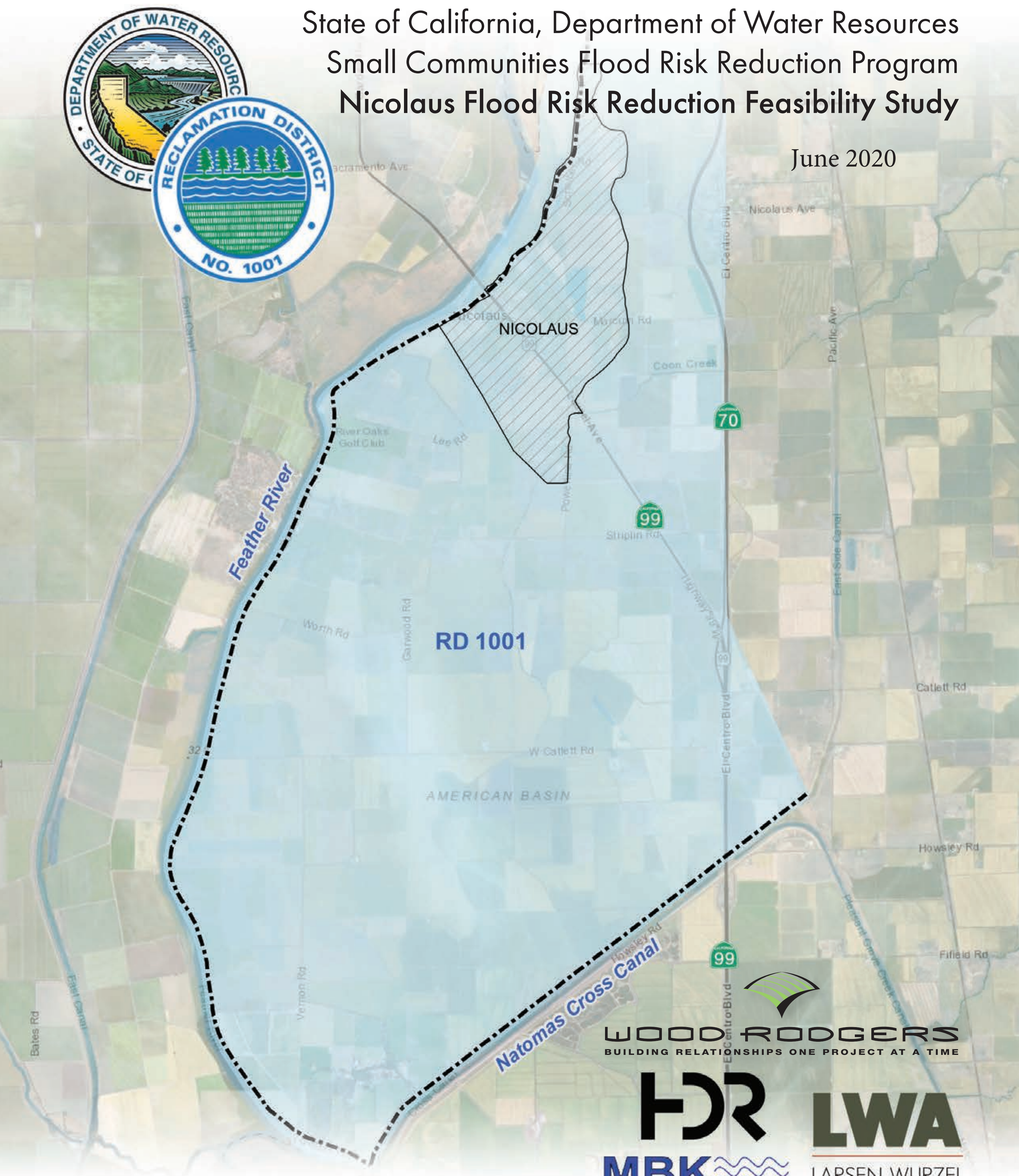
State of California, Department of Water Resources

Small Communities Flood Risk Reduction Program

Nicolaus Flood Risk Reduction Feasibility Study

June 2020



DEPARTMENT OF WATER RESOURCES · STATE OF CALIFORNIA

RECLAMATION DISTRICT NO. 1001

WOOD RODGERS
BUILDING RELATIONSHIPS ONE PROJECT AT A TIME

HDR

LWA
LARSEN WURZEL & Associates, Inc.

MBK ENGINEERS

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1. ACRONYMS AND ABBREVIATIONS

AEP – Annual Exceedance Probability
AC – Acre
BCR – Benefit to Cost Ratio
BFE – Base Flood Elevation
Cal-IPC – California Invasive Plant Council
CDFW – California Department of Fish and Wildlife
CDIAC – California Debt and Investment Advisory Commission
CEQA – California Environmental Quality Act
CIP – Capital Improvement Program
CPA – Conservation Planning Areas
CRPR – California Rare Plant Rank
CVFED – Central Valley Floodplain Evaluation and Delineation Project
CVFPB – Central Valley Flood Protection Board
CVP – Central Valley Project
DFM – Division of Flood Management
DPS – Distinct Population Segment
DWR – California Department of Water Resources
DWSE – Design Water Surface Elevation
EIP – Early Implementation Program
ESU – Evolutionary Significant Unit
FDRP – Flood Damage Reduction Projects
FEMA – Federal Emergency Management Agency
FIRM – Floodplain Insurance Rate Maps
FIS – Flood Insurance Study
FMA – Flood Mitigation Assistance
FPS – Feet Per Second
FRMP – Flood Risk Management Plan
FRP – Fish Restoration Program
FSRP – Flood System Repair Projects
FT – Feet or Foot
FY – Fiscal Year
GAR – Geotechnical Assessment Report
GGS – Giant Garter Snake
GIS – Geographic Information System
GO – General Obligation
GOR – Geotechnical Overview Report

HERP – Habitat Enhancement and Restoration Program
HMGP – Hazard Mitigation Grant Program
HSI – Habitat Suitability Index
IWC – Inland Wetlands Conservation Program
LAMP – Levee Analysis and Mapping Procedures
LiDAR – Light Detection and Ranging
LF – Lineal Feet
LS – Landside
MOU – Memorandum of Understanding
NAVD 88 – The North American Vertical Datum of 1988
NGVD 29 – The National Geodetic Vertical Datum of 1929
NEPA – National Environmental Policy Act of 1969
NMFS – National Marine Fisheries Service
NRHP – National Register of Historic Places
NULE – Non-Urban Levee Evaluations
O&M – Operation and Maintenance
OMRRR – Operation, Maintenance, Repair, Replacement, and Rehabilitation
PDM – Pre-Disaster Mitigation
PIR – Problem Identification Report
RACER – Remedial Alternatives and Cost Estimates Report
RD – Reclamation District
RMA – Resource Management Associates
ROW – Right-of-Way
RWQCB – California Regional Water Quality Control Board
SCFRR – Small Communities Flood Risk Reduction
SCFRRP – Small Communities Flood Risk Reduction Program
SFHA – Special Flood Hazard Area
SPFC – State Plan of Flood Control
SR – State Route
SRFCP – Sacramento River Flood Control Project
TCE – Temporary Construction Easement
ULE – Urban Levee Evaluations
UPRR – Union Pacific Railroad
USACE – US Army Corps of Engineers
WFPO – Watershed and Flood Prevention
WPIC – Western Pacific Interceptor
WS – Waterside
WSE – Water Surface Elevation
YFFPP – Yuba Feather Flood Protection Program

2. EXECUTIVE SUMMARY

The purpose of the Nicolaus Feasibility Study (Feasibility Study) is to advance flood risk reduction for the community of Nicolaus and the surrounding areas, with the ultimate goal of achieving a 100-year level of protection for this legacy small community.

The Feasibility Study was funded by the California Department of Water Resources (DWR) by way of a Small Communities Flood Risk Reduction Program (SCFRRP) grant. The grant funds are a part of the Disaster Preparedness and Flood Prevention Bond act of 2006 (Proposition 1E).

2.1. Background and Existing Conditions

The community of Nicolaus is located within Sutter County (County) between State Route (SR) 99 and SR 70 and is situated southeast of the Feather River left (south) bank levee, approximately 20-25 miles north of the city of Sacramento, California. The community is protected from flooding by State Plan of Flood Control (SPFC) levees along the left (south) bank of Yankee Slough, the left (south) bank of the Bear River, the left (east) bank of the Feather River, the right (north) bank of the Natomas Cross Canal (NCC), the right (west) bank of the East Side Canal, and the Reclamation District (RD) 1001 Main Drain and Main Pumping Plant. For a map showing the location of Nicolaus in relation to the levees, see **Figure 1** (attached).

To identify and quantify deficiencies associated with the existing flood control system protecting the community, a variety of relevant information was compiled, including flood history information from landowners and stakeholders in the study area, data and analyses developed during previous studies, and new investigations and analyses that were completed as part of this feasibility study.

2.2. Formulation of Alternatives

Structural remediation measures were developed to address the identified problems with the system under existing conditions. A broad preliminary array of alternatives was evaluated and screened down to two final structural alternative approaches for each reach. These final two alternatives consisted of an earthen berm remediation measure and a cutoff wall remediation measure. It should be noted that reaches that showed increased potential for seepage and erosion had additional measures included to mitigate these issues. Where additional seepage potential was identified, a combination seepage/stability berm was proposed in place of the standard stability berm. In reaches with high erosion potential, a waterside toe berm was proposed to increase bank protection. Additional technical evaluations were used to compare the benefits and costs of these alternatives and a preferred structural alternative was selected based on the results. The cutoff wall alternative was the selected alternative for both the Bear River East Levee and the Yankee Slough South Levee.

Non-structural measures and multi-benefit opportunities were also analyzed and discussions of these measures are included in the report. Recommended non-structural measures are listed below:

- Flood Emergency Evacuation Plan
- Flood Evacuation Warning System
- Emergency Flood Fight Plan
- Levee Relief Cuts
- Voluntary Structure Elevation & Flood-Proofing
- Changes to National Flood Insurance Program (NFIP)
- Agricultural Conservation Easements

It should be noted that these items are considered separate from the structural alternatives and therefore can be implemented independently of the structural alternative.

2.3. Findings and Recommendations

The analyses showed that the entire length of each of the studied levees contains one or more of the analyzed deficiencies (geotechnical stability, freeboard, crown width, and geometry) and therefore will require remediation along the entirety of the levee length. The feasibility-level cost estimate for the project containing the recommended structural alternative at each reach was approximately $382 million.

An analysis of the financial feasibility of the preferred Project found that, due to an anticipated lack of federal and state funding and the limited amount of local funding potential, other avenues for developing implementation funding will be necessary to fund the project. With an expected local funding capacity of between 1.47 percent and 1.88 percent of the total preferred alternative cost, the typical local cost share of 10 percent to 15 percent needed to qualify for state and federal programs is not feasible under current funding mechanisms.

2.4. Next Steps

With a preferred project now identified, and the limitations associated with local cost share development understood, it is recommended that the County further explore potential means to generate local cost sharing commensurate with State and Federal grant program requirements. A phasing plan that identifies elements of the overall Project that could be implemented over time and within the funding constraints should also be developed.

3. INTRODUCTION

The Feasibility Study was funded by the California Department of Water Resources (DWR) with a Small Communities Flood Risk Reduction Program (SCFRRP) grant. The grant funds are a part of the Disaster Preparedness and Flood Prevention Bond act of 2006 (Proposition 1E).

The community of Nicolaus is located within Sutter County (County) between State Route (SR) 99 and SR 70 and is situated southeast of the Feather River left (south) bank levee, approximately 20-25 miles north of the city of Sacramento, California. The community is protected from flooding by State Plan of Flood Control (SPFC) levees along the left (south) bank of Yankee Slough, the left (south) bank of the Bear River, the left (east) bank of the Feather River, the right (north) bank of the Natomas Cross Canal (NCC), the right (west) bank of the East Side Canal, and the Reclamation District (RD) 1001 Main Drain and Main Pumping Plant. For a map showing the location of Nicolaus in relation to the levees, see Figure 1 (attached).

The focus of this study is analysis of the levees on the left bank of the Feather River and the north bank of the Natomas Cross Canal. The levee systems along Yankee Slough and Bear River are being analyzed as part of a separate feasibility study effort for the community of Rio Oso, which is within the same hydraulic basin as Nicolaus. Since the two communities share the same basin, the levees near each community will impact each other; therefore, while the levees are identified individually with two separate feasibility studies, they act as one system. As such, remediation of all levees protecting the basin will be required to achieve the planned flood risk reduction goals. Furthermore, some of the analyses completed for this Feasibility Study looked at the project on a basin-wide level and, therefore, will be discussed in both Rio Oso and Nicolaus studies.

RD 1001 has the operation and maintenance (O&M) responsibility for the levees' drainage facilities and the pumping stations analyzed within this study. This Feasibility Study was developed under the direction of RD 1001 and its District Engineer, MBK Engineers (MBK). It should be noted that the East Side Interceptor Canal was not analyzed as part of this study.

4. BACKGROUND

A number of studies have been conducted in the past to evaluate the levee systems protecting the study area. A summary of each of these studies is provided below. A more detailed description of these studies can be found in the Geotechnical Summary Report included as **Attachment A** (attached) **(Reference 1)**.

4.1. DWR Non-Urban Levee Evaluation Project (2012)

The DWR's Levee Evaluation Program was initiated in 2006 and concluded in the spring of 2015. The Levee Evaluation Program was divided into two projects: the Urban Levee Evaluations (ULE) Project and the Non-Urban Levee Evaluations (NULE) Project

(**References 2, 3, 4** and **5**), which were further divided into multiple study areas. In 2012, the levees protecting the communities of Nicolaus and Rio Oso were evaluated as part of the NULE Project. The evaluation used existing geologic information; however, no new explorations were performed. The following hazards were identified and the prevalence of each as a percentage of the total reach length was identified:

- **Yankee Slough South Levee**: Underseepage (100%), Through seepage (100%), Stability (25%), and Erosion (40%).
- **Bear River South Levee**: Freeboard less than design (15%), Underseepage (100%), Stability (20%), Through seepage (100%), and Erosion (50%).
- **Feather River East Levee**: Underseepage (100%), Stability (50%); Through Seepage (100%), and Erosion (50%).
- **Natomas Cross Canal (NCC) North Levee**: Underseepage (75%), Stability (50%), Though Seepage (25%), and Erosion (100%).

The program also identified erosion, bank caving, and/or seepage instabilities as "Critical" in six locations. These sites subsequently qualified for funding assistance through DWR's Flood System Repair Project (FSRP) and the district is waiting for approximately $4.1 million in funds to be made available from DWR. Repair of these critical items has not yet been accomplished.

4.2. U. S. Army Corps of Engineers (USACE) Mid-Valley Area, Phase III

In 1994, the USACE prepared the Mid-Valley Area, Phase III Study (**Reference 6**) to determine the need for levee repairs within the Mid-Valley study area. This study area includes the Sacramento River East Levee between the Tisdale Bypass and the Sacramento Bypass, the Yolo Bypass north of the Sacramento Bypass, the Sutter Bypass West Levee, the Feather River South Levee between the Bear River and the Natomas Cross Canal, Yankee Slough, the Knights Landing Ridge Cut East Levee, the Natomas Cross North Levee, and the East Side Canals. The study was based upon four previous exploration programs, new site inspections, new explorations, new laboratory testing, and new seepage and stability analyses at various sites. The study identified twenty-nine total sites for remediation, including four within the Nicolaus and Rio Oso study area (Sites 20-23). Due to funding limitations, these sites have not been addressed by a subsequent construction project and there has been no indication that federal action will occur at any time in the near term.

4.3. Feather River Regional Flood Management Plan

The Nicolaus and Rio Oso study areas are described within the Mid & Upper Feather River Regional Flood Management Plan (FRRFMP) (**Reference 7**). Within the FRRFMP, the flooding history of the area is described, the results and actions of the NULE project are identified, and a listing of locally proposed projects is provided. **Table 1** (below), which describes each of the projects and their anticipated costs, is excerpted from the FRRFMP below. Although some of the projects have been advanced through DWR's FSRP (L2: re-rock levee crown patrol roads) and Deferred Maintenance Program (L3: Repair, replace, or abandon existing drains and pipes through the levees), none of the major projects in the table have been advanced to a planning study or design phase.

Table 1: RD 1001 Structural Flood Protection Improvements (FRRFMP)

ID	DESCRIPTION	ESTIMATED COST	COMMENTS
L1	Address specific seepage, underseepage, erosion, and stability concerns for the Feather River Levee, from the Natomas Cross Canal to the River Oaks Golf Course (Levee Unit 4, Levee Miles 5.2 to 13.4) and repairs to the Natomas Cross Canal downstream of SR 99.	$5.4 M	50% of 8.2 miles of seepage berm; seepage berm 80' x 4' with collection pipe.
L2	Re-rock levee crown patrol roads	$1.5 M	AB for 75% of levees in district
L3	Repair, replace, or abandon existing drains and pipes through the levees.	$86,680	Replacement and repair expected to be completed by farmer. District would only abandon. Grouting 2/mile. 14" pipe, 70' total length. Assumed 10' below WSE.
L4	Improve erosion protection along the Bear River South Levee.	$2.6 M	12.6 miles total. 50% erosion protection 2' thick.
L5	Upgrade the Main Drain Pumping Plant	$500,000	Assumption for whole project?
L6	Construct a replacement pumping plant on the Cross Canal at end of Lateral 4.	$500,000	Assumption for whole project?
L7	Phased improvements to the RD 1001 levee system to achieve 100-year FEMA levee protection		
L7A	Natomas Cross Canal North Levee	$123.9 M*	Use NULE RACER Segment 284
L7B	Feather River east levee, Cross Canal to River Oaks Golf Course	$349.8 M*	NULE RACER Segment 247

ID	DESCRIPTION	ESTIMATED COST	COMMENTS
L7C	Bear River south bank, Yankee Slough to Pleasant Grove Road	$75.2 M*	NULE RACER Segment 283
L7D	Yankee Slough north and south banks, from confluence to Pleasant Grove Road	$57.6 M*	NULE RACER Segments 144, 145
L7E	Bear River south bank, Pleasant Grove Road to high ground	$109.7 M*	NULE RACER Segment 246
L7F	Coon Creek Group Interceptor Canal Levee, Natomas Cross Canal to high ground	$13.5 M*	NULE RACER Segment 285

[1]Due to potential effects on stages upstream of Fremont Weir in the lower Sutter Bypass and the Feather River
**Estimates from North NULE Study Area Remedial Alternatives and Cost Estimates Report (RACER)*

5. EXISTING CONDITIONS AND PROBLEM IDENTIFICATION

This section describes the methods and analyses utilized to determine existing conditions and to identify existing problems within the Project area.

5.1. Hydrology and Hydraulic Analyses

5.1.1. Design Water Surface

Water surface profiles corresponding to the 100-year recurrence interval event and the 1957 design flood profile were developed for each of the streams in the study area for use in the Feasibility Study. Hydraulic routings from the Sacramento River General Re-Evaluation Report (Sac-GRR) were analyzed to develop 100-year water surface profiles for the Feather and Bear Rivers, Natomas Cross Canal, and Yankee Slough. The Sac-GRR analyzed alternatives that included widening of the Fremont Weir, which is in geographic proximity to the communities of Rio Oso and Nicolaus. That analysis also included a USACE required Central Valley Hydrology Study (CVHS) event selection process, which refined the flood centering of major tributaries in this area. A design water surface profile that considers the maximum water surface elevation for centerings that concentrate flows for each tributary was thus produced.

5.1.2. Levee Breach Analyses

As is performed for Federal Emergency Management Agency (FEMA) flood mapping, critical levee section breach analyses were performed to characterize the existing flood risk to the community. The levee sections along the Feather River South Levees at SR 99 and the South Bear River Levees at SR 70 were breached to determine the resulting flood inundation. The breach along the Feather River Levees at a location just south of the Bear/Feather Rivers confluence has the potential to draw in a large volume of water from the Sutter Bypass, Feather and Bear Rivers. The breach on the South Bear River Levee was selected because it is representative of a higher initial breach water surface elevation for the basin, which has the potential to result in greater flood depths and a flood wave through the communities of Rio Oso and Nicolaus provided that there is sufficient flood volume emanating from the Bear River.

Levee breaches are assumed to occur wherever the water surface elevation (WSE) exceeds the original design WSE for a federal/state project levee. This height is measured from the top-of-levee downwards and is identified as the levee reduction height (Reference 2). The levee reduction height is determined through geotechnical assessment and is a concept derived from the NULE program. Once the levees fail, the levee structure is assumed to erode completely to the landside levee toe elevation. The analysis is discussed in more detail in **Attachment B (Reference 8**).

5.1.2.1. Feather River Breach

A breach on the Feather River results in southwesterly flows and the filling of the RD 1001 basin. Once flood depth in the basin exceeds the crown elevation of SR 99, the floodwater backs up northeasterly towards SR 70 in the area of Rio Oso. Flood depths in this scenario reach more than 20 feet in the lower lying areas. The floodwaters also have the potential to overtop the north (right bank) Natomas Cross Canal Levee without adequate relief cuts to allow water back into the Feather River.

5.1.2.2. Bear River Breach

For a breach on the Bear River, floodwaters overtop SR 70 and flow southwesterly towards RD 1001. Similar to the Feather River Levee breach, floodwater fills the RD 1001 basin to an elevation that floods all of the area between the Bear/Feather/Natomas Cross Canal and SR 99 to the northeast. The flood source from this breach is not solely from the Bear River watershed. The breach opening size has the potential to divert most of the Bear River and draw additional water from the Feather River into the basin. Further, because of the elevation of the Bear River compared to the interior basin, this breach has the potential for significant flood waves and high flows through the upper portion of the basin.

5.2. Geotechnical Analyses

The existing conditions geotechnical analyses for the Nicolaus study area included a study of the past performances of the levee segments protecting Nicolaus. This study is documented in the NULE Geotechnical Assessment Report (GAR) (Reference 2) and discussed in more detail in Attachment A (Reference 1). Past performance events include a levee break, underseepage, through seepage, erosion, overtopping, and slope instability. The past studies of the Nicolaus area levees indicated a high likelihood of either levee failure or the need to flood-fight in order to prevent levee failure. Additionally, the studies also summarized that the subject levees lacked sufficient data to analyze the underseepage and through seepage risk. A supplementary exploration program was carried out as a part of the Feasibility Study in order to obtain additional subsurface information. Updated analyses were carried out using the 100-year WSE in order to evaluate the threat of underseepage, through seepage, and slope stability. The summary of results for the existing conditions analysis is shown below in **Table 2**. The approach, results, and a discussion of the geotechnical analyses are provided in Attachment A (Reference 1).

Table 2: Summary of Existing Condition for 100-Year WSE

Maintained By	Segment	Reach	Levee	Station	Levee Miles	Assessment Type		
						Under Seepage	Through Seepage	Stability
RD 1001	247	A	Feather River Left Bank	FR 700+89 to FR 640+20	LM 0.0 to 1.2	Does Not Meet Criteria	Does Not Meet Criteria	Does Not Meet Criteria
RD 1001	247	B	Feather River Left Bank	FR 640+20 to FR 580+40	LM 1.2 to 2.3	Meets Criteria	Does Not Meet Criteria	Does Not Meet Criteria
RD 1001	247	C	Feather River Left Bank	FR 580+40 to FR 531+55	LM 2.3 to 3.3	Meets Criteria	Does Not Meet Criteria	Does Not Meet Criteria
RD 1001	247	D	Feather River Left Bank	FR 531+55 to FR 0+00	LM 3.3 to 13.3	Does Not Meet Criteria	Does Not Meet Criteria	Does Not Meet Criteria
RD 1001	284	A	Natomas Cross Canal Right Bank	CC 0+00 to CC 284+80	LM 0.0 to 5.4	Does Not Meet Criteria	Does Not Meet Criteria	Does Not Meet Criteria

5.2.1. Seepage Analyses

Seepage analyses were conducted using a finite elements analysis on select cross-sections for the study area levees to evaluate the underseepage and through seepage performance. Underseepage problems commonly occur when a surficial layer of fine-grained, relatively impervious soils (also known as a blanket layer), overlays a layer of coarse-grained, more pervious soil. When the water level in a channel reaches an elevated stage, pressure builds up in the confined coarse-grained sublayers and can cause subsurface erosion or piping at or beyond the landside toe of the levee. Through seepage occurs when water enters the waterside slope of the levee and exits through the landside slope, passing through the levee core. Through seepage can cause surficial erosion at the landside slope face and possibly internal erosion of the levee as soil particles are moved from the levee interior to the levee landside slope.

5.2.2. Stability Analyses

Stability analyses were conducted by analyzing the same cross sections to evaluate levee landside slope stability and waterside slope stability during a rapid draw-down condition. The steady state case occurs when the water remains at or near flood stage levels long enough for a fully-saturated condition to become established in the embankment soil. Rapid draw-down is a condition where the levee experiences a sudden draw-down of the water surface following a fully saturated embankment condition, and the embankment remains saturated without an elevated water surface to counteract the weight of the saturated soil. When this condition occurs, the levee can experience a circular or wedge-type failure that results in the loss of levee thickness at the location of the failure. A heightened risk of levee breaching can occur at the location thereafter.

5.2.3. Erosion Analysis

Erosion analyses were conducted to qualitatively assess the potential for erosion to occur within the study area. The analyses consisted of the collection and review of past erosion problem areas and analyses performed to determine the erosion risk. Updated erosion analyses were not carried out as a part of this study.

5.3. Freeboard and Geometry Analysis

An analysis of existing freeboard and a review of the exiting levee geometry was performed for the existing levee embankments in order to determine if the levees meet the minimum requirements of the Sacramento River Flood Control Project (SRFCP) authorized design. The SRFCP requires a minimum of three feet of freeboard above the design water surface elevation (DWSE), a 12-foot-wide or 20-foot-wide levee crown (depending on the stream being analyzed as described below), a 3:1 waterside slope, and a 2:1 landside slope (see **Figure 2**) (**Reference 9**). The Memorandum of Understanding (MOU) between the USACE and the State of California (State) acting through the Reclamation Board dated November 6, 1953 (**Attachment G**) (**Reference 10**), states that levee crown widths for all levees shall be 20 feet in width, unless the waterway is designated as a “minor tributary” and listed as an exception within the MOU. These exceptions are required to have a crown width of 12 feet, instead of the normal 20 feet.

Following this criterion, both the Feather River East Levee and the Natomas Cross Canal North Levee require 20-foot crown widths.

The freeboard and geometry analysis was conducted using available topographic data developed for use on the DWR Central Valley Floodplain Evaluation and Delineation (CVFED) Project (developed in 2007). Cross sections of the existing levee were evaluated every 100 feet for slope and crown width deficiencies. The elevations of the levee crest from these cross sections were compared to the DWSE to determine if the available freeboard meets SRFCP requirements. The DWSE is considered the greater of both the 100-year WSE provided by the hydraulic analysis from MBK and the 1955/57 DWSE. Any cross section that did not meet the criteria for slope, crown width, or freeboard was considered deficient and was flagged as requiring geometry or freeboard remediation. Results from this analysis show that nearly 100 percent of the levees within the study area have geometry deficiencies and that will require correction through future projects. See **Attachment H** for strip maps displaying locations of geometric deficiencies. See **Attachment I** for exhibits of the evaluated cross sections overlain by a theoretical SRFCP levee geometry template. Freeboard and geometry analysis results are also included in Attachment I.

5.4. Previously Identified Levee Performance Issues

The Feasibility Study has identified a number of previously identified performance issues with the Feather River East Levee and Natomas Cross Canal North Levee within the study area. The identified geotechnical problems with the existing levees includes underseepage, through seepage and erosion. Additionally, portions of the existing levees do not have the required minimum freeboard, while a majority of the levees do not meet the minimum SRFCP geometry requirements throughout their length. These identified problems reduce the ability of the existing levees to provide the minimum level of protection sought for the community of Nicolaus.

A description of past levee performance follows below.

5.4.1. Past Levee Performance Documented in the NULE GAR

The past performance of the levees analyzed within this Feasibility Study is documented in the NULE GAR (Reference 2). Past performance events documented by the NULE include a levee break, underseepage, through seepage, erosion, overtopping, and slope instability. This study was focused on the levee alignment upstream of the SR 99 Bridge at Nicolaus on Segment 247 of the Feather River Levee as per the direction of RD 1001. The Feather River Levee downstream of the SR 99 Bridge contains a known area of underseepage distress that leads to underseepage occurring during high water events. Since its construction, the Feather River Levee protecting Nicolaus has experienced multiple high-water events, including high water in 1995, 1986, 1995, 1997, 1998, 2007, and 2006. Detailed descriptions of levee segments' past performances, based on information contained in the NULE project, are provided below.

5.4.1.1. Feather River – NULE Segment 247

Segment 247 is located along the left (east) banks of the Bear, Sacramento, and Feather Rivers and the Sutter Bypass. It begins upstream of the confluence of the Bear and Feather Rivers and extends approximately five miles southwest toward the confluence of the Feather River and the Sutter Bypass. From this confluence, it continues south along the left (east) bank of the Feather River and the Sutter Bypass for approximately 8.3 miles and ends at the confluence of the Sacramento River and the Natomas Cross Canal. This segment is 13.3 miles long and is maintained by RD 1001. The levee segment was originally constructed in 1910 and was reconstructed several times through 1955. Although information on the initial construction was not available, it is likely that clamshell dredges were used for its construction. This method of construction consisted of the excavation of a trench along the stream edge wherein the spoils of the excavation were placed adjacent to the trench to form two small levees (auxiliary levees) on either side of the trench. Sand material was then dredged from the river and placed in the trench and in the area contained by the auxiliary levees. This method of construction resulted in creating a high risk of levee through seepage failure and did not provide resistance to levee underseepage. The levee between Levee Mile (LM) 3.02 and LM 4.40 was set back and reconstructed by the USACE between 1955 and 1956 and again in 1959 between LM 0.0 and LM 2.57.

Levee past performance events reported for Segment 247 include a total of six levee breaches and one levee cut, numerous underseepage occurrences during high-water events, landside slope stability problems, a through seepage incident (no distinction between through seepage and underseepage was documented), several erosion problems, and one identified overtopping incident. The locations, types of events, and documented mitigations for Segment 247 are detailed below in Table 3.

Table 3: NULE Segment 247 Reported Levee Performance Events

Flood Season	Reported Performance Event	Approximate Location (LM)	Mitigation
Unknown	Site of old levee break, deep hole on the landward side.	0.29	Levee repairs not documented.
Unknown	Site of old levee break, deep hole on the landward side.	0.95	Levee repairs not documented.
Unknown	Site of an old levee break.	9.9	Levee repairs not documented.
Unknown	Site of an old levee break. Large hole on landward side.	10.15 to 10.22	Levee repairs not documented.

Flood Season	Reported Performance Event	Approximate Location (LM)	Mitigation
Past Flood Events	Through seepage through the old levee cut section as it was repaired using boulders and cobbles.	11.83 to 12.03	Levee repairs not documented.
1955	Site of old levee break.	3.50 to 3.76	Levee repairs not documented.
1955	Site of a cut in the levee for dewatering landward side during the 1955 flood. Bank cobble revetment placed to waterline in 1956.	11.83 to 12.03	Repaired March 1956. Levee repairs not documented.
1986	Artesian well reported at landside slope.	9.8	USACE 1991 appraisal report for Sacramento River Flood Control Project (SRFCP) recommended a drained stability berm but it is not known whether it was constructed.
1986	All of the levee downstream of Lee Road reported to have seepage problems during flood conditions.	5.2 to 13.3	Not documented.
1986	Continuous boils during high water.	12.5 to 13.3	USACE 1991 appraisal report for SRFCP recommended a drained stability berm but it is not known whether it was constructed. .
1986	Landside depression with significant growth of brush at landside toe.	11.68	USACE 1991 appraisal report for SRFCP recommended a drained stability berm but it is not known whether it was constructed. .
1995	Excessive seepage resulted in a pond.	11.5	Not documented.
1997	Erosion, scour.	0.02, 5.4, 5.63, 5.66, 5.72, 5.83, 6.84, 10.33, 10.67, 11.36, 12.04, and 13.36	Not documented.
1997	Seepage.	9.36, 9.71, 10.00, 10.57, 11.91, 11.92, 12.02, and 13	Not documented.
1997	Boils.	9.56, 9.58, 9.63, 9.71, 12.23, and 13.25	Not documented.
1997	Seepage and boil.	9	Not documented.
1997	Sand boils on levee landside. Sand bags were used to circle the boil and reduce exit velocity.	9.52	Phase III of Mid-Valley project proposed a slurry wall at this location, but whether work was done is unknown.
1997	Sloughing at landside toe.	10.31	Phase III of Mid-Valley project proposed a slurry wall at this location, but whether work was done is unknown.

Flood Season	Reported Performance Event	Approximate Location (LM)	Mitigation
1997	Numerous small boils.	12.73 to 13.26	Phase III of Mid-Valley project proposed a slurry wall at this location, but whether work was done is unknown.
1997	Levee breach, overtopping.	10.02	Not documented. Believe to have actually occurred on Yankee Slough.
1997	Erosion to waterside berm.	5.58 to 5.67	Not documented.
1998	Scour on the waterside levee slope with 1-foot vertical face.	10.26 to 10.36	Not documented.
1998	Erosion on the waterside levee slope 30 feet in length halfway down the slope.	11.34	Not documented.
1997	Erosion on the waterside levee slope, 20 feet in length from the levee shoulder to toe.	12.03	Not documented.
2008	USACE Sacramento River Bank Protection Project (SRBPP) 2008 field reconnaissance report erosion site. Some active toe erosion of damaged old cobble site. Need to monitor closely.	5.45 to 5.55	Not documented. Believed to have been repaired through SRBPP or PL84-99 in 2011 or 2012
2008	USACE SRBPP 2008 field reconnaissance report erosion site. Whole bank rotational failure.	7.05 to 7.15	Not documented.
2008	USACE SRBPP 2008 field reconnaissance report erosion site. Active erosion, steep bank off berm with slumps and fallen trees.	7.73 to 7.90	Not documented.
2008	USACE SRBPP 2008 field reconnaissance report erosion site. Whole bank rotational failure.	8.72 to 8.85	Not documented.
2008	USACE SRBPP 2008 field reconnaissance report erosion site. Whole bank rotational failure.	8.95 to 9.08	Not documented.
2008	USACE SRBPP 2008 field reconnaissance report erosion site. Inactive scour site.	11.29 to 11.47	Repaired through SRBPP (Site FR 1.0) in 2019.
2008	USACE SRBPP 2008 field reconnaissance report erosion site. Scour and bank retreat. Deposit over top of cobble.	11.82 to 11.85	Not documented.

Source: Reference 2

In addition, significant seepage occurred during the 2017 high water event. Seepage resulted in emergency rock berms being installed by DWR along several segments between LM 11 and 13 and a PL84-99 repair of a significant boil near LM 12.8.

5.4.1.2. Natomas Cross Canal – NULE Segment 284

Segment 284 is located along the right bank of the Natomas Cross Canal. The downstream end of the segment is the confluence of the Natomas Cross Canal with the Sacramento River. The segment extends eastward for approximately 5.4 miles to its upstream end at the confluence of the Natomas Cross Canal and the East Side Canal. The segment is maintained by RD 1001. The levee segment was constructed between 1911 and 1914. Construction and reconstruction of the segment took place in stages between 1957 and 1964. Reported levee performance events for Segment 284 include four slope failures (including landslides), three seepage events, and several erosion events. The locations, types of flood events, and documented mitigations for Segment 284 are detailed below in **Table 4**.

Table 4: NULE Segment 284 Reported Levee Performance Events

Flood Season	Reported Performance Event	Approximate Location (LM)	Mitigation
Recurring	Seepage	2.1 to 2.2	Not documented.
Recurring	Seepage	3.9 to 4.6	Not documented.
1970	Landside levee slope slide	1.2	Repaired by RD 1001; no documentation on the construction.
1983	Landside levee slope slide	1.5	Repaired by RD 1001; no documentation on the construction.
1983	Landside levee slope slide	1.85	Repaired by RD 1001; no documentation on the construction.
1986	Erosion	0.9 to 4.4	Repaired under PL 84- 99
1997	Erosion, wave wash damage	0.6, 0.64, 0.74, 0.75, 0.82, 1.12, 1.29, 1.30, 1.57, 1.73, 1.76, 1.78, 1.79, 1.81, 1.94, 2.04, 2.23, 2.75, 3.03, 4.03, 4.14, 4.22, 4.23, 4.30, 4.32, 4.33, 4.37, and 4.47	Not documented.
1997	Rotational slope failure, slippage	5.05 and 5.39	Not documented.
1998	Severe scouring and wave wash damage	0.05 to 4.5	Not documented.
Pre-2007	Approximately 2,500 feet of intermittent wave wash damage	1.0 to 5.0	Repaired in 2007 under PL 84-99.
2007	Saturation slump into the top of the levee	3	USACE SRBPP 2008 field reconnaissance report erosion site; not documented.
2008	Longitudinal cracks appear during the dry season	0.0 to 5.4	Not documented.
Not Identified	Flood Fights	0.8, 1.0, 1.7, 1.37, 1.53, 2.0, & 4.33	

Source: Reference 2

In addition to the above events identified in NULE, two additional storm events have resulted in performance issues and repairs.

High water in March 2011 resulted in a landside levee slip at LM 1.6. This slip was repaired by RD 1001, through direct funding assistance from DWR, by over excavating the landside foundation and reconstructing the landside embankment to a 3:1 slope for the critical 800-foot reach. An undrained stability berm was also added for 500 feet downstream of the critical reach to address longitudinal cracking and minor slumping along the crown. During construction both repairs noted high organic content and visible slip planes in the upper 2 feet of the foundation which resulted in the need to over excavate the foundation to approximately 3-4 feet deep to find competent material.

The 2017 high water events resulted in a large sand boil near LM 3.3. The boil was discovered at the bottom of an irrigation canal located approximately 40 feet from the landside levee toe. The site was repaired by lining the canal with geotextile fabric, rock, and a large culvert for approximately 150 feet.

5.4.2. Past Levee Performance Issues Identified by Stakeholders and Landowners

As part of this study, outreach efforts were made to area stakeholders and landowners in order to foster community involvement in the study process. As part of this outreach, stakeholders were invited to a meeting at the RD 1001 main office so that the study's initial findings on past levee performance could be shared and stakeholder input on those findings could be solicited. This outreach meeting was well attended, with many of the local landowners coming to participate. After the findings had been presented, the consensus of those present was that all known past performance issues had been identified within the initial effort. As such, the study was able to proceed with confidence that all past levee issues had been identified.

5.5. Levee Encroachments and Penetrations

A number of encroachments are present along the Feather River Levee and the Natomas Cross Canal Levee within the Study Limits.

In order to identify existing encroachments, the USACE Levee Enterprise Geographic Information System (EGIS) (**Reference 11**), and the DWR Utility Crossing Inventory Program (UCIP) (**Reference 12**) were used to identify existing encroachments along the levees. A table of the identified encroachments is included in **Attachment L**. The Central Valley Flood Protection Board (CVFPB) encroachment permit number for an identified encroachment, where known, is included. As-built data for each encroachment was not available during the feasibility analysis, but major encroachments (e.g.; utility poles, private irrigation facilities, electrical transmission towers, houses and other structures) were identified where possible. Costs to acquire properties and remove or relocate encroachments outside of the proposed right-of-way were included in each of the analyzed alternatives. Future design phases of the work should review each individual encroachment to determine appropriate remedial alternatives in order to meet current requirements.

5.6. Biological Resources

Desktop and reconnaissance biological surveys were mapped in support of the Feasibility study. Nine vegetation communities were identified in the Project area: annual grassland, irrigated agriculture, oak woodland, open water, orchard, pasture, rice, riparian vegetation, and urban landscaping. The review of the Project area also described the observed wildlife, evaluated the potential for special-status species, and described United States Fish and Wildlife Service (USFWS) designated critical habitat units, other sensitive habitats, protected areas, conservation easements, and wildlife movement corridors. Additional detail is provided in **Attachment C** (**Reference 13**).

5.6.1. Wildlife Observed

Wildlife observed during the February 12, 2019 site visit included numerous bird species such as acorn woodpecker (*Melanerpes formicivorus*), American crow (*Corvos brachyrhynchos*), yellow-billed magpie (*Pica nutalli*), European starling (*Sturnus vulgaris*), coot (*Fulica* sp.), great egret (*Ardea alba*), mourning dove (*Zenaida macroura*), California scrub jay (*Aphelocoma californica*), finches (Fringillidae), killdeer (*Charadrius vociferus*), mallard duck (*Anas platyrhynchos*), great blue heron (*Ardea herodias*) (and other various shore birds). Also included in this group were raptors such as red-tailed hawk (*Buteo jamaicensis*), turkey vulture (*Cathartes aura*), red-shouldered hawk (*Buteo lineatus*), white-tailed kite (*Elanus leucurus*), and American kestrel (*Falco zoniventris*). Dozens of Swainson's hawks (*Buteo swainsoni*) were observed along the riparian corridor adjacent to the Natomas Cross Canal along the southern edge of the Project area. A northern harrier (*Circus hudsonius*) was observed foraging from an irrigated agriculture field in the southwest portion of the Project area. While no other special status bird species were observed during the survey, they still could potentially be found in the Project area and are discussed in more detail below. Additionally, western gray squirrels (Sciurus griseus) were observed throughout the Project area, and numerous domesticated animals were observed in pastures and residential areas including sheep, cattle, horses, and chickens.

5.6.2. Special-Status Species

Database query results returned a large number of special-status species with a potential to occur in the vicinity of the Project area. Through review of these results, many species were determined to not have the potential to occur in the Project area due to absence of suitable habitat or because the Project area is located outside of known species ranges. Additional detail on the species is provided in Attachment C (Reference 13).

5.6.3. Critical Habitat

Critical habitat units for Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), and green sturgeon (*Acipenser medirostris*) occur within and immediately adjacent to the Project area. Additional detail and a map on the habitat units are provided in Attachment C (Reference 13).

5.6.4. Sensitive Habitats and Aquatic Resources

Several aquatic resources and vegetation communities in the Project area would be considered sensitive communities due to their unique hydrophytic vegetation and ability to support special-status species. These areas include the following communities: riparian, agricultural ditches, open water, and other potential aquatic resources. A formal delineation of aquatic resources would be required prior to any Project work in order to determine the level of impact on sensitive communities.

5.6.5. Protected Areas, Conservation Easements, and Wildlife Movement Corridors

There are no protected areas or easements within the Project area. However, there are numerous protected areas and easements on the lands surrounding the Project area. There is a total of 17 protected areas that are located within two miles of the Project area and eight land parcels with conservation easements within two miles of the Project area.

The Sutter Bypass is located immediately adjacent to the southwestern half of the Project area, on the west side of the Feather River Levee. Just downstream of the Bear River and Feather River confluence, the bypass turns to the northwest and away from the Project area. The bypass is part of a large engineered floodway that runs adjacent to the Sacramento River from south of the Sacramento-San Joaquin Delta to north of the Sutter Buttes. The bypass acts as a wildlife movement corridor for numerous terrestrial and aquatic species.

5.7. Cultural Resources

A preliminary review of potential cultural resources constraints was conducted through records search requests from relevant databases and a field reconnaissance survey.

Archaeological and built-environment sensitivity within the Project area and a 0.25-mile buffer are variable and contingent on the type of resource (prehistoric vs. historical) and geography (proximity to the river or one of the historical ranch complexes). For most of the Project area, near-surface archaeological sites have likely been disturbed, and possibly destroyed, by decades of agricultural practices and levee construction. However, there may be remnants of these sites. Most of the Project area has not been previously surveyed for archaeological sites and, accordingly, there is a low-to-moderate potential for near-surface unrecorded prehistoric or Native American sites within the unsurveyed portions of the Project area. There is also a moderate-to-high potential for buried archaeological sites throughout the entire Project area because of the existence of a floodplain located along the Sacramento and Feather Rivers where it is common to find archaeological sites that have been buried by alluvial sediment. Sensitivity for historic-era archaeological sites and historical built-environment resources ranges from low to high throughout the Project area and is largely contingent on proximity to historical roadways, residences, and ranches.

Additional detail on the cultural resources is provided in Attachment C (Reference 13).

6. GEOTECHNICAL REMEDIATION ANALYSIS

The existing condition analyses of the levees protecting the Nicolaus study area indicated various deficiencies for a 100-year flood stage. Feasibility-level remedial measures were developed for the deficient segments. The remedial measures include at least two remediation alternatives for each deficient segment. Preferred remedial measures may be considered based on land acquisition, stakeholder interests, environmental or cultural resource conflicts, cost, or other pertinent limitations. The analysis of levee segments and the determination of the remediation alternatives are discussed in more detail in Attachment A (Reference 1). In general, the remediation alternatives that were considered consisted of cutoff walls, drained stability berms, drained seepage berms, combined drained stability and seepage berms, landside ditch fill, landside slope flattening, and waterside rock slope protection.

6.1. Underseepage Analysis

Underseepage analysis consists of a finite elements steady state seepage analysis to evaluate the exit gradient at and near the landside toe of the levee. The steady state condition represents the circumstance when the water remains at or near flood stage levels long enough to fully saturate the embankment soil. During this time, the hydraulic load on the levee builds up seepage pressure in the confined coarse-grained sublayers underneath the fine-grained blanket layers. Eventually, water can be pushed through discontinuities within the blanket layer and can carry soil particles with the water as it travels to the surface. This could potentially form seeps that lead to internal erosion and sand boils. Over a period of time, this could contribute to the failure of the levee foundation as increasing amounts of soil are internally eroded away.

In the Nicolaus study area, the Feather River Left Bank Levee Segment 247, Reach A and D and Natomas Cross Canal Right Bank Levee Segment 284, Reach A do not meet criteria for underseepage. The remedial alternatives considered include cutoff walls, combined drained stability and seepage berms, drained stability berms, and landside slope flattening.

6.2. Through Seepage Analysis

Through seepage occurs when water exits through the landside slope above the toe. This could cause surficial erosion at the landside slope as well as internal erosion as soil particles are carried by the seeping water. The levee embankment materials generally govern the potential for through seepage. Levees constructed of easily-erodible materials (e.g.: silt, sandy silt, and sand, etc.) are most susceptible to through seepage erosion.

In the Nicolaus study area, all of the levee segments on the Feather River Left Bank Levee and the Natomas Cross Canal Right Bank Levee are susceptible to through seepage. The remedial measures for through seepage involve either lowering the phreatic surface to a point at or below the levee landside toe or constructing a filtered exit in order to reduce the potential for internal erosion. The remedial alternatives considered for through seepage include cutoff walls, combined drained stability and seepage berms, drained stability berms, and landside slope flattening.

6.3. Landside Slope Stability

The landside slope stability analysis consisted of the performance of a limit-equilibrium analysis to evaluate the factor of safety of the landside slope under steady state seepage conditions. The pore water pressure from the steady state seepage condition is used to determine the phreatic surface for the stability analysis. The ratio of resisting forces to the driving forces for failure of the slope is obtained as the factor of safety from the limit equilibrium analysis. With a higher flood stage, a larger proportion of the levee embankment is saturated, and that results in lower material strength and an increasing likelihood of failure.

In the Nicolaus study area, all the levee segments on the Feather River Left Bank Levee and the Natomas Cross Canal Right Bank Levee are susceptible to landside slope stability failure. The remedial measures for landside slope stability either lowers the phreatic surface to reduce the saturated portion of embankment (which minimizes the loss in strength) or uses berms to provide a physical buttress to prevent the slope instability. Additionally, materials on the levee embankment and foundation can be modified or replaced resulting in materials with higher strength that can accommodate the loading demand placed on the segment. The remedial alternatives considered include cutoff wall, combined drained stability and seepage berm, drained stability berm, and flattening landside slope.

6.4. Rapid Drawdown Waterside Slope Stability

A rapid drawdown slope stability analysis is used to analyze the stability of the waterside slope when high water conditions fully saturate the levee and then recede quickly before the levee embankment soil can drain. This condition represents a critical case for waterside slope failure. The limit equilibrium method applied in stages is used to analyze the levee for rapid drawdown failure. Under this method, the lower of the drained and undrained strengths of the non-free draining material is used.

In the Nicolaus study area, the Natomas Cross Canal Right Bank Levee is susceptible to waterside rapid drawdown slope stability failure. The remedial measure for rapid drawdown slope stability involves armoring the waterside slope to provide adequate protection from the rapidly receding water stage. Rock slope revetment using riprap is generally used as the remedial measure because it provides free drainage for the saturated soil and protects the slope from instability caused by rapid drawdown. The addition of a waterside toe berm comprised of riprap may also be used to mitigate a deeper failure surface at the waterside slope.

6.5. Results Summary

A summary of the feasibility-level remedial alternatives for the levee segments with respect to the 100-year WSE is shown below in Table 5. Each levee reach includes a minimum of two remedial alternatives that were identified in the geotechnical evaluation.

Table 5: Remediation Alternatives

Segment	Reach	Station	Levee Miles	Remediation Alternative 1	Remediation Alternative 2
247	A	FR 700+89 to FR 640+20	LM 0.0 to 1.2	Cutoff Wall – 60 feet below 1/2 levee degrade; 65 feet below 1/3 levee degrade	Combined Drained Stability and Seepage Berm - 300 feet wide
247	B	FR 640+20 to FR 580+40	LM 1.2 to 2.3	Drained Stability Berm - 15 feet wide and backfill landside depression with locally available materials	Cutoff Wall – 55 feet below 1/2 levee degrade; 60 feet below 1/3 levee degrade
247	C	FR 580+40 to FR 531+55	LM 2.3 to 3.3	Waterside Toe Berm - 30 feet wide and 10 feet high; Landside - Drained Stability Berm - 15 feet wide and backfill landside and waterside depression with locally available materials	Cutoff Wall – 18 feet below 1/2 levee degrade; 22 feet below 1/3 levee degrade; Waterside Toe Berm - 30 feet wide and 10 feet high

Segment	Reach	Station	Levee Miles	Remediation Alternative 1	Remediation Alternative 2
247	D	FR 531+55 to FR 0+00	LM 3.3 to 13.3	Waterside Slope - Rock Slope Protection; Landside - Combined Drained Stability and Seepage Berm - 80 feet wide	Waterside Slope - Rock Slope Protection; Cutoff Wall - 80 feet
284	A	CC 0+00 to CC 284+80	LM 0.0 to 5.4	Cutoff Wall – 71 feet below the 1/2 levee degrade; 76 feet below the 1/3 levee degrade (similar remediation as the levee on left bank of Natomas Cross Canal)	Drained Stability Berm - 20 feet wide and 10 feet high and backfill landside depression with locally available materials; Or, Flatten Landside Slope to 1V:4H and backfill the landside depression with locally available materials

7. PROJECT ALTERNATIVES

7.1. Study Goals, Objectives, Measures/Management Actions

The primary purpose of the Feasibility Study is to identify all of deficiencies within the levee system and to recommend a preferred project to rehabilitate the levees. It is recognized that implementation of all measures may be difficult for small communities with limited resources and, therefore, measures can be implemented independently to reduce flood risk and consequences of flooding in a prioritized manner. Objectives of the study also included minimizing impacts to adjacent prime agriculture and preserving the general rural nature of the community. Other objectives include being consistent with the goals and objectives of the CVFPP and FRRFMP.

A summary of the measures/management actions to fulfill this purpose can be found in the sections below.

7.2. Alternatives Screened Out of the Feasibility Study

In the preliminary stages of this study, a preliminary array of alternatives was developed; and as the study progressed, alternatives were screened out when they were found to be infeasible. These screened alternatives did not require detailed analysis, because it was clear that they would not meet Project objectives by simple inspection. Below is a brief description of each alternative that was considered as part of the preliminary array, but was screened out prior to detailed analysis.

7.2.1. No Action Alternative

As the name implies, this alternative proposes that no action be taken. This alternative was screened out because it does not increase the flood protection of the study area and would not be satisfactory to stakeholders.

7.2.2. Ring Levee

This alternative would propose building ring levees around areas deemed important within the study area, such as where urbanization has occurred within the community. This alternative was screened out as infeasible because the rural nature of the area is characterized by dispersed buildings and residences that cannot be readily encircled by a levee.

7.2.3. Floodwall

This alternative would propose a floodwall along the study area in lieu of levee raising. This was found to be infeasible as floodwalls are significantly more expensive than levee raising on a per-lineal-foot basis, and would increase maintenance costs due to the resulting restricted access. Furthermore, a floodwall would not mitigate for seepage and stability issues that are prevalent throughout the study area.

7.2.4. Setback Levee

This alternative would propose building setback levees in lieu of remediating the existing levees. While setback levees can provide flood benefits by increasing the conveyance capacity of the channels while also providing environmental benefits by returning land to the floodplain promoting regular inundation of riparian habitat, the alignment of the study area, unfortunately does not lend itself to the construction of setback levees. Due to the geographic location of the basin near the confluence of the Feather River, Sacramento River, Sutter Bypass and Fremont Weir creating significant backwater conditions in the System, there are no appreciable hydraulic benefits to setting these levees back. Furthermore, similar to the previously discussed floodwall alternative, this alternative is costly in comparison to remediation of the existing levee.

7.2.5. Purchase Flood Easements

This alternative would propose to purchase flood easements covering much of the land within the study area, with the intent of allowing flooding to occur on a regular basis. This alternative was deemed infeasible as the study area is made up of valuable farmland and would be very costly. Further, this alternative would not be satisfactory to the landowners and other stakeholders within the study area.

7.3. Final Structural Alternatives

Using the information in Section 4, as well as the results of the analyses described in Sections 5 and 6, deficiencies were identified for the levee systems within the study area. These include deficiencies caused by through seepage, underseepage, slope stability, embankment geometry, and erosion. The team analyzed these deficiencies to develop management actions for their mitigation.

The following sections contain a description of the final structural alternatives that were considered for each reach within the study area.

7.3.1. Feather River Reach A (Station 640+20 to Station 700+89, 6,069 feet)

7.3.1.1. Combination Seepage/Stability Berm

A 300-foot-wide drained combination seepage/stability berm is recommended to meet the criteria for through seepage and underseepage mitigation. The combination berm (see **Figure 4**) would be constructed along the proposed landside toe following the geometry remediation required to meet current requirements (see Figures 2 and **Figure 3**). The construction of the landside combination berm will require the acquisition of additional rights-of-way for the proposed mitigation plus additional land at the landside toe to provide a 20-foot-wide operation and maintenance corridor (see **Figure 9**). It should be noted that the current CVFPB Title 23 Standards only require a 15-foot-wide maintenance corridor, but a 20-foot-wide corridor was analyzed in this study to take into account proposed changes to the standards as part of Title 23 Tier II update.

7.3.1.2. Seepage Cutoff Wall

A soil-bentonite seepage cutoff wall constructed to a depth of 65 feet from the one-third levee height elevation is recommended in order to meet the criteria for through seepage mitigation. Construction of a seepage cutoff wall (see **Figure 5**) will incorporate a one-third levee degrade. After cutoff wall installation, the levee will be reconstructed to address geometry deficiencies in order to meet current requirements (see Figure 2 and Figure 3). The geometry remediation will require the acquisition of additional rights-of-way to accommodate the new levee footprint plus additional land at the landside toe to provide a 20-foot-wide operation and maintenance corridor (see Figure 9).

7.3.2. Feather River Reach B (Station 580+40 to Station 640+20, 5,980 feet)

7.3.2.1. Drained Stability Berm

A 15-foot-wide drained stability berm is recommended to meet the criteria for through seepage mitigation. It is also recommended that any depressions along the landside toe of the levee be backfilled with locally available material. The stability berm (see **Figure 6**) would be constructed along the proposed landside toe following the geometry remediation required to meet current requirements (see Figures 2 and 3). Construction of the landside stability berm will require the acquisition of additional rights-of-way for the proposed mitigation plus additional land at the landside toe to provide a 20-foot-wide operation and maintenance corridor (see Figure 9)..

7.3.2.2. Seepage Cutoff Wall

A soil-bentonite seepage cutoff wall constructed to a depth of 60 feet from the one-third levee height elevation is recommended in order to meet the criteria for through seepage mitigation. Construction of a seepage cutoff wall (see Figure 5) will incorporate a one-third levee degrade. After installation of the cutoff wall, the levee will be reconstructed to address geometry deficiencies in order to meet current requirements (see Figures 2 and 3). The geometry remediation will require the acquisition of additional rights-of-way for the new levee footprint plus additional land at the landside toe to provide a 20-foot-wide operation and maintenance corridor (see Figure 9).

7.3.3. Feather River Reach C (Station 531+55 to Station 580+40, 4,885 feet)

7.3.3.1. Waterside Toe Berm and Landside Drained Stability Berm

A 15-foot-wide drained stability berm is recommended in order to meet the criteria for through seepage mitigation. This will be used in combination with a 30-foot-wide, 10-foot-high waterside toe berm (see **Figure 8**) to help mitigate slope instabilities. It is also recommended that any depressions along either the landside or waterside of the levee be backfilled with locally available material. The stability berm (see Figure 6) would be constructed along the proposed landside toe following the geometry remediation that is required to meet current requirements (see Figures 2 and 3). The construction of the landside stability berm will require the acquisition of additional rights-of-way for the proposed mitigation plus additional land at the landside toe to provide a 20-foot-wide operation and maintenance corridor (see Figure 9).

7.3.3.2. Waterside Toe Berm and Seepage Cutoff Wall

A soil-bentonite seepage cutoff wall constructed to a depth of 22 feet from the one-third levee height elevation is recommended to meet the criteria for through seepage mitigation. This will be used in combination with a 30-foot-wide, 10-foot-high waterside toe berm (see Figure 8) to help mitigate for slope instabilities. Construction of a seepage cutoff wall (see Figure 5) will incorporate a one-third levee degrade. After cutoff wall installation, the levee will be reconstructed to address geometry deficiencies in order to meet current requirements (see Figures 2 and 3). The geometry remediation will require the acquisition of additional rights-of-way to accommodate the new levee footprint plus additional land at the landside toe to provide a 20-foot-wide operation and maintenance corridor (see Figure 9).

7.3.4. Feather River Reach D (Station 0+00 to Station 531+55, 53,155 feet)

It should be noted that, from Station 0+00 to approximately Station 429+00, the Garden Highway is situated on the existing levee crown. To reconstruct the levee through this reach, the width of the levee crown road would be subject to Sutter County roadway standards, which would require a 16-foot-wide travelled way and a 3-foot shoulder width representative of a rural collector road. The resulting 38-foot roadway width is significantly wider than the 20-foot crown required by SRFCP standards. This section of levee crown road would also require asphalt-concrete (AC) pavement, as opposed to a normal aggregate base (AB) levee crown road. Both of these items result in significant costs associated with the remediation alternatives.

In addition, from Station 480+00 to Station 531+55, the Garden Highway is located directly adjacent to the existing levee toe and would require replacement if a proposed remediation measure encroached into the roadway area. For the combination seepage/stability berm alternative, reconstruction of the roadway would be required, but not the cutoff wall alternative because it was assumed that the minor geometry remediation associated with cutoff wall installation could be accomplished without encroaching on the Garden Highway. Any required removal and replacement of adjacent roadway sections were assumed to be performed per Sutter County standards as referenced above.

Finally, it should also be noted that rock slope protection (see **Figure 7**) has been recommended as an erosion protection measure for this reach, but it is not included as a reach-long mitigation measure due to the associated costs. It is assumed that portions of the levee sections that might suffer erosion damage during a high-water event would be remediated following the event under the USACE PL84-99 program or as part of regular O&M activities performed by RD 1001.

7.3.4.1. Combination Seepage/Stability Berm

An 80-foot-wide drained combination seepage/stability berm is recommended to meet the criteria for through seepage and underseepage mitigation. The combination berm (see Figure 4) would be constructed along the proposed landside toe of the levee following the geometry remediation required to meet current requirements (see Figures 2 and 3). Construction of the landside combination berm will require the acquisition of additional rights-of-way for the proposed mitigation, plus additional land at the landside toe to provide a 20-foot-wide operation and maintenance corridor (see Figure 9).

7.3.4.2. Seepage Cutoff Wall

A soil-bentonite seepage cutoff wall constructed to a depth of 80 feet from the one-third levee height elevation is recommended to meet the criteria for through seepage and underseepage mitigation. Construction of a seepage cutoff wall (see Figure 5) will incorporate a one-third levee degrade. After the cutoff wall is installed, the levee will be reconstructed to address geometry deficiencies to meet current requirements (see Figures 2 and 3). The geometry remediation will require the acquisition of additional rights-of-way as well as additional land at the landside toe to provide a 20-foot-wide operation and maintenance corridor (see Figure 9). This width is the minimum as required by CVFPB Title 23 Standards.

7.3.5. Cross Canal Reach A (Station 0+00 to Station 284+80, 28,480 feet)

It should be noted that the RD 1001 Main Pump Station is located within this reach. As the main pump station for the entirety of RD 1001, this facility has a capacity of approximately 640 cfs and is vital to the drainage of the district. The existing station was built in the early 1900s, was incorporated in the SRFCP design as a required drainage feature for the performance of the levee system, but is showing signs of its age. Due to the energy load needed to start the outdated pump motors, they cannot be started from generators; therefore, any time there is a power outage to the adjacent electrical substation, the entire pump station is inoperable. This leaves the district in a dangerous position, as the chances for power outages are higher during flood events, which is the time that the station is most severely needed.

It should also be noted that there is currently a project in development that would propose an auxiliary pump station for the district (with an approximate capacity of 125 cfs), to be located further north along the Natomas Cross Canal. This auxiliary station would lessen the burden on the existing pump station and provide more resiliency to the district's drainage system.

For the purposes of this study, it was assumed that the main pump station would need to be replaced as part of the levee remediation measures. This cost is reflected in the estimate for each alternative.

7.3.5.1. Drained Stability Berm

A 20-foot-wide, 10-foot-high drained stability berm is recommended to meet the criteria for through seepage and underseepage mitigation. It is also recommended that any depressions along the landside of the levee be backfilled with locally available material. The stability berm (see Figure 6) would be constructed along the proposed landside toe following the geometry remediation required to meet current requirements (see Figures 2 and 3). The construction of the landside stability berm will require the acquisition of additional rights-of-way for the proposed mitigation plus additional land at the landside toe to provide a 20-foot-wide operation and maintenance corridor (see Figure 9).

7.3.5.2. Seepage Cutoff Wall

A soil-bentonite seepage cutoff wall constructed to a depth of 76 feet from the one-third levee height elevation is recommended to meet the criteria for through seepage mitigation. Construction of a seepage cutoff wall (see Figure 5) will incorporate a one-third levee degrade. After cutoff wall installation, the levee will be reconstructed to address geometry deficiencies to meet current requirements (see Figures 2 and 3). The geometry remediation will require the acquisition of additional rights-of-way plus additional land at the landside toe to provide a 20-foot-wide operation and maintenance corridor (see Figure 9).

7.4. Non-Structural Measures

A discussion on non-structural measures can be found in Section 8.5. It should be noted that these non-structural measures would not impact the structural alternatives presented above as they can be implemented independently to address residual risk.

7.5. Multi-Benefit Concepts

A discussion on the multi-benefit concepts that were analyzed as part of this study can be found in Section 8.6.

8. EVALUATION OF FINAL STRUCTURAL ALTERNATIVES

Several factors were incorporated into the evaluation effort of the final structural alternatives in order to identify the preferred alternative. A summary of each factor can be found in the sections below.

8.1. Environmental Constraints Analysis

The purpose of including an environmental constraints analysis (Attachment C) (Reference 13) within the feasibility study is to assist with the identification of key environmental issues that should be given due consideration during the planning and design phase of a project.

The analysis of constraints is intended to facilitate the project planning process, assist with the evaluation of various alternatives, define a recommended project, and assess potential permitting and mitigation requirements. Specifically, the environmental constraints analysis: 1) identifies potential constraints based on the anticipated presence or absence of environmental resources; 2) describes the consistency and/or compliance of each alternative with existing policies; and 3) identifies potential environmental mitigation costs for each alternative site. This analysis also provides basic permit information.

The California Environmental Quality Act (CEQA) Guidelines Section 15262 states that a project involving only feasibility or planning studies for possible future actions which an agency, board, or commission has not approved, adopted, or funded does not require the preparation of an Environmental Impact Report (EIR) or a Negative Declaration. Section 15262 of the CEQA Guidelines does not apply to the adoption of a plan that will have a legally binding effect on later activities. Therefore, a Notice of Exemption under CEQA was adopted for the Feasibility Study.

8.2. Project Costs

To estimate preliminary project costs, unit prices were developed and material quantities were calculated for all project features. Estimated quantities for alternatives in each reach were developed using specific cross sections taken at locations where the existing levee geometry was representative of the reach. The representative cross section was applied to the whole segment in order to estimate quantities. Cross sections that were used to estimate quantities for the alternatives considered are included in Attachment I and **Attachment J**. Unit prices for typical levee construction (e.g.: site clearing, borrow excavation and hauling, levee embankment fill, and rock slope protection) were determined based upon recent contractor bid summaries for similar levee improvement projects in Northern California. Where recent bid tabulations were not available, cost-determination publications, such as RS Means' *Heavy Construction Cost Data*, were used to develop costs.

For the purposes of this Study, it was assumed that levee degrade material cannot be reused, and would need to be hauled off-site and disposed of. Therefore, levee embankment material to be used in the regrading of existing levees to address freeboard and geometry deficiencies, as well as for seepage berm construction would need to be sourced from a borrow site. Based on prior study-level investigation of borrow sources in the project area, an assumption was made that this borrow material could be sourced from a site within 15 miles of the project.

Further, embankment material shrinkage is assumed to be 20 percent, and borrow acreages were estimated assuming a borrow depth of five feet.

Included in each cost estimate line item is a contingency amount of 30 percent. Where costs are known with greater certainty, a lower contingency was used. Planning, Engineering, and Design were included at eight percent, and Construction Management at six percent.

Cost estimates reflect 2019 cost levels escalated to 2022 costs at a rate of 3.3 percent per year.

This escalation rate was determined from a review of the Engineering News Record (ENR) Historical Cost Index for the years of 2015 through 2018. Unit costs used for this Study and detailed cost estimates for each levee system are included in **Attachment K**.

8.3. Rights-of-Way

To accommodate the expanded footprint that may be required due to levee geometry corrections, toe berms, stability berms, seepage berms, and O&M corridors, additional permanent Rights-of-Way (ROW) will need to be acquired. In addition, temporary construction easements (TCE) may be needed in some areas. Figure 9 shows typical land acquisition requirements for various toe/stability/seepage berms, seepage cutoff fill and cutoff wall remediation. It should be noted that the current CVFPB Title 23 Standards only require a 15-foot-wide maintenance corridor, but a 20-foot-wide corridor was analyzed in this study in order to take into account the proposed changes to the standards as part of the Title 23 Tier II update. Acquisition will include land required for remediation, a 20-foot-wide operation and maintenance easement along the landside toe to be consistent with SRFCP requirements, and a 10-foot-wide additional temporary easement that provides a 30-foot construction corridor when combined with the operation and maintenance easement.

Due to the lack of available easement data, it was assumed that no easements currently exist outside the levee prism within the cost determinations. The costs associated with permanent and temporary ROW are preliminary and will need to be further reviewed at the time of project design or implementation.

8.4. Alternative Costs Analysis

8.4.1. Feather River East Levee

Costs for remedial alternatives for the Feather River East Levee can be found in **Table 6** below. Each remedial alternative includes remediation to address geometry deficiencies.

Table 6: Feather River East Levee Alternative Costs

NULE Seg.	Project Reach	Project Station Range	Remedial Alternative	Cost
247	A	FR 640+20 - 700+89	Combination Seepage/Stability Berm w/ Rock Slope Protection	$39,945,500
			Seepage Cutoff wall w/ Rock Slope Protection*	**$11,331,900**
247	B	FR 580+40 - 640+20	Drained Stability Berm	$13,137,400
			Seepage Cutoff Wall*	**$14,284,600**
247	C	FR 531+55 - 580+40	Drained Stability Berm w/ Waterside Toe Berm	$33,807,400
			Seepage Cutoff Wall w/ Waterside Toe Berm*	**$30,870,400**
247	D	FR 0+00 - 531+55	Combination Seepage/Stability Berm	$224,986,800
			Seepage Cutoff Wall*	**$171,836,000**
			Total Cost of Preferred Alternative:	**$228,322,900**

*Preferred Alternative for single segment

8.4.2. Natomas Cross Canal North Levee

Costs for remedial alternatives for the Natomas Cross Canal North Levee can be found in Table 7 below. Each remedial alternative includes remediation to address geometry deficiencies.

Table 7: Natomas Cross Canal North Levee Alternative Costs

NULE Seg.	Project Reach	Project Station Range	Remedial Alternative	Cost
284	A	NCC 0+00 - 284+80	**Drained Stability Berm***	**$153,971,800**
			Seepage Cutoff Wall	$171,733,700
			Total Cost of Preferred Alternative:	**$153,971,800**

*Preferred Alternative for single segment

8.5. Non-Structural Recommendations

Residual risk is defined as the product of: 1) the chance of damage or other adverse consequence; and 2) the impact or damage resulting from the adverse consequence after flood management actions have been taken. Therefore, even after implementing the recommended alternative, Nicolaus would still face residual risk from flooding. Although it is not possible to completely eliminate residual risk, it can be reduced with the implementation of non-structural measures that improve flood system performance for existing facilities and/or reduce the exposure, vulnerability, and consequences of flooding by adapting to the natural floodplain or inherent features of the floodplain.

For this study, several non-structural measures were evaluated for future consideration by Nicolaus. The measures are presented in the order of their potential feasibility and benefit to the community:

1. Flood Emergency Evacuation Plan
2. Flood Evacuation Warning System
3. Emergency Planning
4. Levee Relief Cuts
5. Voluntary Structure Elevation & Flood Proofing
6. Changes to National Flood Insurance Program (NFIP)
7. Agricultural Conservation Easements

The results of the non-structural measures evaluation are summarized in this section. A more detailed overview of the non-structural measure evaluation is presented in **Attachment M** (**Reference 14**).

8.5.1. Flood Emergency Evacuation Plan

Flood emergency evacuation plans can help a community address residual risk by reducing the time required to initiate and execute a community evacuation when necessary. The Sutter County Emergency Operations Plan (EOP) **(Reference 15**) was updated in 2015 and provides a detailed flood emergency evacuation plan for Sutter County. In the event of an emergency, this plan would be implemented by the County Administrative Officer, the Sheriff, the County Fire Chief or the Incident Commander as appropriate. Many factors need to be considered during evacuations such as the magnitude of the hazard, its intensity, and its anticipated duration. These factors are essential for determining the scope and timeframe for any evacuation that is considered necessary in response to an emergency.

According to the EOP, Sutter County has the responsibility for monitoring hazardous situations as they develop and then determining the areas that are most likely to be impacted by the event. Sutter County may issue one of two types of evacuations in response to an emergency: advisory evacuation and mandatory evacuation. The State of California and Sutter County are to coordinate together in order to: 1) ensure the appropriate deployment of resources; 2) monitor and communicate evacuee shelter capacities; and 3) direct modifications to evacuation routes as necessary.

8.5.2. Flood Evacuation Warning System

The flood evacuation warning system for the community, which can help reduce residual risk by increasing the flood warning time associated with a forecasted flood event, is also detailed within the Sutter County EOP. There are three types of flooding that may occur in the Sutter County Operational Area. The first type is localized flooding due to severe rainfall and flash flooding. The second is slow-rise flooding due to rising river levels in response to continued and heavy precipitation. The last type is that flooding corresponds to a catastrophic dam failure at locations that include Oroville Dam, New Bullards Bar Dam, or Camp Far West Dam.

The EOP presents information regarding public notifications including the following: 1) preparations of evacuation orders; 2) outlines of the responsible agencies and their respective duties; 3) information on slow-rise flood threats from river stages on the Feather River; and 4) outlines of the dam and/or levee failure planning and response actions.

8.5.3. Emergency Planning

Emergency planning can help a community address residual risk by increasing the ability to respond to floods by pre-identifying actions that facilitate flood response and emergency actions. In 2013, Sutter County developed an Updated Local Hazard Mitigation Plan (LHMP) (**Reference 16**) to make the County and its residents less vulnerable to future hazards. The purpose of the LHMP Update is to reduce or eliminate long-term risk to people and property from hazards including flooding. According to the Sutter County LHMP Update, one of the mitigation actions for RD 1001 includes a Flood Emergency Response Project. This Project includes the development of a hazard response training video, the coordination of training, the establishment of an evacuation location, and the purchase of emergency equipment and supplies.

In 2018, Sutter County received a Statewide Flood Emergency Response grant from DWR to update its countywide Emergency Operations Plan and develop emergency response plans for various communities, including Nicolaus. The Sutter County Board of Supervisors approved a resolution to begin the update process during the summer of 2019.

8.5.4. Levee Relief Cuts

Attachment B presents a hydraulic analysis to evaluate the stage reduction benefits associated with proposed relief cuts that could be implemented to reduce flooding associated with a breach on the Feather River Levees near SR 99. Levee relief cuts are pre-identified areas where a levee section can be lowered or removed during a flood event to return floodwaters to the main river channel. Relief cuts can address residual risk by limiting the total depth of flooding that occurs in areas upstream of the cut and by reducing the overall duration of the flood event. The proposed site of the relief cut is at the Feather River left (east) bank near Verona. Three potential relief cuts were explored in the hydraulic analysis with varying widths. The three different widths of the potential relief cuts are 100 feet, 500 feet, and 1,000 feet, respectively. The final crest elevation for all of the relief cuts is 40 feet utilizing the North American Vertical Datum of 1988 (NAVD 88). The approximate time needed to implement an effective relief cut after a breach occurs is 24 hours for all of the relief cut alternatives. The results of the hydraulic analysis indicate that the maximum flood stage reduction resulting from a relief cut is 0.1 foot to 0.6 foot as a result of breach inflows far exceeding the relief cut outflows. However, relief cuts could provide additional benefits with lower river stages and would allow flood waters to be more quickly evacuated form the basin once the breach is closed. Therefore, it is recommended that relief cuts be considered as part of future emergency operations planning.

8.5.5. Voluntary Structure Elevation & Flood-Proofing

The 2012 Central Valley Flood Protection Plan (CVFPP) (**Reference 17**), the 2017 Update of the CVFPP (**Reference 18**), and the Feather River Regional Flood Management Plan (RFMP) (Reference 7) assert DWR's interest in elevation and flood-proofing of structures in small communities. Structure elevation and flood-proofing can address residual risk by reducing flood damages to existing structures. A GIS analysis was performed to assess structures that are potential candidates for flood-proofing by comparing the 2012 CVFPP structure inventory data points to a composite of maximum WSEs from the hydraulic analysis. Of the 202 structures in Nicolaus and the surrounding areas (including East Nicolaus and Trowbridge), only 33 of them would experience less than three feet of flooding and, thus, would be potential candidates for dry flood-proofing. Fifty-nine structures would have flood depths between three and eight feet and, therefore, would be potential candidates for elevating. The remaining 110 structures with flood depths of greater than eight feet would be candidates for acquisition or relocation.

More outreach and education are required to determine if a structure elevation and flood-proofing program would be viable in Sutter County. A program such as this would require public acceptance and willing landowners. In addition, there may be concerns that structure elevations and flood-proofing would only benefit certain landowners and may divert funds from needed levee improvements that would benefit more of the basin. Therefore, a voluntary program may be considered if the County is able to secure funding.

8.5.6. Changes to Nation Flood Insurance Program (NFIP)

Changes to the NFIP have been proposed by previous studies. Based on the 2012 CVFPP (Reference 17), the 2017 Update of the CVFPP (Reference 18), and the RFMP (Reference 7); some proposed changes to the NFIP include:

1. Revising FEMA Operating Guidance 12-13 to designate areas behind a certified levee reach as Zone X (Shaded) if the certified reach of levee is part of a larger levee system and is providing protection from the Base Flood. Currently, FEMA's Operating Guidance 12-13 does not allow accreditation of a reach of levee unless the entire levee system can be certified and accredited, and therefore Zone D is used.
2. Setting insurance rates for structures protected by non-accredited levees by affording some credit for the presence of the existing levee, even if it is also not accredited. The current flood insurance mapping standards treat a non-accredited levee as non-existent.

In order for Option 1 to be feasible, the levees required for identifying a Zone X (Shaded) would need to be evaluated and certified by an engineer and accredited by FEMA.

In order for Option 2 to be feasible, a change to Code of Federal Regulations (CFR) 65.10 may be required. In the case of Nicolaus, even after changes to the NFIP, additional hydraulic analyses and levee evaluations/improvements would be needed in order to determine the level of risk.

FEMA recently made changes to the NFIP that apply to new businesses and renewals, effective April 1, 2019. These changes include premium increases, changes to primary residence determination, introduction of a Severe Repetitive Loss (SRL) Premium, and clear communication of these changes to policy holders. To date, DWR has not developed a program for funding any changes to the NFIP standards. Without sufficient funding, it is highly unlikely that changes to the NFIP would be a feasible non-structural alternative for Nicolaus at this time.

8.5.7. Agricultural Conservation Easements

While agricultural easements do not address the current risk, they do address potential future residual risk by preventing development in the agricultural areas of the floodplain. The 2012 CVFPP (Reference 17) and 2017 Update of the CVFPP (Reference 18) both assert DWR's interest in acquiring agricultural conservation easements in order to limit rural development. However, DWR has not yet developed a program for acquiring agricultural easements, and funding has not been made available. If DWR acquires funding and develops a program for agricultural easements, then the community of Nicolaus should evaluate the program as it would apply in the Nicolaus area and make a determination as to whether or not the program would reduce the impacts of the current flood threat on the community.

Participation would be on a voluntary basis with only willing sellers. This could provide the community with more resiliency during major flood events. The Nicolaus area comprises only a small portion of the lands protected by the State Plan of Flood Control, and it is currently mapped by FEMA as a Special Flood Hazard Area. DWR's funding for agricultural conservation easements in the Nicolaus area may be very limited.

8.6. Multi-Benefit Opportunities

A number of opportunities to promote multi-benefit concepts were evaluated as a part of the Feasibility Study. These multi-benefit concepts include the following:

8.6.1. Nelson Slough Improvements

The Feather River Wildlife Area - Nelson Slough Unit is located on the right bank of the Feather River immediately upstream of the Sutter Bypass and is owned and managed by CDFW. The unit occupies a terrace that is from 500 to 3,800 feet wide between the levee and the low-flow channel along a 3.5-mile reach of the river. State Route 99 bisects the unit via a bridge and causeway. A debris weir is located where the Feather River empties into the Sutter Bypass. The weir was originally constructed to keep Feather River sediment from being deposited in the Sutter Bypass; however, the functionality of the weir has been reduced by the accumulation of approximately 15 feet of sediment on the upstream side. In addition, the weir may be adversely affecting the hydraulics and sediment deposition dynamics of the Feather River that could threaten the integrity of the levee on the opposite bank by directing the flow of the river into the right bank during high flows.

The Nelson Slough Unit is currently managed to provide riparian habitat for migratory birds and special-status species, as well as to provide public opportunities for wildlife-oriented recreation. The unit is located on previously farmed terraces formed by thick deposits of sandy hydraulic mining debris between the levee and the river. A number of low areas such as sloughs, side channels, remnant borrow pits, and floodplain scour depressions presently support healthy vegetation and provide excellent rearing habitat for juvenile salmonids. A dense riparian canopy is present at the base of the Feather River levee along the sloughs fed by the Feather River. The extent of these habitats is limited at the unit, and vegetation does not naturally regenerate or become established in most areas because the terraces are too high and dry as well as being dominated by dry grassland habitat.

Ecosystem restoration could be implemented at the Nelson Slough Unit by rehabilitating or removing the weir and lowering the floodway. This would create a variety of flood surface elevations that would support a diversity of habitats (e.g.: riparian woodland and scrub, marsh, native grassland, and frequently inundated floodplain) while also providing additional flood conveyance through the removal of accumulated sediment. Additionally, side channels could be excavated to provide spawning areas for anadromous fish and to limit fish stranding after flood events. Along with side channels, benches and shelves could be graded from the floodplain to reconnect the flows or re-engineer the floodplain. Because the Nelson Slough Unit occurs at the junction of the Feather River with the Sutter Bypass, large volumes of sediment are deposited in the area during flood events. Thus, ongoing maintenance of the area would probably be required to maintain the ecosystem functions and services of any habitats that were created within the Nelson Slough Unit. It should be noted that the Nelson Bend Rock Weir is currently a part of the SPFC and, therefore, would require a substantial effort to remove the facility from the SPFC before it could be modified.

8.6.2. Natomas Cross Canal Stability Berm and Channel Habitat Improvements Project

The Natomas Cross Canal Stability Berm and Channel Habitat Improvements Project would construct a stability berm along 11,000 feet of the NCC Levee in areas that have not been previously repaired, and would plant additional riparian vegetation to act as a natural wind-induced wave defense. The project will also enhance local aquatic and riparian habitat through vegetation management; enhance terracing and grading of the in-channel geometry near the NCC and Sacramento River confluence; and reconfigure downstream portions of the NCC into a more meandering channel. This effort will utilize waterside berm plantings of varietal native understory and native plant species; thus, it will provide a natural wind-wave buffer that will also afford shaded riverine aquatic habitat over an additional 2,400 linear feet along the channel edge. These habitat enhancements and channel modifications will benefit water quality, improve water flow along the channel, and provide more non-natal rearing habitat for juvenile salmon – particularly winter-run salmon and other commercially important fishes (including fall-run Chinook, steelhead, and green sturgeon). In addition, the habitat enhancements and channel modifications will also provide additional flood control conveyance and natural erosion protection features. Fish screens will also be installed on existing intakes to protect the fish within their new environment.

Construction of the proposed in-channel habitat improvements will yield a large enough quantity of borrow to construct up to 11,000 linear feet of stability berm. The NCC Stability Berm & Channel Habitat Improvement Project plans to add riprap, soil, and plants on another 3,600 linear feet of the north NCC Levee between the RD 1001 main pumping plant, the NCC, and the Sacramento River confluence, to correct channel scour that is encroaching into the levee prism. These features will also provide adequate waterside berm to allow riparian habitat between the levee toe and the channel.

These various improvements of the Stability Berm and Habitat Improvement Project will support many of the Central Valley Protection Plan's Conservation Strategy goals. At the same time, these improvements will reduce flood risk, provide significant fish and wildlife habitat benefits, maintain the existing high-water quality within the NCC, and protect local agricultural and forested landscapes. These actions and benefits are also consistent with the State of California's planning priorities.

8.6.3. Sutter Bypass Hook Levee

The Sutter Bypass Hook Levee is a discontinuous training levee located on the right bank of the Feather River at Nelson Slough. Implementing this project would increase river floodway capacity, reduce the high velocities that are associated with flood flows in the channel bend, and reduce scour of the riverbed near the left-bank levee. Hydraulic and sediment transport modeling of the 10-year and 100-year floods conducted by CBEC, Inc. indicates that deep channel scour and very high velocities occur within the constricted channel, between the training hook levee and the east levee of Feather River, and that depositional patterns exist upstream of the artificial constriction. Additional hydraulic and geomorphic analysis is needed to determine the best realignment of the training levee and to evaluate the feasibility of relocating the hook levee westward (farther from the left bank of the Feather River). The hook levee and a rock weir at Nelson Slough were constructed before construction of flood control dams at Oroville and New Bullards Bar, in order to reduce sediment deposits in the Sutter Bypass and prevent avulsion of the Feather River into the bypass. Since then, the bed of the river has continued to incise relative to the elevation of the high floodplain at Nelson Slough. Recent sediment-transport modeling does not indicate a tendency for channel migration at this location, but deep scour potential at the levee toe is a concern.

9. RECOMMENDED PROJECT

A summary of costs for the recommended geotechnical remedial alternatives can be found below in **Table 8**. It should be noted that the recommended remediation measure is not always the least-cost alternative. In these instances, the purpose of selecting the higher cost alternative is to maintain a continuous geotechnical remediation measure among consecutive levee segments (decreasing overall project costs).

The recommended remediation measure for the Feather River East Levee would be a seepage cutoff wall. As part of this effort, the levee embankment would be raised, widened, and/or slope flattened in localized areas where freeboard and/or embankment geometry were found to be deficient.

The recommended remediation measure for the Natomas Cross Canal North Levee would be a drained stability berm. As part of this effort, the levee embankment would be raised, widened, and/or slope flattened in localized areas where freeboard and/or embankment geometry were found to be deficient.

Table 8: Summary of Recommended Project Costs

Levee	NULE Seg	Project Reach	Project Station Range	Remedial Alternative	Cost
Feather River East Levee	247	A	FR 640+20 - 700+89	Seepage Cutoff Wall w/ Rock Slope Protection	$11,331,900
	247	B	FR 580+40 - 640+20	Seepage Cutoff Wall	$14,284,600
	247	C	FR 531+55 - 580+40	Seepage Cutoff Wall w/ Waterside Toe Berm	$30,870,400
	247	D	FR 0+00 - 531+55	Seepage Cutoff Wall	$171,836,000
Natomas Cross Canal South Levee	284	A	NCC 0+00 - 284+80	Drained Stability Berm	$153,971,800
Total Cost of Recommended Project:					**$382,294,700**

Due to the high cost of the preferred structural alternative cited above, the Community should consider implementing non-structural alternatives to reduce the consequences of flooding. From a structural risk reduction standpoint, incremental improvements to the upper portion of the Feather River (Reaches A, B, and C) would provide the greatest incremental flood risk reduction benefit for the Community of Nicolaus and also allow for some potential relief from FEMA rates by reducing the base flood elevation in the upper portion of the basin.

Advancement of the multi-benefit projects discussed in Section 8.6 is also recommended.

9.1. Environmental Documentation and Permitting

The following sections contain summary information on the expected environmental documentation and permitting for the project.

9.1.1. California Environmental Quality Act (CEQA)

Based on the results of the Environmental Constraints Analysis (Attachment C), it is probable that the recommended alternative would result in an impact on the environment and, therefore, CEQA documentation would be required. The CEQA requires that all state and local government agencies consider the environmental consequences of the projects they propose to carry out or over which they have discretionary authority, before implementing or approving those projects. As specified in Section 15367 of the State CEQA Guidelines, the public agency that has the principal responsibility for carrying out or approving a project (as defined above and as described in more detail below) is the lead agency for purposes of CEQA. As specified in Section 15064(a) of the State CEQA Guidelines, if there is substantial evidence (such as the results of an Initial Study (IS)) that a Project, either individually or cumulatively, could have a significant effect on the environment that cannot effectively be mitigated to a less-than-significant level, the lead agency must prepare EIR. The lead agency may prepare a Mitigated Negative Declaration (MND), if in the course of the IS analysis, the agency finds that the Project would have no significant environmental impacts or could have a significant impact on the environment but that implementing specific mitigation measures would reduce any such impacts to a less-than-significant level (State CEQA Guidelines, Section 15064[f]). The level of CEQA documentation that would be required for the proposed Project would be determined during the permitting process.

9.1.2. National Environmental Policy Act (NEPA)

Based on the results of the Environmental Constraints Analysis (Attachment C), it is likely that the Project would require compliance with federal regulations, such as the Clean Water Act, Section 404; National Historic Preservation Act, Section 106; and Endangered Species Act (ESA), Section 7. Because these federal permits and consultations would probably be required, compliance with the NEPA could be triggered. In addition, the levee systems protecting the project area are part of the SPFC and, thus, are identified as state/federal facilities; therefore, any modifications to the levees could also trigger the need for NEPA compliance and for a Rivers and Harbors Act, Section 408 Permit. The level of NEPA documentation that would be required for the proposed Project would be determined during the permitting process.

9.1.3. Permits and Approvals

Several federal, state, and local permits and/or authorizations are anticipated for the proposed Project. Attachment C summarizes the permits and approvals that may be associated with the proposed Project. The regulations and ordinances listed below represent a preliminary assessment of permitting requirements, which would be refined through subsequent Project design and preparation of a detailed Project description.

The proposed alternatives would directly and indirectly affect sensitive natural resources, including waters of the United States (U.S.). All potential waters of the U.S., including wetlands, identified within the Project area, may be regulated by the USACE through Section 404 of the Clean Water Act (CWA) and by the Regional Water Quality Control Board (RWQCB) as waters of the State through Section 401. All ecological systems associated with drainages (i.e.: potential waters of the U.S.), and drainage features with bed and bank topography may also be regulated by Sections 1600-1616 of the California Fish and Game Code. In conjunction with the USACE Section 404 Permit, impacts on wetlands and waters would require a Section 401 Water Quality Certification or Waste Discharge Requirement from RWQCB and CDFW Section 1602 Streambed Alteration Agreement. In addition, the proposed Project has the potential to affect more than 1.0 acre of soil, triggering the requirement of a National Pollutant Discharge Elimination System (NPDES) General Permit from the RWQCB.

Finally, the proposed Project has the potential to adversely affect special-status species. Direct and/or indirect impact on federal- and state-listed species and their habitats would require formal consultation with the USFWS (Biological Opinion/Take Statement for federal-listed species) and CDFW (2081 Incidental Take Permit for State-listed species) to determine the levels of take.

9.2. Project Implementation

9.2.1. Financial Feasibility Constraints

9.2.1.1. Demonstrating Federal Interest

The USACE planning process has a defined approach to determine flood risk reduction benefits. The USACE analysis is based on the value of damageable property and the projected reduction in flood damages once flood risk reduction measures are implemented. Less densely populated areas with agricultural land produce lower benefits than do densely populated areas. This makes demonstrating a federal interest in small communities situated in agricultural regions very difficult.

Securing federal funding for flood risk reduction projects will continue to become more competitive. In the past, funding for authorized projects has relied heavily on prioritizing appropriations based on a project's Benefit to Cost Ratio (BCR). This approach limits federal investments to areas that can achieve a very robust BCR and, generally, these projects are in urban areas where significant flood damage reduction benefits exist. In fiscal year (FY) 2019 budget requests, the current administration sought to limit funding to ongoing flood risk reduction projects with a BCR greater than 2.5 to 1. While the BCRs for projects vary each year, the competition for limited federal funding also increases as authorizations continue to outpace appropriations.

9.2.1.2. Limited Availability of Federal Funds

The USACE has historically been a major financial contributor in the development of flood risk reduction infrastructure in California. It is estimated that the USACE has a backlog of authorized projects with budgets totaling greater than $96 billion. Annual appropriations for construction funding in FY 2018 and FY 2019 were $2.1 billion and $2.2 respectively, or just over two percent of the total backlog of authorized projects. However, some of the backlogged appropriations are related to projects that are unlikely to be constructed, as throughout the nation they are not competitive when compared against other projects.

There are multiple factors contributing to the growth of the USACE's backlog: authorizations have outpaced appropriations, aging infrastructure requires more significant financial investments, and construction-related costs continue to escalate.

In summary, the potential to obtain federal funding for construction of the features identified in this Feasibility Study is considered to be low.

9.2.1.3. Availability of State Funds

Following the passage of the Water Resources Development Act of 1986, non-federal interests were required to share more of the financial and management burdens. These new requirements, coupled with more stringent environmental regulations, resulted in a further reduction of the federal share of spending for flood and water management projects. With the reduction in federal authorizations and the more stringent conditions on State and local financing of flood management projects, the State turned to general obligation (GO) bonds.

In 2006, the State passed water management Bond Propositions 84 and 1E. The Disaster Preparedness and Flood Protection Bond Act of 2006 (Proposition 1E) authorized $4.09 billion in GO bonds to rebuild and repair California's most vulnerable flood control structures. This was done in order to protect homes and prevent loss of life from flood-related disasters, including levee failures, flash floods, and mudslides; it was also done to protect California's drinking water supply system by rebuilding delta levees that are vulnerable to earthquakes and storms. Proposition 84 enhanced these efforts with an additional $800 million for flood projects. Proposition 1 was passed on November 4, 2014, and it included $395 million for flood projects. Proposition 68 was passed on June 5, 2018, and it included another $550 million for flood projects.

Proposition 1E funds have been allocated to conduct Feasibility Study investigations that are consistent with DWR's SCFRRP Guidelines (2016) and support the (2012 and 2017) Central Valley Flood Protection Plan goals of promoting flood risk management actions to reduce flood risk to people and property protected by State Plan of Flood Control facilities. The study objectives include the following: assessing a community's existing flood hazards; evaluating structural, non-structural and multi-benefit projects; and making recommendations to implement a flood risk protection project that integrates other resources' needs, as much as is feasible.

9.2.1.4. Limited Local Funding Sources/Proposition 218 Assessment

Funding local infrastructure and services (including flood and water management projects) became more difficult when voters in California passed Proposition 13 in 1978, Proposition 62 in 1986, and Proposition 218 in 1996. Proposition 13 limited ad valorem taxes on California properties. The proposition limited the amount of tax that could be collected based on the assessed value of private property, including real estate, to 1 percent of the assessed value of the property. Proposition 13 also decreased the assessed value of the properties to 1975 values (negating three years of increased value), and limited increases of assessed value to a maximum of 2 percent per year. Property that is sold or declines in value after an initial purchase may be reassessed. The enactment of Proposition 13 cut local property tax revenue significantly, causing cities and counties to raise user fees and other local taxes. In response, voters approved Proposition 62, the Voter Approval of Taxes Act, in 1986. This proposition required that new general taxes be approved by two-thirds of the local agency's governing body and a majority of voters, and that new special taxes be approved by a two-thirds majority of voters. This led local agencies and communities to use assessments and property-related fees (among other fees) to pay for government services. Proposition 218 was passed by voters in 1996, and added requirements and limits on local governments' ability to impose or increase assessments and fees.

Proposition 26, which was passed in 2010, redefined many existing fees as taxes. The impacts of institutional and legal constraints associated with raising local funding for flood infrastructure and services is described in greater detail in a 2014 Public Policy Institute of California's report, *"Paying for Water in California"*. Constraints from Propositions 218 and 13 have been thoroughly documented by the California State and have also been highlighted as a major challenge in DWR's January 2005 White Paper, "*Responding to California's Flood Crisis*."

9.2.1.5. Tax Rate and Infrastructure Burden Consideration

In order to consider an area's ability to generate new revenue through special taxes and assessments, the uses of taxing capacity for all infrastructure and services should be considered. The California Debt and Investment Advisory Commission (CDIAC) promulgates guidelines with respect to land-secured financing, including the use of assessments and Mello-Roos Special Taxes. The CDIAC's Mello-Roos Guidelines (1991) suggests that jurisdictions should integrate Mello-Roos financing into the land use regulatory framework. Local governments can create a process for coordinating the use of land-secured financing through the provision of this form of integration. The main concern is that, in the absence of coordinated planning, property owners/taxpayers could find themselves vulnerable to onerous overlapping property tax burdens imposed by a multitude of local governments that may provide services to the same group of properties. Furthermore, the services funded by these burdens may not reflect property owners' collective priorities for services and infrastructure. This issue is analogous to the current ongoing efforts associated with planning for the future of flood management infrastructure to the extent that there are a multitude of planning efforts, all developing concurrent funding and financing strategies. These efforts should be coordinated in order to ensure that there is sufficient funding capacity available from the identified beneficiaries and that the funding is dedicated toward the beneficiaries' collective highest priorities.

9.2.1.6. Preferred Alternative Costs Summary

The small communities for Nicolaus and Rio Oso are within the same hydraulic basin and, therefore, remediation of levees near each community impacts the entire basin. All of the levee improvements are required to achieve the planned flood risk reduction goals. A breach in the levees in the Nicolaus plan would inundate Rio Oso, and a breach in the levees in the Rio Oso plan would inundate Nicolaus.

Therefore, a combined cost for the preferred alternative was prepared for both communities. Through geotechnical evaluation, an alternative alignment with multiple alternative remediations was identified for the Nicolaus and Rio Oso Projects. For the purpose of this analysis, the minimum and maximum repair costs associated with each remediation alternative was considered in determining the recommended approach. **Table 9** includes a list of Project cost estimates provided by the Nicolaus Project team for the remediation measures. **Table 10** below, includes a list of Project cost estimates provided by the Rio Oso Project team for the remediation measures. **Table 11**, below, displays the combined costs for both the Nicolaus and Rio Oso Projects. The estimated construction costs for the region is $465,678,200 under the preferred alternative plan.

Table 9: Project Costs Estimates for Community of Nicolaus

System	Station	Station	Preferred Alternative	Min	Max
	Start	End	[1]	[2]	[3]
Feather River Reach D	0+00	531+55	$171,836,000	$171,836,000	$224,986,800
Feather River Reach C	531+55	580+40	$30,870,400	$30,870,400	$33,807,400
Feather River Reach B	580+40	640+20	$14,284,600	$13,137,400	$14,284,600
Feather River Reach A	640+20	700+89	$11,331,900	$11,331,900	$39,945,500
Cross Canal Reach A	0+00	284+80	$153,971,800	$153,971,800	$171,733,700
Total			**$382,294,700**	**$381,147,500**	**$484,758,000**

Notes:
1. Preferred Repair Costs Per Remediation Area Provided by Nicolaus Project Team.
2. Minimum Repair Costs Per Remediation Area Provided by Nicolaus Project Team.
3. Maximum Repair Costs Per Remediation Area Provided by Nicolaus Project Team.

Table 10: Project Costs Estimates for Community of Rio Oso

System	Station	Station	Preferred Alternative	Min	Max
	Start	End	[1]	[2]	[3]
Bear River Reach C	0+00	85+00	$45,105,800	$45,105,800	$50,572,100
Bear River Reach B	85+00	130+72	$9,630,500	$9,630,500	$20,426,800
Yankee Slough Reach A.1	4+64	38+30	$5,217,000	$5,217,000	$523,190
Yankee Slough Reach A.2	38+30	231+17	$23,430,200	$23,430,200	$34,552,100
Total			**$83,383,500**	**$83,383,500**	**$106,074,190**

Notes:
1. Preferred Repair Costs Per Remediation Area Provided by Rio Oso Project Team.
2. Minimum Repair Costs Per Remediation Area Provided by Rio Oso Project Team.
3. Maximum Repair Costs Per Remediation Area Provided by Rio Oso Project Team.

Table 11: Cost Summary

Alternative	Nicolaus	Rio Oso	Total Construction Cost Estimate
Preferred	$382,294,700	$83,383,500	$465,678,200
Min	$381,147,500	$83,383,500	$464,531,000
Max	$484,758,000	$106,074,190	$590,832,190

9.2.1.7. Financial Feasibility

The small communities of Nicolaus and Rio Oso are within the same hydraulic basin, and remediation of levees near each community impacts the entire basin. All of the levee improvements are required to achieve the planned flood risk reduction goals. A breach in the levees in the Nicolaus plan would inundate Rio Oso, and a breach in the levees in the Rio Oso plan would inundate Nicolaus. Therefore, a combined financial feasibility analysis was performed for Nicolaus and Rio Oso. The first step in analyzing financial feasibility starts with the assumption that a property-based special assessment will be utilized to raise the local funding required for a flood risk reduction project. The general approaches utilized are summarized below:

1. Estimate the assessment rates required to generate, on an aggregate basis, $100,000 of annual revenue, and review the resulting rates to determine whether any land use assessment rate exceeds a level that could preclude approval of the assessment;

2. Establish the O&M funding requirements based on the project teams' input, and determine whether or not there is sufficient revenue to fund adequate levee maintenance;

3. Establish criteria based on an assumed maximum single-family residence assessment rate ($200) developed by the project team; and

4. Estimate the maximum amount of annual revenue that could be generated from project beneficiaries in the local community.

The methodologies utilized to determine the project beneficiaries and the relative benefits received are documented in **Attachment D (Reference 21)** and are based upon the assumption that a Proposition 218 Assessment will fund the local cost share of the project.

The capital costs of the remediation alternatives were compared to the two community's ability to generate local matching funds as a percent of the total project cost. The ability to pay analysis was a three-step screening process. First, a new maximum annual land-based assessment was calculated assuming the limitations noted above along with the proportionality requirements of Proposition 218 for the benefited area. Second, based on the calculated assessment revenue, it was determined that $88,000 in new assessment revenue would be allocated toward the local share of the capital costs either on a pay-go basis or to service debt. Finally, the project team determined that the existing local assessment generates a total annual revenue of $953,000, of which $470,000 will cover required O&M costs. Sixty-five percent (65%) or $313,950 of the remaining existing assessment revenue, in addition to $88,000 in new assessment capacity, was allocated toward the capital assessment capacity of $401,950. This represents the total amount of local assessment capacity available to advance the preferred alternative.

The results of the local funding analysis are shown in the **Table 12** below. The preferred, minimum, and maximum alternatives would raise between $5.62 million to $7.16 million on varying debt financing interest rates between 3% to 5%. A range of local capital amount was developed and compared to the estimated alternative cost to determine the percent of local matching funds available for the range of remediation alternatives. The alternatives are ranked based on the percent of the project that could be paid with local capital.

Table 12: Local Funding Analysis Results

Alt.	Capital Assessment Capacity ($)	Low Interest Rate (Millions $) [1,2,4]	High Interest Rate (Millions $) [1,3,4]	Project Cost (Millions $)	Local		Non-Local		Fund Capacity Ranking
					High (%)	Low (%)	High	Low	
Preferred	$401,950	$7.16	$5.62	$382.29	1.87%	1.47%	98.53%	98.13%	2
Min	$401,950	$7.16	$5.62	$381.15	1.88%	1.47%	98.53%	98.12%	1
Max	$401,950	$7.16	$5.62	$484.76	1.48%	1.16%	98.84%	98.52%	3

Notes:
1. Assumes 1.1 Debt Coverage Ratio
2. Low Interest Rate for Debt Issuance Assumed to be 3%
3. High Interest Rate for Debt Issuance Assumed to be 5%
4. Term for Bond Repayment Assumed to be 30 Years

9.2.1.8. Funding Source Analysis

This Study also evaluated potential State and federal funding sources available to match local funding. These sources include partners for the multi-benefit portions, structural and non-structural projects. **Table 13** provides a summary of potential State and federal funding sources that could be sought to complete the proposed improvements. A detailed summary of these findings is provided in the Funding Sources Analysis, which is attached as **Attachment F (Reference 23)**.

Table 13: State and Federal Funding Sources Summary Table

Funding Program	Agency	Structural		Non-Structural		Study / Plan / O&M	
		Levees/ Floodwalls/ Dams/ Erosion	Bypasses	Changes to NFIP	Relief Cuts	Feasibility Study/Flood Management Plan	OMR R&R
Urban Stormwater and Waterways Improvement Program	CNRA	X	X		X		
Urban Green Infrastructure Program	CNRA	X	X		X		
Flood Control Subventions Program (FCSP)	DWR	X	X		X		
Central Valley Tributaries Program (CVTP)	DWR	X	X		X		
Flood Damage Reduction Projects (FDRP)	USACE	X	X		X	X	
Flood Related Continuing Authorities Program (FRCA)	USACE	X	X		X	X	
Sacramento River Bank Protection Project (SRBPP)	USACE	X	X		X		
Watershed and Flood Prevention (WFPO)	USDA	X			X		
Inland Wetlands Conservation Program (IWC)	WCB	X	X		X		

Source: Reference 23

9.2.1.9. Funding Plan

The County should work to determine if advancing a land-based assessment would be a viable approach and if it should refine assumptions associated with the amount of funding required to complete the proposed improvements. In order to secure local funding, the County will need to prepare a detailed project financing plan and a cash flow model to support a land-based assessment. This plan would ultimately become part of a required Engineer's Report. The County should advance design and environmental compliance of the preferred alternative in order to develop a construction-ready project that can better compete for state and federal funding.

The Project Team determined that existing local funding revenues are sufficient to fund all of the Alternative Remediation's' O&M costs for the two small communities. The remaining capacity of the local assessment net O&M costs could be used to raise between 1.47 percent and 1.88 percent of the total Preferred Alternative project costs. In LWA's experience, typical capital improvement projects require at least 10 percent to 15 percent of the local matching funds in order to qualify for state and federal funding programs.

The County should explore developing a regional assessment district to fund a regional Capital Improvement Program (CIP) that could leverage a larger benefit assessment area than the two small communities to generate local funds to match state and federal funding. The regional assessment district could initially be utilized to fund SCFRRP projects within the County, and then other critical projects within Sutter County.

As part of developing a larger regional program and CIP, the County would need to determine how to address governance prior to advancing the preferred alternative under this regional approach.

For further details regarding this analysis, refer to the Financial Conceptual Plan that is attached as **Attachment E (Reference 22)**.

10. REFERENCES

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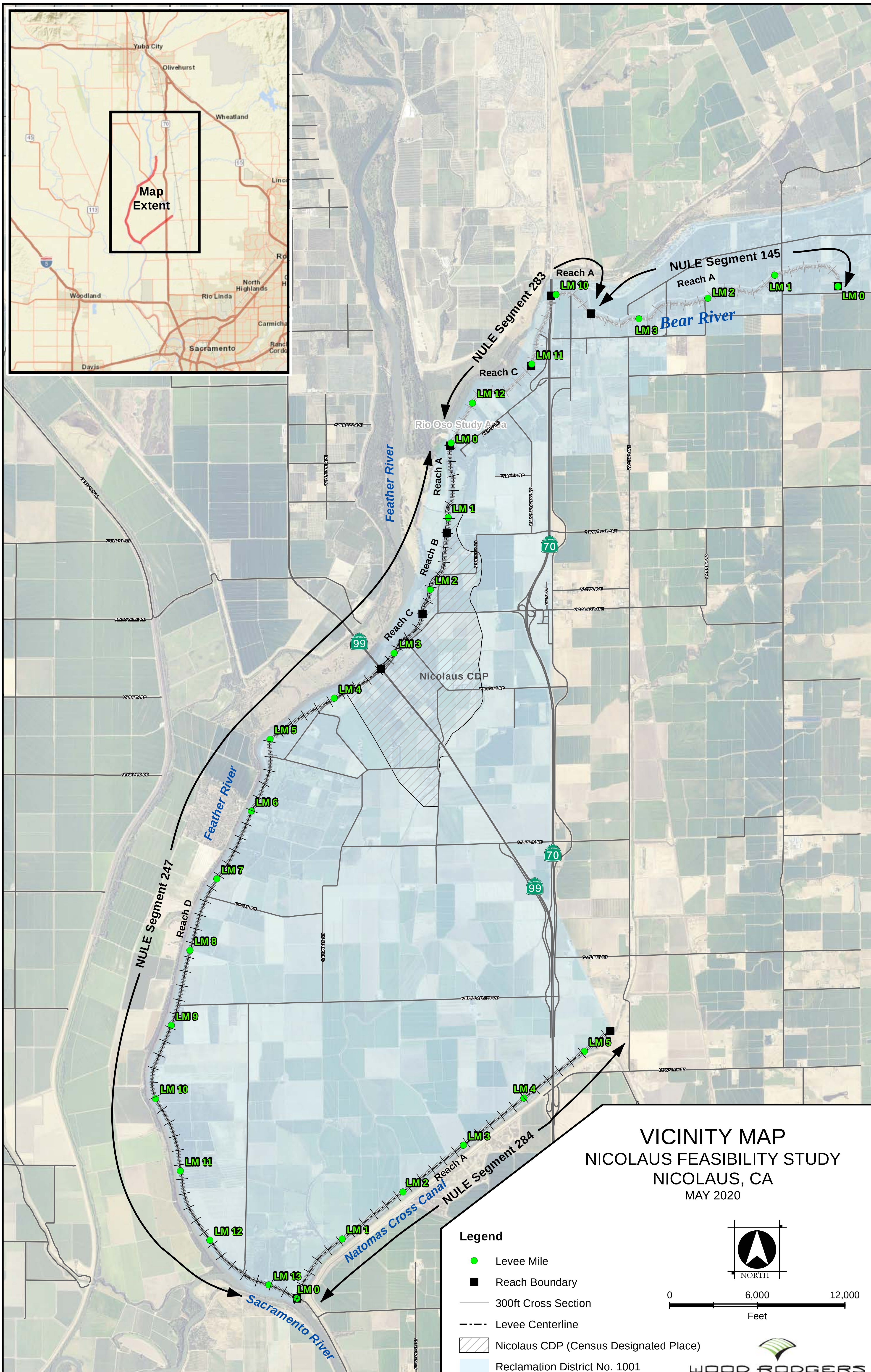
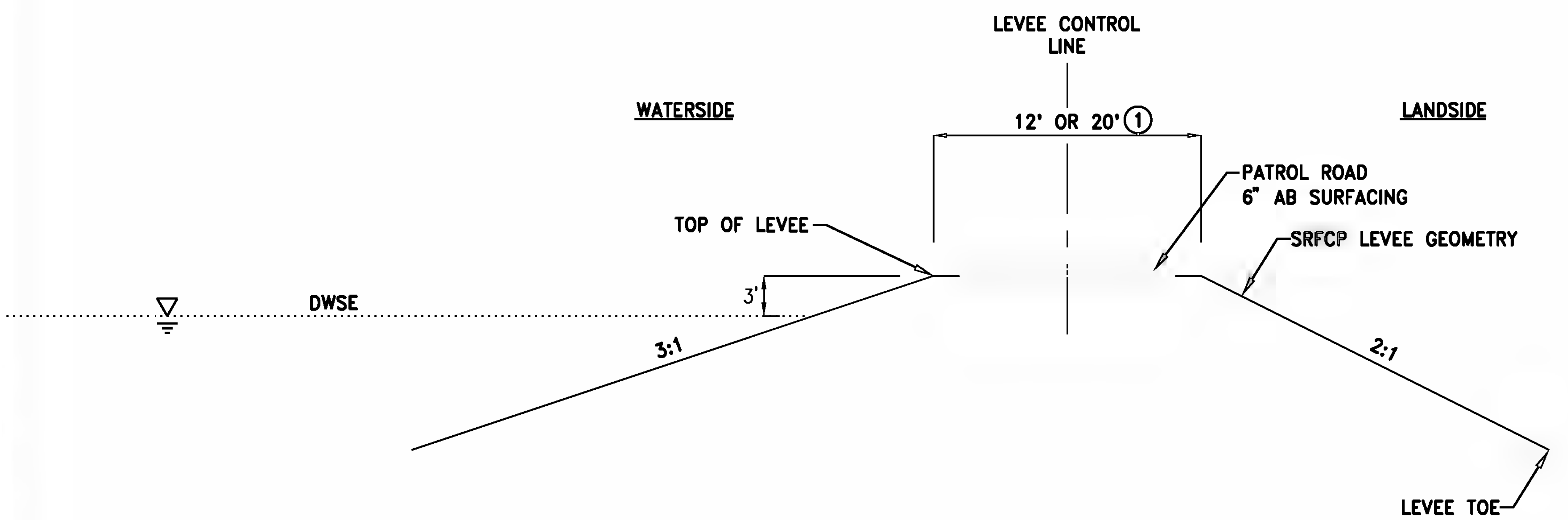
23. (LWA, 2019) Technical Memorandum, Smaller Community Flood Risk Reduction (SCFRR), Funding Sources Memorandum. November. 2019.

FIGURES



\\woodrodgers.loc\ProductionData\Jobs\3000-s\3614_MBK_Engineers\3614005_Nicolaus_Rio_Oso_FS\GIS\Tasks\Nicolaus_Vicinity_Map_11x17.mxd 5/12/2020 3:49:02 PM jcarey

FIGURE 1



TYPICAL SECTION
SRFCP AUTHORIZED DESIGN - LEVEE GEOMETRTY

SCALE: N.T.S.

LEGEND

EXISTING GROUND
ULDC LEVEE GEOMETRY
DESIGN WATER SURFACE ELEVATION (DWSE)

NOTES

(1) MINIMUM 12' CROWN WIDTH FOR MINOR STREAM LEVEES
MINIMUM 20' CROWN WIDTH FOR MAJOR STREAM LEVEES

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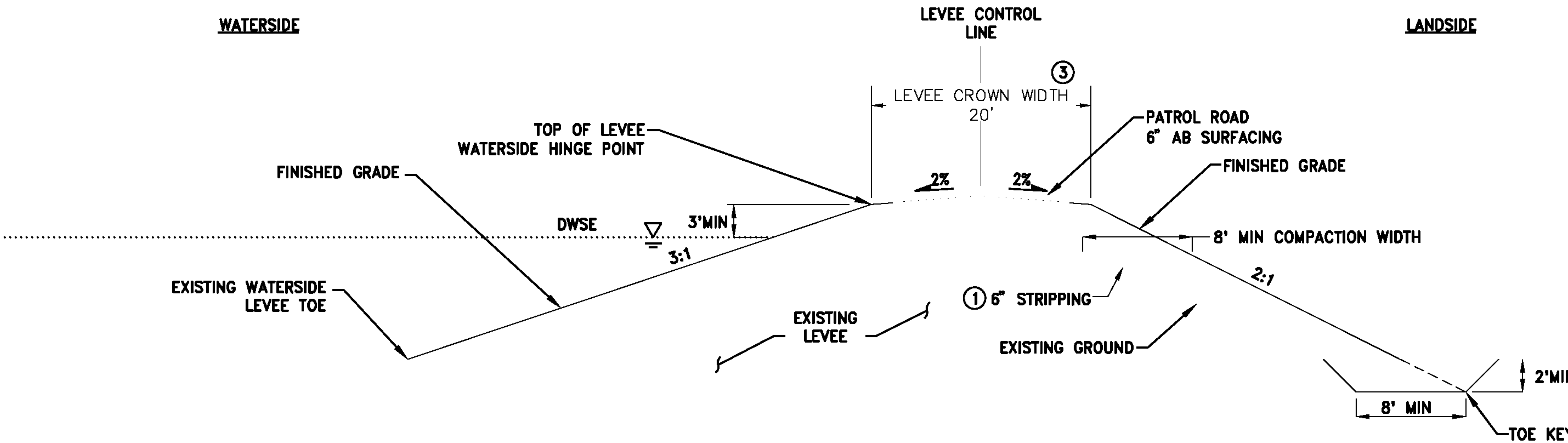
SRFCP AUTHORIZED DESIGN – LEVEE GEOMETRY
TYPICAL SECTION

FIGURE 2

8:52 AM Chuck Hilliard



NOTE

1. EXCAVATE LEVEE SLOPE, AS NEEDED, TO CREATE MINIMUM COMPACTION WIDTH.
2. SEE FIGURE 2 FOR LEVEE RAISE AND LANDSIDE GEOMETRY FIX TYPICAL CROSS SECTION FOR FEATHER RIVER LEVEE STA 0+00 TO 429+00.
3. FEATHER RIVER REACH D WILL REQUIRE A 38 FOOT WIDE CROWN WIDTH TO ACCOMMODATE THE REQUIRED WIDTH OF GARDEN HIGHWAY, WHICH RUNS ON TOP OF THE LEVEE CROWN IN THIS REACH.

TYPICAL SECTION
LEVEE RAISE AND GEOMETRY IMPROVEMENT - LANDSIDE

SCALE: 1" = 10'

LEGEND

	EXISTING GROUND
———	FINISHED GRADE
....	DWSE

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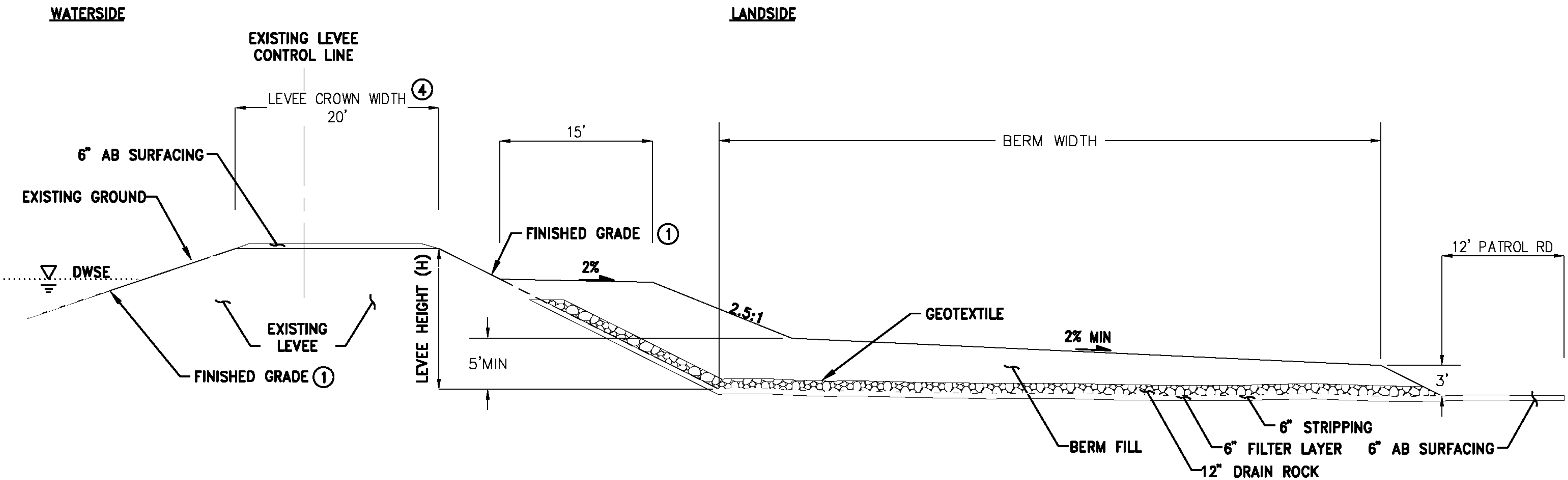
NATOMAS CROSS CANAL NORTH LEVEE
FEATHER RIVER EAST LEVEE STA 429+00 TO 700+89
LEVEE RAISE AND GEOMETRY IMPROVEMENT - LANDSIDE TYPICAL SECTION

FIGURE 3



NOTE

1. SEE FIGURE 3 FOR TYPICAL GEOMETRY FIX CROSS SECTION.
2. SEE FIGURE 4 FOR TYPICAL SEEPAGE/STABILITY BERM CROSS SECTION FOR FEATHER RIVER EAST LEVEE STA 0+00 TO 429+00.
3. TOP OF BERM SHALL BE SET AT THE DWSE.
4. FEATHER RIVER REACH D WILL REQUIRE A 38 FOOT WIDE CROWN WIDTH TO ACCOMMODATE THE REQUIRED WIDTH OF GARDEN HIGHWAY, WHICH RUNS ON TOP OF THE LEVEE CROWN IN THIS REACH.

TYPICAL SECTION
LANDSIDE COMBINATION SEEPAGE/STABILITY BERM

SCALE: 1" = 10'

LEVEE	STATION RANGE	BERM WIDTH (FT)
FEATHER RIVER	429+00 – 531+55	80
	640+20 – 700+89	300

LEGEND

	EXISTING GROUND
———	FINISHED GRADE
— — —	PROJECTED FINISHED GRADE
....	DWSE
	DRAIN ROCK
	FILTER SAND

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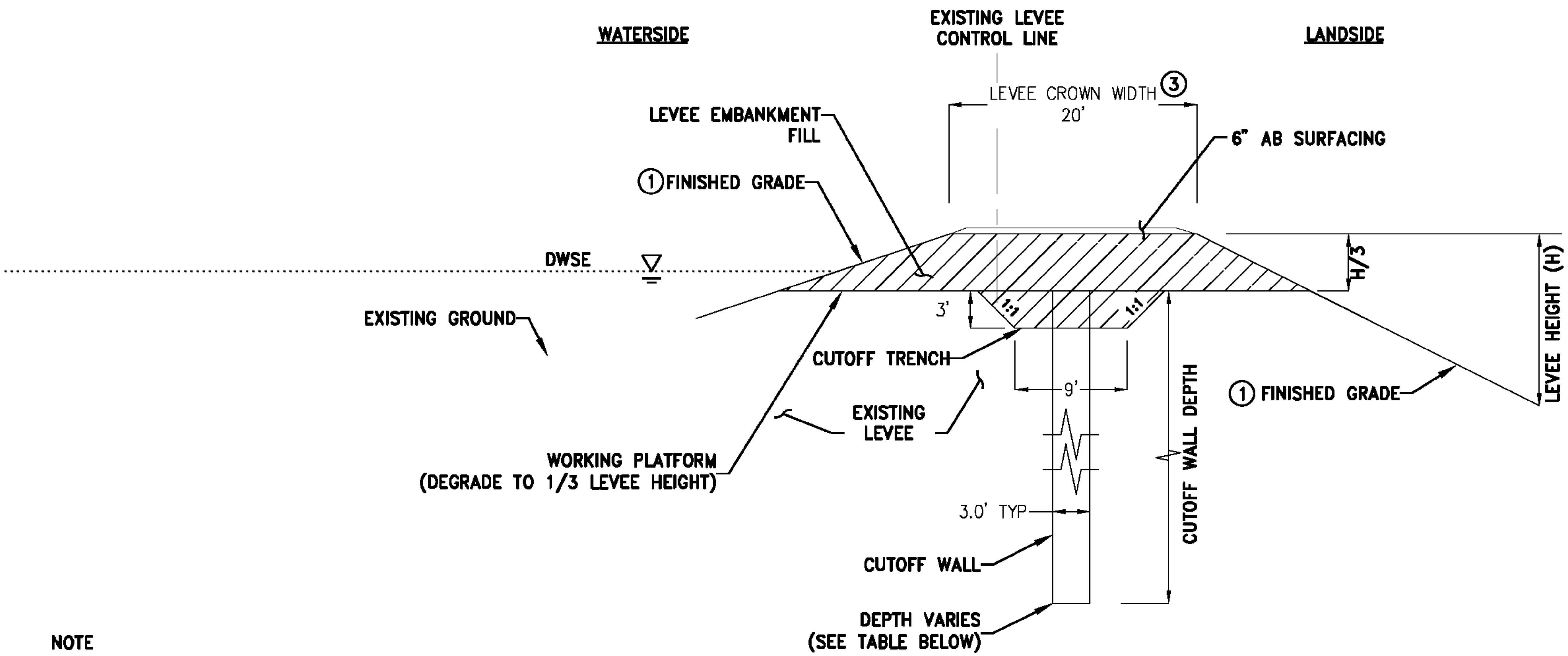
FEATHER RIVER EAST LEVEE STA 429+00 TO 700+89
LANDSIDE COMBINATION SEEPAGE/STABILITY BERM
TYPICAL SECTION

FIGURE 4



NOTE

1. SEE FIGURE 3 FOR TYPICAL GEOMETRY FIX CROSS SECTION.
2. SEE FIGURE 6 FOR CUTOFF WALL TYPICAL SECTION FOR FEATHER RIVER EAST LEVEE STA 0+00 TO 429+00.
3. FEATHER RIVER REACH D WILL REQUIRE A 38 FOOT WIDE CROWN WIDTH TO ACCOMMODATE THE REQUIRED WIDTH OF GARDEN HIGHWAY, WHICH RUNS ON TOP OF THE LEVEE CROWN IN THIS REACH.

TYPICAL SECTION
SOIL BENTONITE SEEPAGE CUTOFF WALL

SCALE: 1" = 10'

LEVEE	STATION RANGE	CUTOFF WALL DEPTH (FT)
NATOMAS CROSS CANAL	0+00 – 284+80	76
FEATHER RIVER EAST	429+00 – 531+55	80
	531+55 – 580+40	22
	580+40 – 640+20	60
	640+20 – 700+89	65

LEGEND

- EXISTING GROUND
- FINISHED GRADE
- CUTOFF WALL EXCAVATION
- CUTOFF WALL
- DWSE

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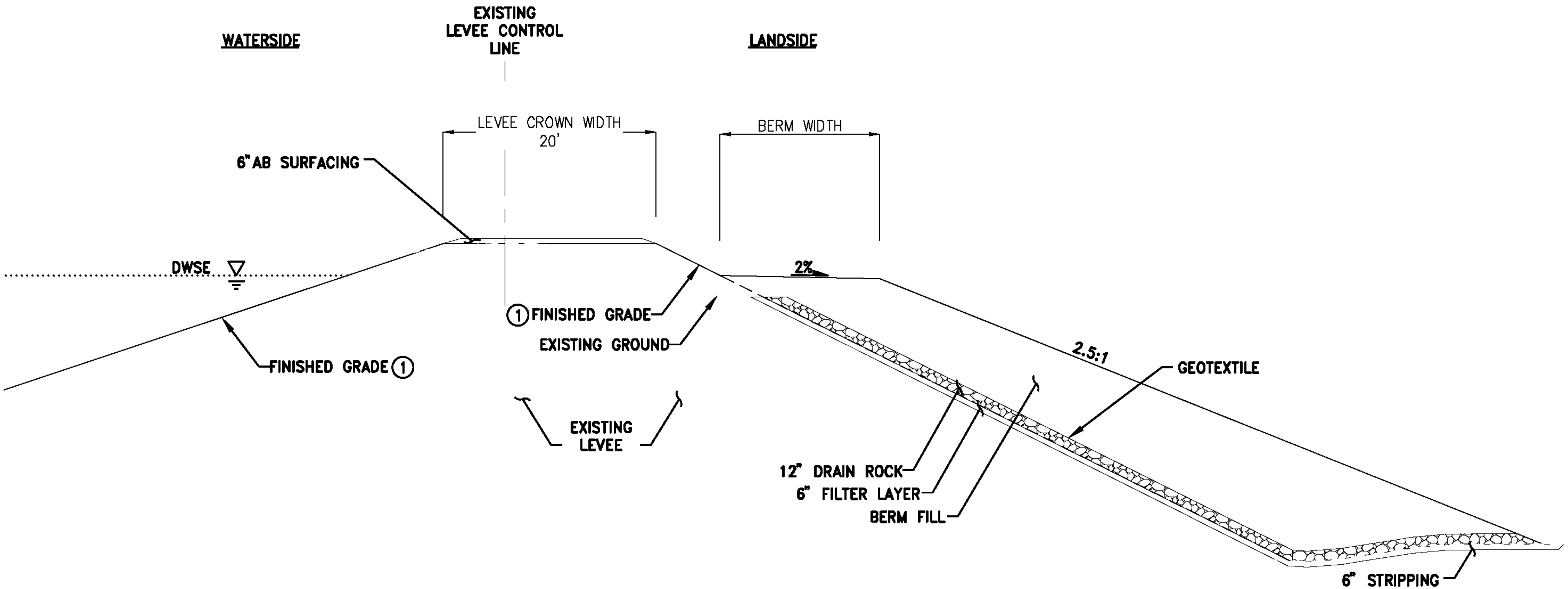
NATOMAS CROSS CANAL NORTH LEVEE
FEATHER RIVER EAST LEVEE STA 429+00 TO 700+89
SOIL BENTONITE SEEPAGE CUTOFF WALL
TYPICAL SECTION

FIGURE 5



NOTE

1. SEE FIGURE 3 FOR TYPICAL GEOMETRY FIX CROSS SECTION.
2. TOP OF BERM FOR FEATHER RIVER LEVEE SHALL BE SET TO THE DWSE. TOP OF BERM AT NATOMAS CROSS CANAL SHALL BE SET AT A HEIGHT OF 10' FROM THE EXISTING LANDSIDE TOE.

TYPICAL SECTION
DRAINED STABILITY BERM

SCALE: 1" = 10'

LEVEE	STATION RANGE	BERM WIDTH
NATOMAS CROSS CANAL	0+00 – 284+80	20
FEATHER RIVER EAST	531+55 – 580+40	15
	580+40 – 640+20	15

LEGEND

	EXISTING GROUND
———	FINISHED GRADE
— — —	PROJECTED FINISHED GRADE
....	DWSE
(hatched)	DRAIN ROCK
(box)	FILTER SAND

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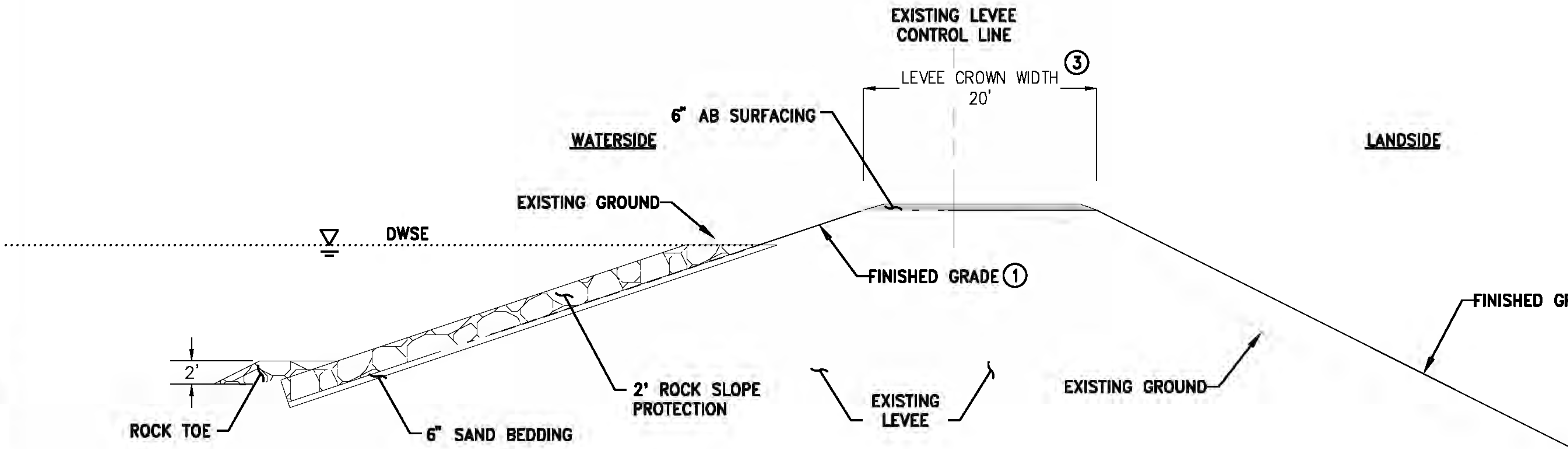
DRAINED STABILITY BERM
TYPICAL SECTION

FIGURE 6



NOTE

1. SEE FIGURE 3 FOR TYPICAL GEOMETRY FIX CROSS SECTION.
2. SEE FIGURE 10 FOR ROCK SLOPE PROTECTION TYPICAL SECTION FOR FEATHER RIVER EAST LEVEE STA 0+00 TO 429+00.
3. FEATHER RIVER REACH D WILL REQUIRE A 38 FOOT WIDE CROWN WIDTH TO ACCOMMODATE THE REQUIRED WIDTH OF GARDEN HIGHWAY, WHICH RUNS ON TOP OF THE LEVEE CROWN IN THIS REACH.

TYPICAL SECTION
ROCK SLOPE PROTECTION

SCALE: 1" = 10'

LEGEND

- EXISTING GROUND
- FINISHED GRADE
- DWSE
- ROCK SLOPE PROTECTION
- SAND BEDDING

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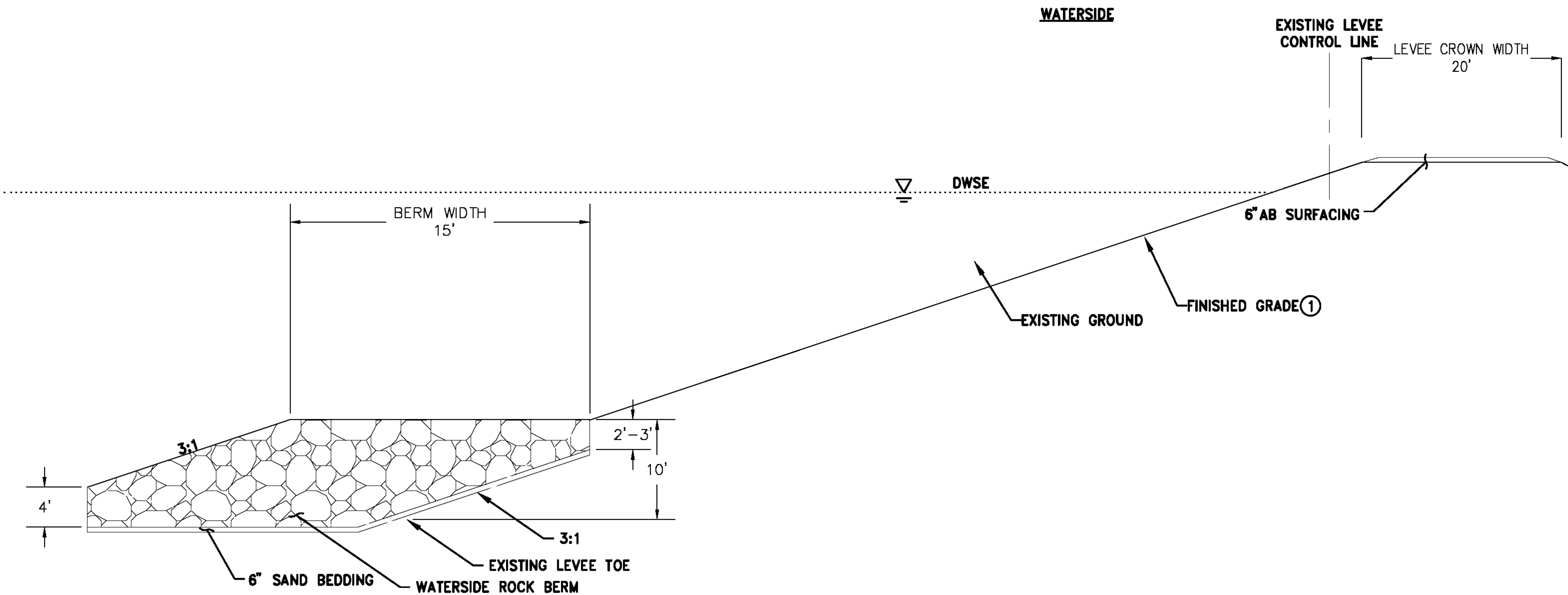
ROCK SLOPE PROTECTION
TYPICAL SECTION

FIGURE 7



TYPICAL SECTION
WATERSIDE TOE BERM

SCALE: 1" = 10'

NOTE

① SEE FIGURE 3 FOR TYPICAL GEOMETRY FIX CROSS SECTION.

LEGEND

	EXISTING GROUND
———	FINISHED GRADE
....	DWSE
	ROCK SLOPE PROTECTION
	SAND BEDDING

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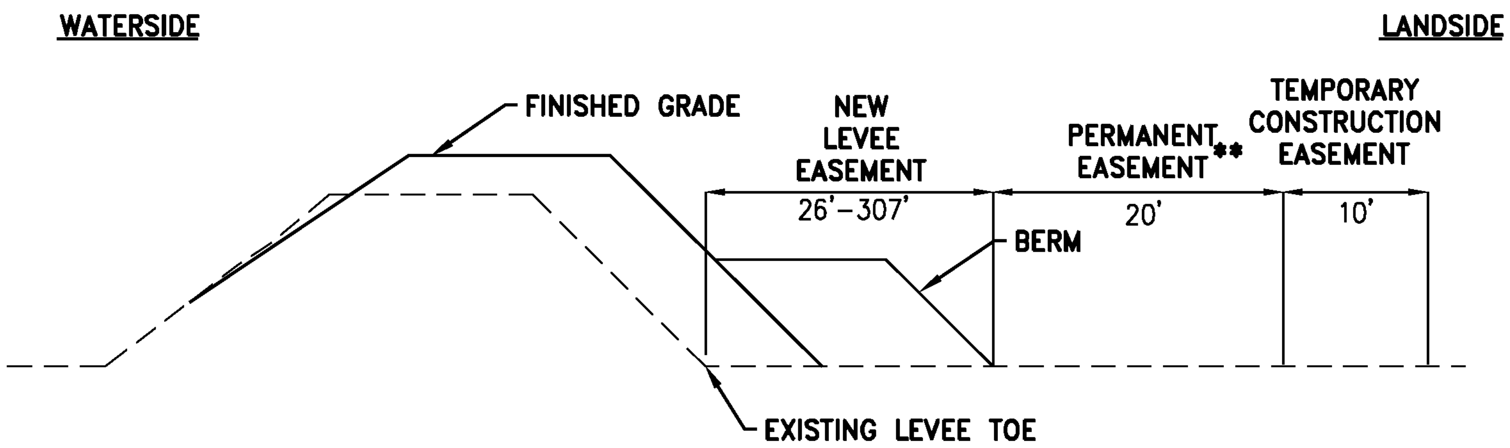
WATERSIDE TOE BERM
TYPICAL SECTION

FIGURE 8

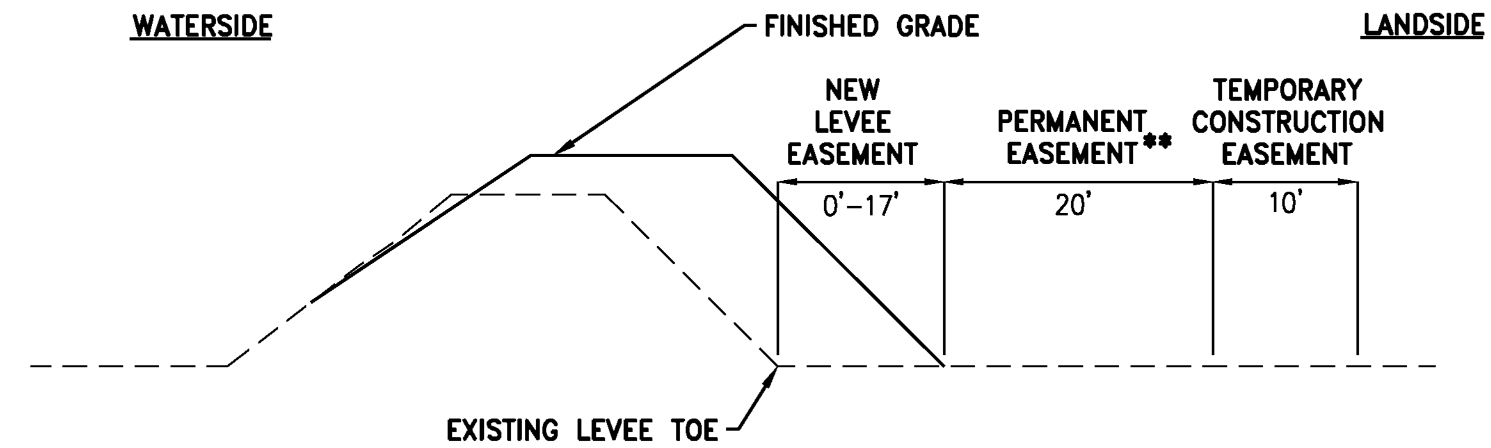


* ASSUME NO EXITING LEVEE EASEMENT BEYOND EXISTING LEVEE TOE

** PERMANENT EASEMENT IN ACCORDANCE WITH CVFPB

COMBINATION / DRAINED STABILITY BERM

SCALE: N.T.S.

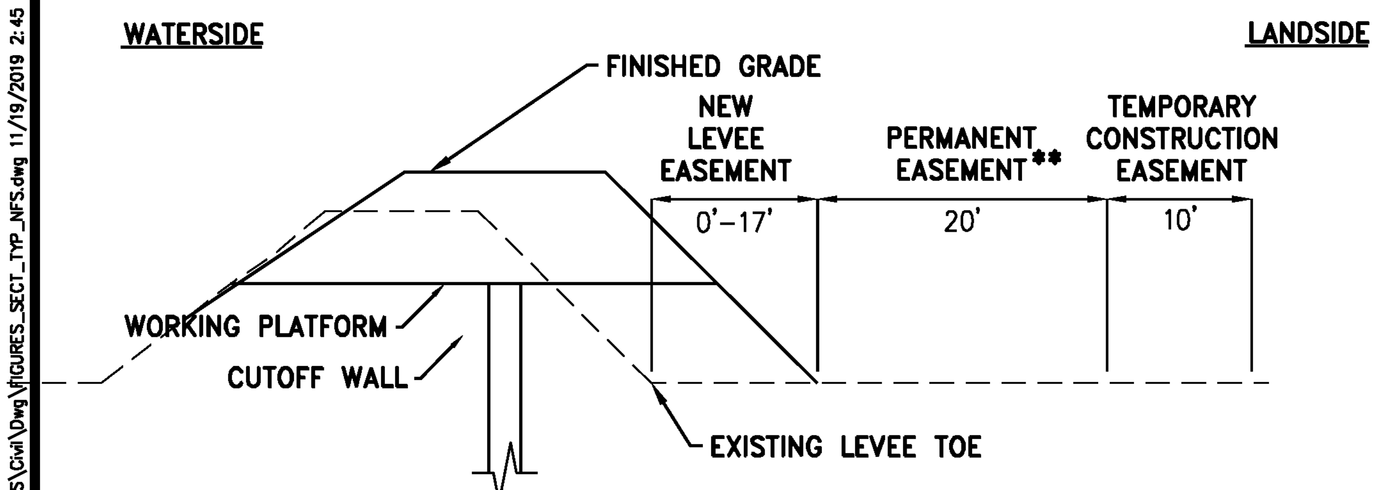


* ASSUME NO EXITING LEVEE EASEMENT BEYOND EXISTING LEVEE TOE

** PERMANENT EASEMENT IN ACCORDANCE WITH CVFPB

LEVEE RAISE/ GEOMETRY FIX

SCALE: N.T.S.

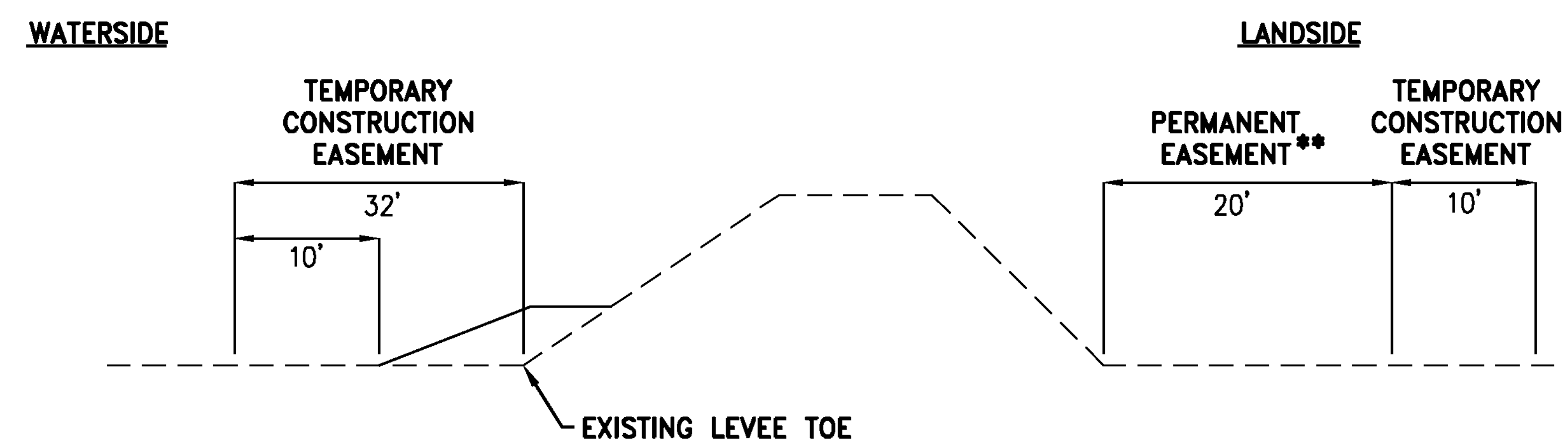


* ASSUME NO EXITING LEVEE EASEMENT BEYOND EXISTING LEVEE TOE

** PERMANENT EASEMENT IN ACCORDANCE WITH CVFPB

CUTOFF WALL

SCALE: N.T.S.



* ASSUME NO EXITING LEVEE EASEMENT BEYOND EXISTING LEVEE TOE

** PERMANENT EASEMENT IN ACCORDANCE WITH CVFPB

WATERSIDE TOE BERM

SCALE: N.T.S.

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NICOLAUS FLOOD RISK REDUCTION PROGRAM FEASIBILITY STUDY

LAND ACQUISITION TYPICAL SECTIONS

FIGURE 9

ATTACHMENTS

Attachment A – Geotechnical Summary Report, Nicolaus Flood Risk Reduction Feasibility Project

Attachment B – Small Communities Flood Risk Reduction Program – Hydraulic Analysis for the Communities of Rio Oso and Nicolaus

Attachment C – Draft Environmental Constraints Analysis, Nicolaus Flood Risk Reduction Feasibility Study

Attachment D – Financial Feasibility – Technical Memorandum

Attachment E – Conceptual Finance Plan – Technical Memorandum

Attachment F – Funding Sources – Technical Memorandum

Attachment G - Memorandum of Understanding Respecting the Sacramento River Flood Control Project

Attachment H – Freeboard and Geometry Analysis - Levee Deficiencies Strip Maps

Attachment I – Freeboard and Geometry Analysis - Levee Cross Sections

Attachment J – Cost Estimate Cross Sections

Attachment K – Cost Estimate – Summary

Attachment L – Levee Encroachments Table

Attachment M – Draft Nonstructural Measures, Nicolaus Flood Risk Reduction Feasibility Project