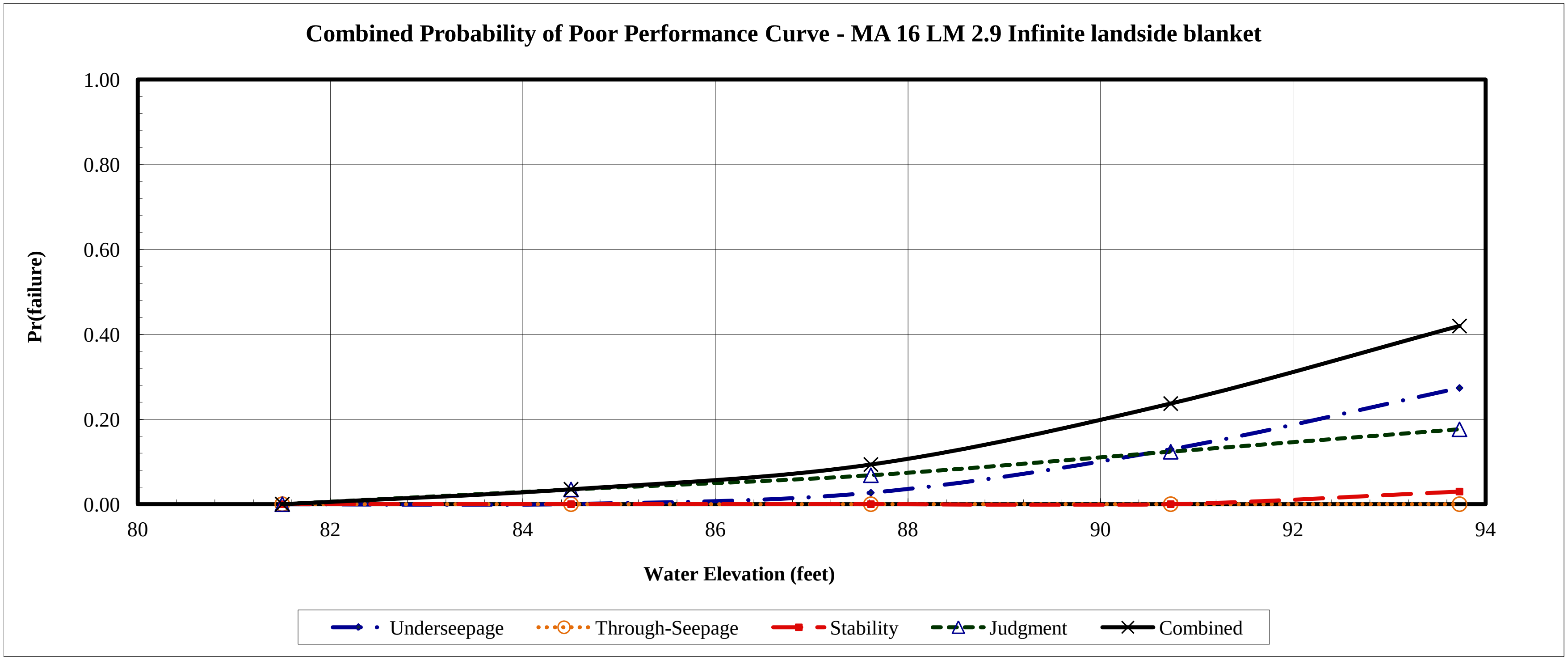
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

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



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

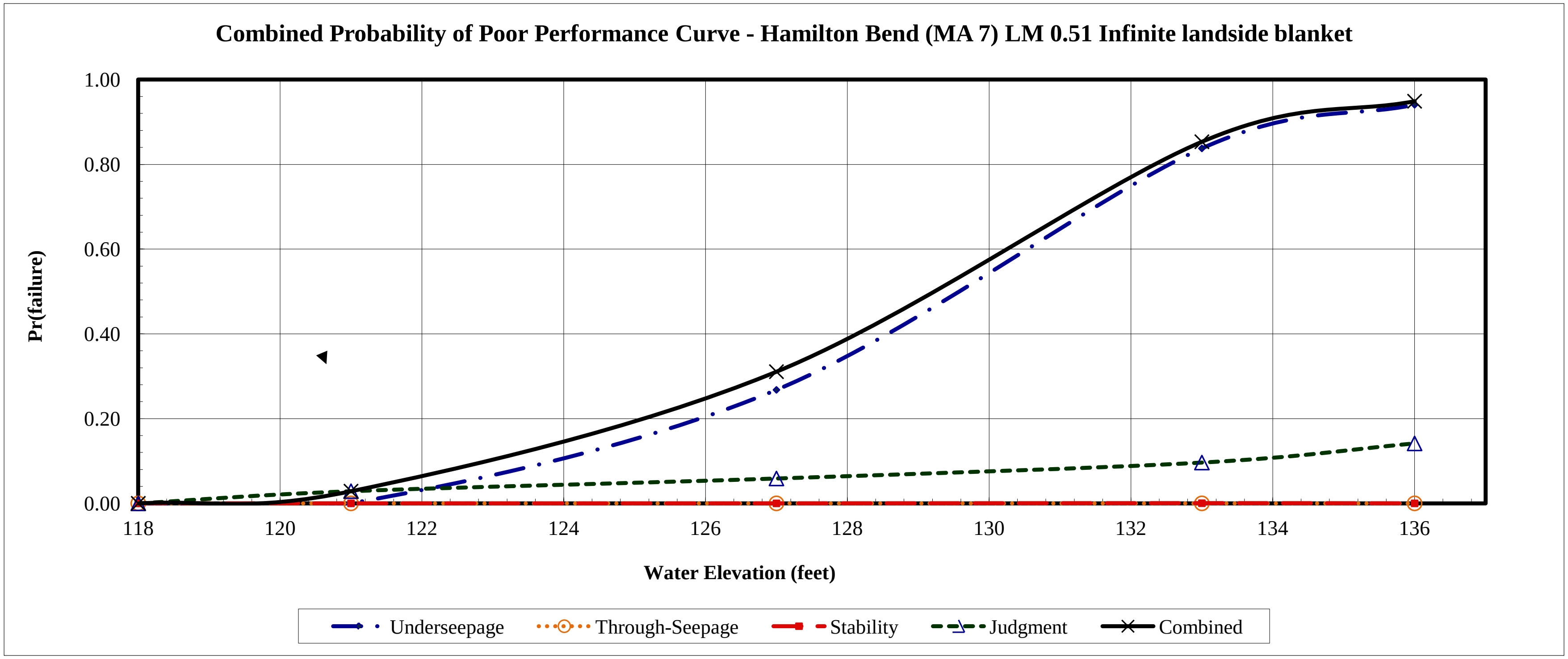
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: Hamilton Bend (MA 7)

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 Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	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
Combined Probability of Poor Performance Curve

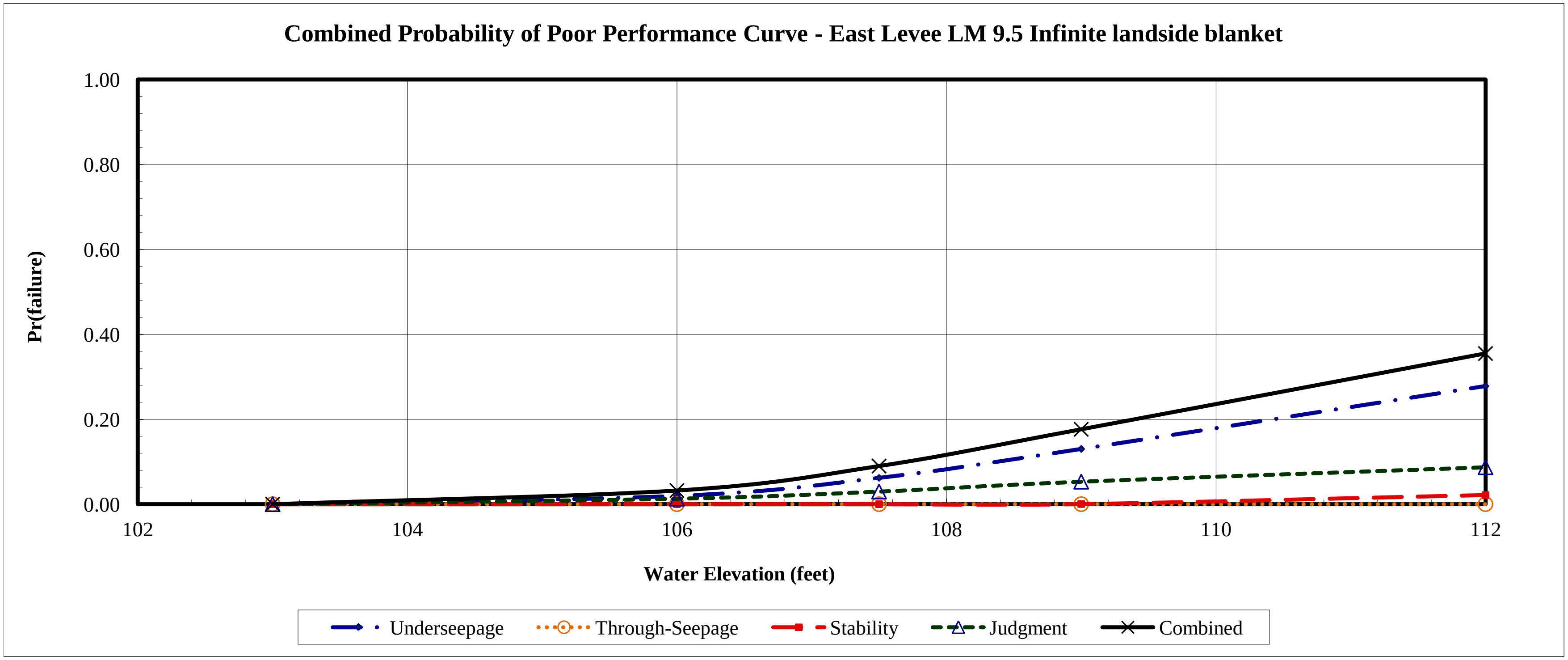
Project: Sutter Feasibility Study
Study Area: Cherokee Canal
River Section: East Levee

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 Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	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
Combined Probability of Poor Performance Curve

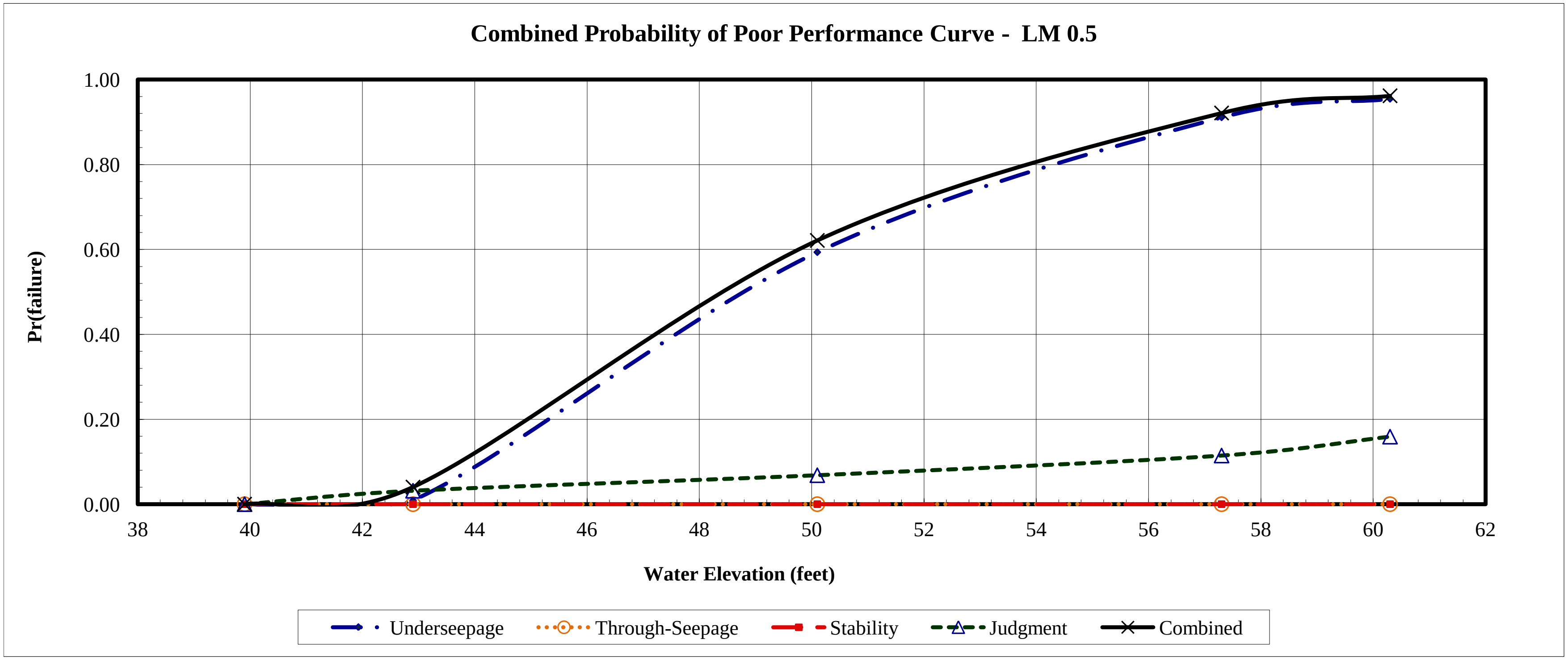
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

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 09/14/2

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
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
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 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	0.0004	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