Knights Landing

Small Community Flood Risk Reduction Feasibility Study

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Acronyms and Abbreviations

AFOTF	Agricultural Floodplain Ordinance Task Force
ASFPM	Association of State Flood Plain Managers
BFE	Base Flood Elevation
BWFS	Basin Wide Feasibility Studies
CDIAC	California Debt and Investment Advisory Commission
CFR	Code of Federal Regulations
CLD	California Levee Database
CRHR	California Register of Historical Resources
CSA #6	Yolo County Service Area #6
CVFED	Central Valley Floodplain Evaluation and Delineation Program
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CVHS	Central Valley Hydrology Study
DAC	Disadvantaged Community
DMP	Deferred Maintenance Program
DWR	California Department of Water Resources
EAD	Expected Annual Damage
EOC	Emergency Operations Center
FEMA	Federal Emergency Management Agency
FIRM	Floodplain Insurance Rate Maps
FIS	Flood Insurance Study
FMAP	Flood Maintenance Assistance Program
FSRP	State's Flood System Repair Program
GAR	Geotechnical Assessment Report
GDRs	Geotechnical Data Reports
GLO	General Land Office
GORs	Geotechnical Overview Reports
HCP	Habitat Conservation Plan

IWMP	Integrated Water Management Plan
KLRC	Knights Landing Ridge Cut
KLRDD	Knights Landing Ridge Drainage District
KLLS	Knights Landing Levee System
LMAs	Local Maintaining Agencies
LOI	Letter of Intent
LSDN	Lower Sacramento/Delta North
NAVD	88 North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NRHP	National Register of Historic Places
NULE	Non-Urban Levee Elevation
O&M	Operations and Maintenance
PIR	Periodic Inspection Report
PRC	Public Resources Code
RACERs	Remedial Alternatives and Cost Estimate Reports
RD	Reclamation District
RFMP	Regional Flood Management Plans
RIP	Rehabilitation and Inspection Program
SA	Service Area
SCFRRP	Small Community Flood Risk Reduction Program
SFHAs	Special Food Hazard Areas
SPFC	State Plan of Flood Control
SRA	Shaded Riverine Aquatic
SRFCP	Sacramento River Flood Control Project
SWIF	System Wide Improvement Framework
TCRs	Tribal Cultural Resources
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USACE	U.S. Army Corps of Engineers
WWTF	Wastewater Treatment Facility

WSE	Water Surface Elevation
YBW1	Yolo Bypass Levee Unit 1

Executive Summary

In 2017, Yolo County received a grant from the California Department of Water Resources (DWR) Small Community Flood Risk Reduction Program to complete a feasibility study with a primary goal of identifying a preferred plan to reduce flood risk to Knights Landing. The scope of the study is to identify alternatives, indicate preferred structural and non-structural elements, compare implementation costs and schedules, and identify local funding requirements to assess options which will reduce flood risk to the Knights Landing Basin. The study considers potential solutions to reduce flood risk while sustaining agriculture and the regional economy, providing safe access to the river, improving riverine habitat viability, and addressing regional levee maintenance governance.

The Knights Landing Basin is located along the Sacramento River at the northern boundary of Yolo County and northwest end of the Yolo Bypass (Figure 1, Page 9). It is bounded by the Knights Landing Levee System (KLLS) with approximately 15.2 miles of levees that provide protection from flows in the Sacramento River on the East; the Knights Landing Ridge Cut (KLRC) on the West; the Colusa Basin Drain in the North, and the Yolo Bypass in the South. The community of Knights Landing, a disadvantaged community with an estimated population of 1,000 (2010, US census survey), is in the northwest portion of the basin at the confluence of the KLRC, the Colusa Basin Drain, and the Sacramento River. In 2016, the median household income in the community was $32,310. As this median household income is less than 80% of the state average of California, Knights Landing is designated as a “disadvantaged community” (DAC).

The levees surrounding the Knights Landing Basin were originally built in the 1800s by local parties and were later incorporated into the Sacramento River Flood Control Project (SRFCP) during the late 1950s. The KLLS was constructed to United States Army Corps of Engineers (USACE) project standards by the late 1940s. Repairs and improvements to the system have been constructed as needed since then.

Historically, the community of Knights Landing flooded in 1878 as a result of Sacramento River levee failures. In 1983, the KLRC flows were impaired by high stages in the Yolo Bypass, ultimately flooding numerous homes. In 2010, the Federal Emergency Management Agency (FEMA) determined that the flood control levees guarding Knights Landing could fail. The current FEMA Flood Insurance Study (FIS), dated 2012 maps the community of Knights Landing into the Zone A flood insurance rate zone, corresponding to the 1-percent annual chance floodplain. Hydrologic and hydraulic modeling indicates if there is ever a levee overtop or breach from the Sacramento River right bank, water in the basin flows from north to south towards Yolo Bypass. However, due to the topography of the area, the Basin acts as a bathtub with

water backing up from Yolo Bypass in the south to the community of Knights Landing in the north. The structures in the community of Knights Landing are subject to flood depths greater than 3.5 ft. As discussed in the 2017 update to the CVFPP, the flood management system has experienced much larger floods than those experienced during the events whch led to the system's original design. Hydrologic variability and uncertainty are increasing as a result of climate change, which may likely result in more severe flooding over time.

Yolo County and its consultants for this Knights Landing Small Community Flood Risk Reduction Feasibility Study coordinated and met with various stakeholders - Knights Landing Ridge Drainage District KLRDD, residents and landowners of Knights Landing, and agricultural land owners within the Basin. Representatives from KLRDD were directly involved in development of this study, and several stakeholder meetings were held to solicit feedback on the project process including alternative formation with local land owners, residents, and Yolo County supervisors. Stakeholders and previous studies identified several locations with underseepage, through seepage, erosion, stability and freeboard problems along the right bank of the Sacramento River and left bank of the KLRC.

To accomplish the goals of this study, the study team examined potential improvements to the surrounding levee system and the possible addition of a new cross levee on the south side of the community. In addition, multiple benefit opportunities were evaluated to leverage future funding scenarios. To protect the community from flood risks surrounding the community and the Knights Landing Basin, various cross levee configurations were modeled. Several locations were identified as potential sites for a cross levee based on available historical levee performance, existing and planned land uses, recommendations of previous studies, hydraulic and geotechnical evaluations, and stakeholder input.

To address these identified problems, 13 structural alternatives were formulated using a combination of cross levee and applicable levee improvements. These 13 alternatives were evaluated qualitatively using flood risk reduction, ecosystem benefits, agricultural sustainability, and recreation criteria and were narrowed down to six structural alternatives. To estimate the costs and further evaluation of these six alternatives, levee remediations have been identified for the levees along the right bank of the Sacramento River and the left bank of KLRC.

Based on the preliminary and final screening, Alternative 12 was selected as the Preferred Alternative that accomplishes the goals of this Study. Cost for the Preferred Alternative are estimated as $72 million that includes levee improvements at $36.3 million, and a new, proposed cross levee at $35.7 million. The Preferred Structural Alternative includes the following:

Levee Improvements along the Right Bank of Sacramento River -

- 290 feet of combination berm and ditch fill at levee mile 0.86 to 0.90 to address underseepage, through seepage, and landside stability concerns adjacent to the community
- 1,010 feet of drained stability berm from levee mile 0.67 to 0.86 to address through seepage concerns adjacent to the community
- 2,620 feet of cutoff wall from levee mile 0.13 to 0.67 to address underseepage concerns adjacent to the community
- 793 feet of cutoff wall from levee mile 2.7 to 2.9 to address through seepage concerns
- 878 feet of cutoff wall from levee mile 3.0 to 3.2 to address through seepage concerns
- 2,400 feet of cutoff wall to address through seepage concerns and 3,157 feet of combination seepage-stability berm to address underseepage and through seepage concerns between levee mile 4.3 and 5.4
- Applicable freeboard/geometry repairs

Levee Improvements along the Left Bank of KLRC -

- 4,830 feet of stability improvements and waterside rock slope protection for erosion repair from levee mile 4.9 to 5.8 adjacent to the community and the Knights Landing waste water ponds

New Cross levee -

- New cross levee just easterly of the densely populated community of Knights Landing between the Sacramento River and the KLRC
- Preferred alignment of the cross levee would be from levee mile 4.9 on the right bank of the Sacramento River and would run approximately 6,800 feet southerly toward levee mile 0.9 of the left bank of KLRC

The total cost for these collective levee improvements and construction of the preferred cross levee is estimated at approximately $72 million in 2018 dollars.

Several non-structural measures were evaluated for their potential to reduce residual flood risk and can be implemented independent of, or in combination with, the structural improvements. This study recommends the following preferred non-structural measures for implementation, some of which are already in the early stages of implementation:

- Voluntary Raising of Structures
- Voluntary Flood Proofing, particularly of Agricultural Structures
- Continued State support for refinements and Amendments to the National Flood Insurance Program (NFIP) via Agricultural Floodplain Ordinance Task Force (AFOTF) and H.R. 3167
- Support continued actions to improve NFIP Community Rating System (CRS) for Yolo County/Knights Landing

- Support for continued use and applicable updates to the KLLS Emergency Operations Plan – Basic Plan Implementation, Inclusive of Flood Emergency Trigger Elevations & Response Actions
- Improved OMRR&R Governance Between Yolo County Service Area #6 (CSA #6), Sutter County, and KLRDD

In addition to these structural and non-structural measures, the team identified several multiple-benefit concepts to include habitat enhancement, water supply improvements and recreation. Ten habitat restoration concepts were identified as part of this Study of which three concepts were identified with the highest potential to implement in connection with the flood risk reduction alternatives. The preferred restoration concepts for potential implementation are the Grays Bend Riparian Enhancement concept, the Portuguese Bend Enhancement concept, and the KLRC Enhancement concept that are estimated at $4.9 million, $6.4 million and $23.8 million respectively. For each of these concepts, the excavated soil could be used as a source material for the construction of berms for improvements along the Sacramento River or for the cross levee. Also, habitat creation would potentially offset any riparian habitat impacts that may occur due to levee repairs along the Sacramento River.

The feasibility study also identified water supply infrastructure improvements to the existing water supply wells and evaluated recreational opportunities to gain better access to the river, walking paths, a river promenade, that can be potentially implemented in the community in conjunction with flood risk reduction measures.

Full implementation of all the elements of the preferred structural alternative (Alternative 12) would likely take five years from the time that funding is secured and would include project design, environmental documentation, and construction. Yolo County is considering implementing the Preferred Alternative as the following three key structural management actions - Structural Levee Improvements Adjacent to the Community of Knights Landing, Structural Levee Repairs Downstream and West of the Community of Knights Landing, and a Cross Levee Structural Phase. The following recommendations are made for the Knights Landing Basin, and can be sequenced or phased in the order as listed below or amended based upon variable funding sources.

- CSA #6, acting through the County of Yolo, seeks immediate financial assistance from DWR through their Small Communities Flood Risk Reduction Program (SCFRRP) Phase 2 – Implementation Program.

- Secure funding for design, permitting and construction of structural levee repairs directly adjoining the community of Knights Landing as previously identified by DWR through their Non Urban Levee Evaluation (NULE) Program primarily along the right bank levee of the Sacramento River, upstream and northwesterly of the preferred cross levee alignment.

- Secure funding for design, permitting and construction of structural levee repairs downstream and east of the community of Knights Landing collectively totaling 1.5 miles along the right bank levee of the Sacramento River.
- Secure funding for design, NEPA/CEQA documentation, permitting and construction of the cross levee alignment of the preferred alternative, Alternative 12, as well as repairs/enhancements to the KLRC levee, adjoining the Knights Landing waste water ponds.
- Conduct and document all activities in accordance with 44 CFR Section 65.10 to meet FEMA 100-year accreditation.
- Concurrently with the implementing the structural phases of the preferred alternative, the recommended non-structural solutions can be implemented to further reduce residual flood risks within the Knights Landing Basin.

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1 Purpose and Scope

1.1 Background

Yolo County received a grant from the California Department of Water Resources (DWR) Small Community Flood Risk Reduction Program (SCFRRP) to complete a feasibility study of structural and non-structural actions that can reduce flood risk to Knights Landing. This report documents the planning process, identifies and evaluates an array of alternatives for flood risk reduction, identifies multiple-benefit alternatives, and recommends a preferred flood risk reduction plan for the Knights Landing Basin.

The planning process reflects Yolo County priorities and preferences while considering the interests of potential project partners, permitting agencies, stakeholders, and local agencies. Proper identification of problems and opportunities is the foundation for the planning process.

Knights Landing was founded in 1843 by Dr. William Knight. It is located on the Sacramento River and built on high ground that marked the ancient meeting place of Native Americans inhabiting the region. The area demonstrated its importance as a steamboat landing and point of communication between the people east and west of the Sacramento River. Dr. Knight established a ferry and it was officially given the name of Knight's Landing.

Knights Landing has experienced a population decline from 1,100 residents in the year 2000 to 1,000 in the year 2010 based on the most recent census. According to an annual American Community Survey conducted in 2014, the population continued to decline to approximately 810 residents[1]. In 2016, the median household income in the community was $32,310. As this median household income is less than 80% of the state average of California, Knights Landing is designated as a “disadvantaged community” (DAC)[2].

The levees surrounding the Knights Landing Basin were originally built in the 1800s by local parties and were later incorporated into the Sacramento River Flood Control Project (SRFCP) during the late 1950s. The KLLS was constructed to United States Army Corps of Engineers (USACE) project standards by the late 1940s. Repairs and improvements to the system have been constructed as needed since then.

Knights Landing has invested in risk awareness and change in land use to reduce flood risk. However, the capacity to diversify the economy of Knights Landing and improve

[1] https://datausa.io/profile/geo/knights-landing-ca
[2] https://gis.water.ca.gov/app/dacs

quality of life for area residents is dependent upon agricultural sustainability, regional access to transportation networks, the availability of marketable business sites, and access to public services. All of these benefit from reducing flood risks.

1.2 Purpose and Scope

The purpose of this report is to identify structural and non-structural flood risk reduction actions; compare implementation costs, benefits, and schedules; and identify local funding requirements to implement alternatives. The alternatives are intended to reduce the flood risk to the Knights Landing Basin while sustaining agriculture and the regional economy, providing safe access to the Sacramento River, and improving riverine habitat viability. Alternatives are developed and compared, and a preferred alternative is identified. Opportunities to address water supply and regional levee maintenance governance are also included in the scope.

1.3 Location and Project Study Area

The community of Knights Landing is located along the Sacramento River in the northeastern portion of Yolo County northwest of the Yolo Bypass. It is at the confluence of the KLRC, the Colusa Basin Drain, and the Sacramento River Channel.

The study area is commonly referred to as the Knights Landing Basin which encompasses the densely populated community of Knights Landing and the large 2,754-acre agricultural area extending between Knights Landing and the Yolo Bypass (2014 DWR Landuse). It is bounded by the KLLS which consists of approximately 15.2 miles of perimeter levees.

Figure 1 Location of Knights Landing Flood Risk Reduction Study Area

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1.4 Related Plans, Programs, Studies, and Projects

The development of this Feasibility Study was informed by numerous plans, programs, studies, and projects related to the Knights Landing study area.

1.4.1 Central Valley Flood Protection Plan

The CVFPP is California's strategic blueprint to improve flood risk management in the Central Valley. The CVFPP includes a program to reduce flood risk in existing small communities (with populations less than 10,000 protected by State Plan of Flood Control [SPFC] levees), where feasible and at a level of investment to preserve development opportunities without providing an urban level of flood protection. Additional State investment in small-community flood protection would be prioritized based on relative community flood-threat, considering factors such as population, likelihood of flooding, proximity to flooding source, and depth of flooding. Financial feasibility and achievement of the program objectives to promote multiple benefits would also be considered.

The CVFPP identifies several structural and non-structural actions that the State would consider implementing to protect small communities, including:

- Protecting small communities in-place using ring levees, training levees, cut-off levees, or floodwalls when improvements do not exceed a certain predetermined cost threshold identified in the CVFPP and supporting Basin Wide Feasibility Studies (BWFS).
- Reconstructing or making improvements to existing SPFC levees providing protection to the basin(s) where small communities remain at risk to flooding.
- Implementing non-structural improvements, such as raising or elevating structures, flood proofing, land or easement purchases, relocating structures, or some combination of these when the in-place improvements described are not feasible.

Small-community flood protection is also included in the 2017 CVFPP Update (DWR, 2016a). Specific actions contemplated in the CVFPP have been refined to reflect updates from the BWFS and Regional Flood Management Plans (RFMP). The CVFPP Conservation Strategy supports integrated flood system planning and the development of the 2012 CVFPP and 2017 Update, and the formulation of multi-benefit project concepts articulated in the Sacramento and San Joaquin BWFS.

1.4.2 Sacramento River Basinwide Feasibility Study

The Sacramento River BWFS provides a more detailed and basin-specific description of the flood risk management strategies suggested in the CVFPP for the Sacramento River Basin. The improvements suggested in the Sacramento River BWFS informed the

2017 CVFPP Update and can be further elaborated upon in new or ongoing federal cost-share feasibility studies.

1.4.3 Lower Sacramento/Delta North Regional Flood Management Plan

The RFMPs, called for by the 2012 CVFPP, discuss flood management problems in specific regions within the Central Valley. Flood risks and management strategies for the Community of Knights Landing are evaluated in the Lower Sacramento/Delta North RFMP (LSDN RFMP). The LSDN RFMP (Figure 5-10 Section 5.2.2.1, page 135) introduced a potential cross-levee alignment for consideration just southeast of Knights Landing between the Sacramento River right bank levee and the left bank left of the KLRC. This cross-levee alignment shown in the RFMP is similar and size and scope to another potential cross levee previously identified in the 2012 CVFPP Attachment 8 J, Appendix D. Operations and Maintenance (O&M) issues in the levee system were also highlighted in the RFMP, noting the difficulty inherent to splitting the jurisdiction of the perimeter levee between three different Local Maintaining Agencies (LMAs).

During development of the LSDN RFMP, several key partner agencies recognized a unique opportunity to develop an ambitious multi-objective plan in the heart of the Sacramento River Flood Control Project. This plan, the Yolo Bypass / Cache Slough Integrated Water Management Plan (IWMP), seeks to provide system-wide flood benefits through modifications while simultaneously implementing significant habitat conservation, water supply, and agricultural sustainability improvements. The vision of this IWMP is to reduce the economic, environmental, and social costs of individually implementing competing project objectives in a small geographic area like the Yolo Bypass / Cache Slough complex. To achieve these goals, the current IWMP concept is developed around 11 plan elements and includes small community protection for Knights Landing.

1.4.4 Knights Landing Levee System Emergency Operations Plan Basic Plan 2018

This Joint Plan among KLRDD and CSA #6 establishes the emergency management organization required to mitigate any significant emergency or disaster in the KLLS. The Flood Emergency, Preparedness, Response, and Recovery Plan identifies the roles and responsibilities required to protect the health and safety of Yolo County residents, public and private property, and the environmental effects of natural and technological emergencies and disasters. The noted plan also establishes the operational concepts associated with a field response to emergencies, including actions with the County of Yolo Emergency Operations Center (EOC) during the response and recovery processes. This plan addressed the Flood Emergency Preparedness, including an Emergency Action Plan and flood-fight training deficiencies noted in the LSDN RFMP.

1.4.5 DWR Non-Urban Levee Elevation Geotechnical Assessment Report

DWR's Levee Evaluation Program was initiated in 2006 and concluded in spring 2015. Non-Urban Levee Evaluations (NULE) evaluated approximately 1,220 miles of SPFC levees and approximately 280 miles of appurtenant non-SPFC levees in the Central Valley in areas with populations of less than 10,000. NULE was performed in two phases. For all NULE levees, DWR has conducted extensive historic data collection and performed preliminary geotechnical evaluations using existing data. For NULE levees protecting populations greater than 1,000, DWR conducted a second phase of evaluations. These evaluations included physical explorations and geotechnical analyses and reporting.

All KLSS levees were a part of the NULE study. NULE Phase 1 was completed in 2011 with the publication of the Geotechnical Assessment Reports (GARs) and the Remedial Alternatives and Cost Estimate Reports (RACERs). NULE Phase 2 assessment built on Phase 1 results (as reported in the GAR) in DWR selected study areas by adding targeted field exploration, laboratory testing, and analyses to identify levee areas not meeting criteria established for NULE. Remedial alternatives and cost estimates were developed for levees not meeting these criteria. The Phase 2 work was summarized in Geotechnical Data Reports (GDRs) and Geotechnical Overview Reports (GORs). Only a portion, approximately 1.9 miles, of the KLLS was included in the NULE Phase 2 assessment.

The DWR NULE project collected and cataloged information on historical occurrences of levee settlement and subsidence. Most of the observed subsidence occurrences in the Sacramento River watershed are located along the Colusa Basin Drainage Canal and Yolo Bypass.

1.4.6 USACE Yolo Bypass Reconnaissance Study, March 1992

The purpose of this study was to investigate flooding and related water resources problems associated with the Yolo Bypass and determine federal interest in feasibility phase studies. The study area included lands on the west side of the Yolo Bypass from Fremont Weir in the north to the vicinity of Liberty Island in the south. The Knights Landing area, west of the bypass, was included because it experiences potential flood impacts from the Yolo Bypass.

The study objective was to provide the abovementioned areas with increased levels of flood protection. The three plans for the Knights Landing area and the no action plan were considered as final alternative plans and analyzed in more detail. The Knights Landing area plans consisted of three different alignments to provide flood protection to varying portions of the area. The plans consisted of raising and strengthening existing levees and providing new cross levees if needed. The first costs for the alignments were $8,793,000; $5,184,000; and $7,665,000.

1.4.7 Levee System Wide Improvement Framework, Knights Landing U2 – Yolo Bypass -Service Area 6 Levee System

The purpose of a Levee System Wide Improvement Framework (SWIF) – established in 2011 – is to address levee deficiencies identified by USACE. In 2012, a Periodic Inspection Report (PIR) was conducted of the KLLS levees and found 482 unacceptable items in the system related to encroachments, closure structures, slope stability, erosion or bank caving, and animal control; 36 of which were found to likely prevent the levee system from properly performing during the next flood event. In 2015, the USACE approved a Letter of Intent (LOI) to develop a SWIF for the KLLS which includes the levees on the right bank of the Sacramento River, the left bank levee of the Yolo Bypass, and the left bank levee of the KLRDD.

The SWIF prioritizes efforts toward mitigating identified issues as: 1) enhancing annual maintenance operations, 2) addressing urgent issues in site-specific project, 3) enhancing annual maintenance, 4) initiating environmental review and regulatory permitting for issues outside the purview of routine annual maintenance, and 5) participating in ongoing efforts to give LMAs in KLLS greater influence in the region, maintaining and improving collaborations with flood management agencies at local, State, and federal levels, and assisting LMAs in completing their flood protection measures in a cost effective way.

To mitigate the identified deficiencies, the following actions were suggested in the Draft 2017 SWIF developed by the KLRDD in coordination with CSA #6:

- **Encroachments:** The Central Valley Flood Protection Board (CVFPB) should issue Notices of Violations for those encroachments that are not properly maintained, inspected, or permitted. LMAs within the KLLS agreed to cooperate with the CVFPB to resolve these. Four of the 21 most serious encroachments were already repaired during the Knights Landing Levee Repair Project.
- **Closure Structures:** The Knights Landing Outfall Gate structure was found to be wholly unacceptable in the 2012 PIR due to two of the nine gates being non-functional. All deficiencies in this closure structure were remedied due to an extensive repair project in 2012, erosion repairs in 2015, and installation of a security gate in 2016.
- **Slope Stability:** Minor issues such as sloughing are being resolved by maintenance crews in the Knights Landing area, but more extensive issues exceeding the capabilities of routine maintenance are included in the State's Flood System Repair Program (FSRP). Those necessary repairs which are classified as "critical" warrant funding from the State to the appropriate LMA. Currently, the most critically unstable stretch of levee in KLLS is along CSA #6 in Yolo County, and it has an over-steepened vertical face cutting into the levee prism.

- **Erosion/Bank Caving:** In many instances, erosion and caving issues are related to animal burrows, which can be repaired with routine maintenance. Those erosion issues which are more severe have been included in the State's FSRP.
- **Animal Control:** This issue comprises approximately 19% of the deficiencies in the KLLS. Rodent damage is an ongoing issue for the system, and these critical issues can be fully addressed through routine maintenance. A significant portion of the Yolo Bypass West Levee Unit 1 (YBW1) is within the endangered Giant Garter Snake habitat, causing it to experience a grouting moratorium for the past 3 years. To address this, DWR is considering working with USACE to develop a SWIF Programmatic Biological Opinion. Furthermore, before rodent damage repair can continue, state and federal permits need to be acquired by DWR. Funding from the Deferred Maintenance Program will aid in procuring permits for endangered species and implementing rodent damage control measures. Incidental take permits should be acquired by 2019, at which point grouting of rodent holes in Giant Garter Snake habitat areas can resume.

DWR prepared an Environmental Impact Report (EIR) for these repairs and expects state and federal permits to be implemented within the next seven years[3].

1.4.8 Colusa Trough Drainage Canal (USACE 1993)

In November of 1986, the Water Resources Development Act authorized restoration of the SRFCP levees along the Colusa Trough Drainage Canal and KLRC. The area of interest included 13 miles of levee on the KLRC, and 36 miles of levee on the Colusa Trough Drainage Canal. In the USACE March 1993 project report, it was found that a total of 11 miles between the two stretches needed remedial construction to correct for stability and seepage issues. These problems were found to be the fault of poor soil conditions, rather than negligent maintenance. Of the 11 miles of levees in need of correction, only 2.5 miles along the KLRC were found to be feasible to repair. This repair was joined with the SRFCP Mid-Valley Area Phase III Levee Reconstruction Project[4].

1.4.9 Sacramento River Flood Control Project, Mid-Valley Area Phase III Levee Reconstruction Project (USACE/CVFPB)

The project involves the levee reconstruction as generally described in the Sacramento River Flood Control Mid-Valley Area Phase III Design Memorandum dated March 1996 and approved Chief's Report in August 1996. The Mid-Valley Project Area 3 includes the levees protecting Knights Landing. To support this report, in 1989, USACE performed a geotechnical study of levees comprising the SRFCP which exhibited poor performance, including seepage and boils, or required flood fighting during the 1986

[3] http://yoloagenda.yolocounty.org:8085/docs/2017/BOS/20170627_1799/6364_KnightsLg%20draft%20SWIF%202017-03.pdf

[4] http://www.dtic.mil/dtic/tr/fulltext/u2/b344261.pdf

flood. In 1995, the USACE identified Site 9 from levee mile 2.7 to 2.9, Site 10 from levee mile 3.0 to 3.2 and Site 11 from levee mile 4.3 to 5.4 in the Knights Landing Basin along the right bank for Sacramento River and completed a geotechnical investigation to determine the geotechnical recommendations for remediations. The 1996 Design Memorandum also identified Sites 12, 12A and 13 along the left bank (east) of KLRC.

On April 4, 2000 the CVFPB and USACE entered into a Project Cooperation Agreement for the Separable Elements Areas 2 (RD 1001), 3 (Knights Landing), and 4 (Elkhorn) of the Mid-Valley Phase III Levee Reconstruction Project for a total project cost of $8,681,000 to be cost-shared 25% non-federal and 75% federal. Area 1, at RD 1500, was completed in 1998 under a separate cost-share agreement. Area 3 of the Mid-Valley Area Levee Reconstruction Project levee reconstruction involves 3.4 miles of levee repair along the KLRC and 1.3 miles of levee repair along the west bank of the Sacramento River. The USACE released a Draft Engineering Documentation Report in 2012 to update the project design for these three areas. The repairs are necessary to simply restore the levees to their designed level of flood protection as originally authorized by Congress in the Flood Control Act of 1917. A Final Environmental Assessment/Initial Study was completed in 2013 for USACE Sites 9, 10, 11, 12, 12A, and 13. Sites 12, 12A, and 13 along the Ridge Cut were funded and constructed in 2014 as part of the DWR Early Implementation Program by KLRDD.

Despite the subsequent poor performance of these levees in the 1995 and 1997 flood events and the 2017 and 2019 high water events, these three areas of the Mid-Valley Project have never been completed. As such, the remainder of Area 3 at Knights Landing, Sites 9, 10, and 11 need to be addressed. USACE determined a Post Authorization Study and economic update is needed to confirm federal interest in continuing the project. Federal funding to complete this Post Authorization Study has not been secured and the project has become inactive.

1.4.10 Wallace Weir Improvements

Wallace Weir is a water-control structure on the downstream end of the KLRC where it enters the west side of the Yolo Bypass. The weir was a temporary 450-foot long earthen berm installed to create an irrigation backwater. This temporary berm blocked fish passage in the Colusa Basin Drain system until it was compromised by flood flows each year. The earthen dam, which washed away during high flow events, was replaced with a permanent structure that will withstand winter floods and prevent migration of salmon and sturgeon into the Colusa Basin Drain. A fish rescue facility is incorporated into the weir so fish that arrive at the Wallace Weir via the Yolo Bypass can be safely and effectively rescued and returned to the Sacramento River to resume their migration to upriver spawning grounds. An inflatable dam and positive fish barrier are incorporated into the new weir structure to better control water releases and fish attraction flows through the weir while blocking fish passage.

1.4.11 Agricultural Floodplain Ordinance Task Force Technical Memorandum

In 2014, FEMA officials and the Governmental Accountability Office encouraged exploration of ideas to address sustainability of modern agriculture in deep floodplains. The AFOTF was formed in late 2015, using RFMP grant funding from DWR. Its purpose is to explore ideas that could be implemented administratively by FEMA, without changing laws or regulations, for improving sustainability of agriculture in leveed Special Food Hazard Areas (SFHAs). The Task Force was comprised of officials from FEMA, DWR, CVFPB, RDs, levee districts, flood control agencies, counties, engineers, farmers, and non-governmental organizations (including various farm bureaus, the Association of State Flood Plain Managers (ASFPM), the National Association of Flood and Stormwater Management Agencies, and American Rivers). In 2016, the Task Force completed a Technical Memorandum with recommendations and provided it to FEMA for consideration.

The AFOTF developed recommendations for modifying FEMA's rules and practices under the NFIP to improve sustainability of agriculture in leveed SFHAs. The recommendations addressed how rules and practices could be modified to: (1) reduce or remove elevation and flood-proofing requirements for new and substantially improved agricultural structures, and (2) reduce the cost of flood insurance for agricultural structures with a federally backed mortgage to a more appropriate portion of the financial risk in the NFIP.

1.4.12 The Yolo County Habitat Conservation Plan

The Yolo County Habitat Conservation Plan (HCP) (ICF 2018) is a comprehensive, county-wide plan that identifies 12 sensitive species and the natural communities and agricultural land they use as habitat, as well as providing a streamlined permitting process to address any potential effects to these sensitive species. As the entire project study area is within Yolo County, the project would fall under the guidance of this document.

1.4.13 Yolo County and Knights Landing General Plans

The General Plan is a statement of the community's land use values. It guides virtually all land use decisions in the County. Zoning, Specific Plans, Area Plans, subdivisions, capital improvements, development agreements and many other land use actions must be consistent with the adopted General Plan. The core principles of the County General Plan are to preserve the rich soil resources in the county and to minimize urbanization. The County's plan was amended in 2007, which removed Specific Plan areas and rezoned areas in Knights Landing.

In addition, the Knights Landing Community adopted its own General Plan in 1992. The plan emphasized preserving the small-town character and described how the town is a

unique rural community set in an agricultural area of Yolo County. The plan established a goal to maintain the physical and economic integrity of agricultural lands and laid out how implementation of the General Plan will result in a compact town with a recognizable river theme and historical character.

1.4.14 Knights Landing Revitalization Study

In 2016, Yolo County used funds from a Community Development Block Grant to prepare the Knights Landing Revitalization Study. Completed in September 2016, the Study identified twelve recommendations to improve the economic potential of the Knights Landing community.

1.5 Stakeholder Engagement

Yolo County and its consultants for this Knights Landing Small Community Flood Risk Reduction Feasibility Study coordinated and met with the KLRDD, residents and landowners of Knights Landing, and agricultural land owners within the Basin, including Castle Properties.

Stakeholders played a significant role providing input with the identification of flooding concerns and the development of various alternatives to reduce flood risks. Representatives from the KLRDD participated in team meetings and provided input for the alternative evaluation and the development of this report.

On May 24th, 2018, the KLRDD and Yolo County representatives provided the study team with a tour of the basin to show issues and describe concerns to consider and described whom in the community to perform outreach and coordinate on as the study gets going. An emphasis was placed on the need to find smart funding sources for implementing the recommended plan and the importance of a Governance Study. These have been described in the *Problem and Opportunity* sections of this report.

On June 26th, 2018, Yolo County and the study team met with other land use agencies, DWR and other SCFRRP team members to discuss how non-structural measures were going to be considered and what of the AFOTF recommendations might be recommended for the project.

On July 23rd, 2018, Yolo County hosted an Open House at the Community Center to discuss CSA #6 O&M activities and introduce the study team. The attendees discussed concerns about seepage and drainage at the Post Office and discussed drainage concerns along 4th Street and Railroad. They requested that as we look at multiple benefit opportunities, they did not want any access to the Sacramento River except for a Promenade identified in the Revitalization Study or downstream of the Old River oxbow. Their concern stemmed from experience with the Boat Ramp across the Colusa Drainage Canal noting that cameras and patrol was needed to address homeless, drug use, and vandalism.

At the November 5th, 2018, stakeholder meeting at the Yolo County offices, representatives from the KLRDD, DWR, and a landowner attended. The study team presented the following findings of existing flood and ecosystem conditions

- Goal of the study
- Multiple study objectives for reducing the flood risk, for habitat enhancement, for agricultural sustainability, for providing safe access to the river near the community and along the Sacramento River near the Fremont Weir
- Water supply availability
- Hydraulic model simulation of a levee breach on the Sacramento River, just downstream of the community of Knights Landing
- Alternatives formulated to address the flood risk and how those were screened to focus on a final array that was carried forward for further evaluation and comparison

Stakeholders expressed concern over the lack of progress by the USACE on the Mid-Valley Levee Reconstruction project to address critical seepage and stability issues along the Sacramento River. It is understood that in terms of local acceptability, if the levees surrounding the Basin are not addressed, the KLRDD and assessed landowners will not pay for or support a cross levee option.

On January 21st, 2019, the County met with a representative from Castle Properties to learn more about their plans in the community and to provide an update to the subject study and confirm alignments of potential cross levee options. Castle Properties provides funding to the KLRDD to maintain the levee along the Colusa Drainage Canal along their properties and invested in upgrades to the wastewater treatment ponds.

On February 20th, 2019, Yolo County hosted another public meeting at Knights Landing Community Center to update the community on the progress of the study. A presentation was made on the final array of structural alternatives along with recommended, non-structural and multiple-benefit features considered, and a timeline for when the Draft Feasibility Study Report will be available for public input and comment.

On February 27, 2019, the feasibility study team discussed the study process and recommended alternatives to the KLRDD Board during their regularly scheduled board meeting.

On March 26, 2019, County staff discussed the study process and presented the recommended alternative at the Yolo County Board of Supervisors.

The Draft Feasibility Study Report was released for a 30-day public comment period on April 30, 2019 . No comments were received from the public. DWR provided comments

and feedback to the study team on June 12, 2019. The Draft Feasibility Study Report was revised to prepare the final report based on the comments received from DWR.

2 Problem Identification, Opportunities and Constraints

2.1 Existing Conditions

2.1.1 Hydrology and Hydraulics

The Sacramento River runs along the eastern side of the Knights Landing Basin within a single meandering channel. In 1871, RD108 constructed a 39-mile long levee on the west bank of the Sacramento River between Knights Landing upstream to the town of Sycamore in Colusa County to prevent flooding of district lands between the Sacramento River and the Back Levee. RD108 later contributed most of the funding to extend the west bank levee another 40 miles upstream from Sycamore. Based on the USACE 1957 design flow, the capacity of the Sacramento River reach in the study area is 30,000 cfs. This reach is downstream of the Tisdale Weir and as a result flows are lower when compared to upstream. One relief structure, the Fremont Weir, connects the Sacramento River with the Yolo Bypass just downstream of the Knights Landing Basin. The Fremont Weir is near the confluence of the Sutter Bypass, Feather River, and Sacramento River and is the key location to split flows from the entire Sacramento River System. The weir is intended to remove water from the Sacramento River system into the Yolo Bypass in order to lower water elevations downstream in the main stem of the Sacramento River.

The KLRC runs along the western side of the KLRDD Levee and receives water flows from the Colusa Basin Drain which collects streams and creeks originating in the Coast Range along with local drainage from northwest of the project area. Flood waters in the Colusa Basin Drain are contained by levees on its east side maintained from north to south by Maintenance Area 12, RD 108, and RD 787. At the south end of the Colusa Basin Drain, flood waters pool at the Knights Landing Ridge and flow through the KLRC into the Yolo Bypass. On the north side of the town of Knights Landing, the Knights Landing Outfall Gates and channel allow water to pass between the Colusa Basin Drain and the Sacramento River to allow controlled flow between the two noted waterways.

The Colusa Basin Drain carries runoff from more than a million-acre watershed in Glenn, Colusa, and Yolo Counties. A natural ridge between Knights Landing and the foothills to the west formed a barrier between the Colusa and Yolo basins, causing natural runoff to back up and eventually drain into the Sacramento River. The KLRC, an approximately eight-mile long canal, is designed to drain the Colusa Basin into the Yolo Bypass. It extends through Reclamation District 730 to drain water that backs up into lands lying north, primarily in RD 108. The KLRC, has a bottom width of 400 feet. It was

constructed by excavating two parallel channels and using the excavated material to construct two levees on the outside of each channel. The leveed cut was designed to convey 20,000 cfs. The two combined excavated channels act as low-flow outlet channels for the Colusa Trough Drainage Canal.

During flood conditions, flows from the Sacramento River enter the Yolo Bypass over the fixed Fremont Weir. During low stages on the Sacramento River, flows from the Colusa Trough Drainage Canal are discharged through the Knights Landing Outfall Gates into the Sacramento River. When the stage of the Sacramento River is high, the gates are closed, and flows from Colusa Trough Drainage Canal are conveyed through KLRC into the Yolo Bypass.

2.1.2 Topography and Levees

In general, the ground elevation for the entire length of the Knights Landing Basin descends from the Sacramento River southwestward toward the KLRC in the west and then south towards Yolo Bypass. Flood waters from a breach in Sacramento River levees will flow generally southwest toward the KLRC first then south toward Yolo Bypass rather than directly parallel to the river. The densely populated area of community varies in elevation from 31 to 41 feet and the lowest elevation in the basin is 23 feet. Figure 2 shows the topography of the Knights Landing Basin.

The study area receives an average annual precipitation of 19.5 inches. The levee heights along the Sacramento River right bank above Fremont Weir range from 10 to 20 feet above the landside ground surface within the Knights Landing Basin and crown widths vary between 15 and 45 feet. Within the Knights Landing Basin the levee heights along the KLRC range from 10 to 20 feet above the landside ground surface and crown widths vary between 15 and 45 feet. The levee heights along the Yolo Bypass West Levee range between 15 and 25 feet above the landside ground surface and the crown widths vary between 15 and 35 feet. To bring the system to the standards put forth by the USACE, starting in 1991, landside and waterside toe berms were constructed to stabilize the slopes constructed of soils with high plasticity and weak organic material. Lime was added to the surface where needed to prevent sloughing and cracking.

KLRDD has completed approximately 3.5 miles of landside slope stability repair (including slope flattening, a spoils berm, and landside toe ditch relocation where applicable) along the left bank of the KLRC levee, which was designed as part of Phase III of the USACE Mid-Valley Project, but never constructed by USACE. The improvements extend from the southern end of the Knights Landing wastewater ponds downstream approximately 18,200 feet to a location downstream of Country Road 16.

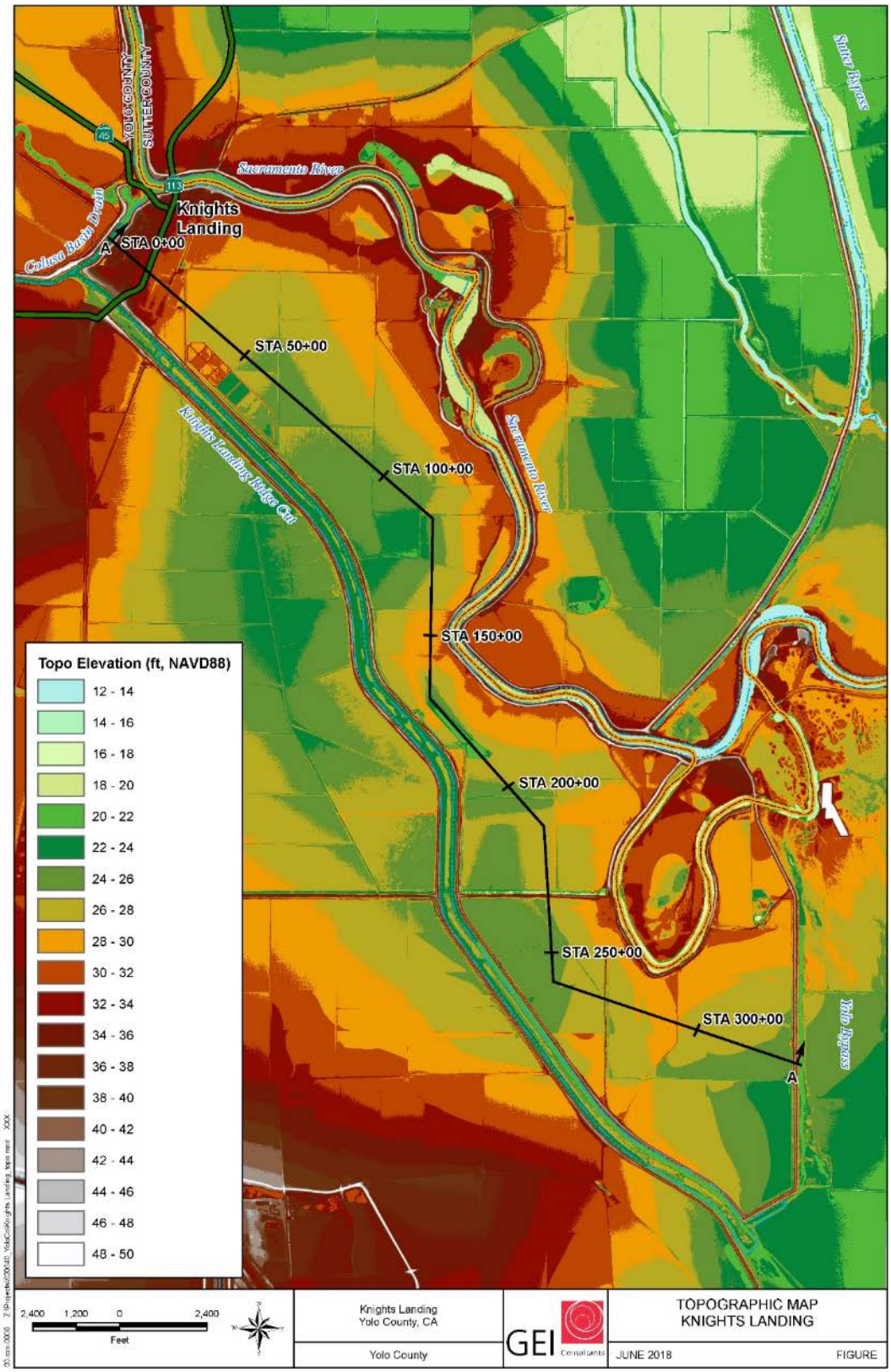

Figure 2 Knights Landing Basin Topography

2.1.3 Existing Infrastructure

The town of Knights Landing itself occupies only a small fraction – about 0.3 square miles – of the larger 5-square-mile Knights Landing Basin, with the large balance being agricultural. There are an estimated 323 structures in the Basin - 277 residential, 32 commercial, 5 industrial, and 9 public structures[6].

The KLSS consists of levees along the KLRC, the Sacramento River, the Colusa Basin Drain, and the Yolo Bypass (Figure 3). The levees were originally built by local interests in the 1800's and were later incorporated into the SRFCP during the late 1950's. The Knights Landing Outfall Gates are adjacent to the levee segment along the KLRC and are part of Sycamore Slough which connects the Sacramento River with the Colusa Basin Drain.

Aging utility penetrations present a greater risk to levee integrity and are a top priority for LMAs. Based on the SWIF developed by USACE in 2017, ten pipes have been identified in KLSS. These pipes are in an unknown condition but suspected to be failing or near failure due to their age.

The Southern Pacific Railroad line once went through Knights Landing to a few miles northeast of Woodland. That line is currently inactive and only the rail embankment still exists. In 2010, the Science and Technology Academy of Knights Landing opened on the former Grafton Elementary campus as a charter school. According to Yolo County, there were 257 students enrolled in 2016. Highway 113 bisects the town. State Route 45 intersects Highway 113 in the town. These are important evacuation routes. There is one post office and one fire department.

Knights Landing Community Services District owns and operates the Knights Landing wastewater treatment facility (WWTF), which is ½ mile south of County Road 116. The facility includes wastewater stabilization ponds on approximately 20 acres and a 31.5-acre spreading basin and percolation/evaporation ponds. This critical infrastructure is currently protected from flows in the KLRC by Levee segment KNT1 but is at risk from a break along the Sacramento River. The length of levee that is directly adjacent to the WWTF is 0.68 miles.

Crops grown within the study area are fairly diverse, including deciduous fruits and nuts, grain, hay, and berries. Primarily, though, the area relies on commodity crops like tomatoes, alfalfa, and rice[7]. There is also land in the region dedicated for pasturing purposes, and some primarily occupied by native vegetation. In order to support this agriculture, there is significant infrastructure including agricultural wells, pumps, storage facilities, barns, shops, and equipment.

2.1.4 Levee Operations and Maintenance and Local Governance for Knights Landing Basin

CSA #6 is responsible for levee operations and maintenance along the right bank levee of the Sacramento River, DWR along the right bank levee of the Yolo Bypass, and KLRDD along the 6.6 miles of left bank levees along the KLRC, Unit 2, Left Bank of the Colusa Basin Drainage Canal to Wallace Weir.

Created in 1975, CSA #6 manages 5.97 miles of the Sacramento Right Bank levee in the Knights Landing Basin, excluding the short, 0.59-mile portion in Sutter County. The CSA #6 levees protect approximately 4,498 acres. CSA #6 functions similar to an assessment district where the County collects a 0.5% property tax from levee-protected landowners to cover levee operations and maintenance activities. CSA #6 contracts with the Yolo County Planning and Public Works department, mining companies, and small contractors for levee O&M. The DWR Fall 2018 Levee Maintenance Deficiency Summary Report gave CSA #6 an Overall Unit Rating of Unacceptable due to encroachments, vegetation, rodent hole, erosion, and slope stability issues.

KLRDD was formed in 1913, primarily to construct the KLRC which was completed in 1916. The KLRC, also known as the Colusa Basin Drainage Canal, was implemented to provide a gravity drainage outlet for the Colusa Basin. KLRDD levies assessments on 71,000 acres and includes most of the land within RD 108. The assessment district extends beyond RD 108 however, roughly 8 miles south and east along the Sacramento River. Now, the KLRDD's primary responsibility is for O&M of the 13 miles of levee constructed as part of the KLRC. KLRDD currently contracts with RD 108 for all staffing and equipment needs. RD 108 General Manager and support-staff manage, design, construct, and provide all O&M needs for KLRDD. The DWR Fall 2018 Levee Maintenance Deficiency Summary Report gave KLRDD an Overall Unit Rating of Acceptable. KLRDD is not part of the Rehabilitation and Inspection Program (RIP) due to erosion along the KLRC.

The Yolo Bypass was designed in the early 1930s as part of the Sacramento Flood Control Project by USACE. The levees are maintained by DWR. The DWR Fall 2018 Levee Maintenance Deficiency Summary Report gave KLRDD an Overall Unit Rating of Acceptable.

2.1.5 Flood History

In January to February of 1878, Sacramento River flooding caused several levees to fail on the west side of the river, submerging multiple communities to the northwest and southwest of the City of Sacramento, including Knights Landing. In March of 1983, sloughs overflowed near Knights Landing, ultimately flooding numerous homes. In 1997, storm-induced floods throughout the state caused highways leading in and out of

the community to shut down[5]. As discussed in the 2017 update to the CVFPP, the flood management system has experienced much larger floods than those experienced during the events which led to the system's original design. Hydrologic variabliyt and uncertainty are increasing as a result of climate change, which may result in more severe or frequent flooding over time.

2.1.6 Biological Resources

Six vegetation communities occur in the project area, including irrigated agriculture, orchard, pasture, riparian, urban, and open water. Agricultural ditches and potential aquatic resources were also recorded in the project area. These resources are described in Appendix D: Environmental Constraints Analysis, Attachment D: Biological Resources Analysis. The vegetation communities in the project area also include habitat used by special status species with a potential to occur in the study area. Figure 4 shows the spatial distribution of vegetation communities in the Knights Landing Study Area. Specific species that could benefit include

[5] https://water.ca.gov/LegacyFiles/sfmp/resources/PRD_AttachC_History_4-3-13.pdf

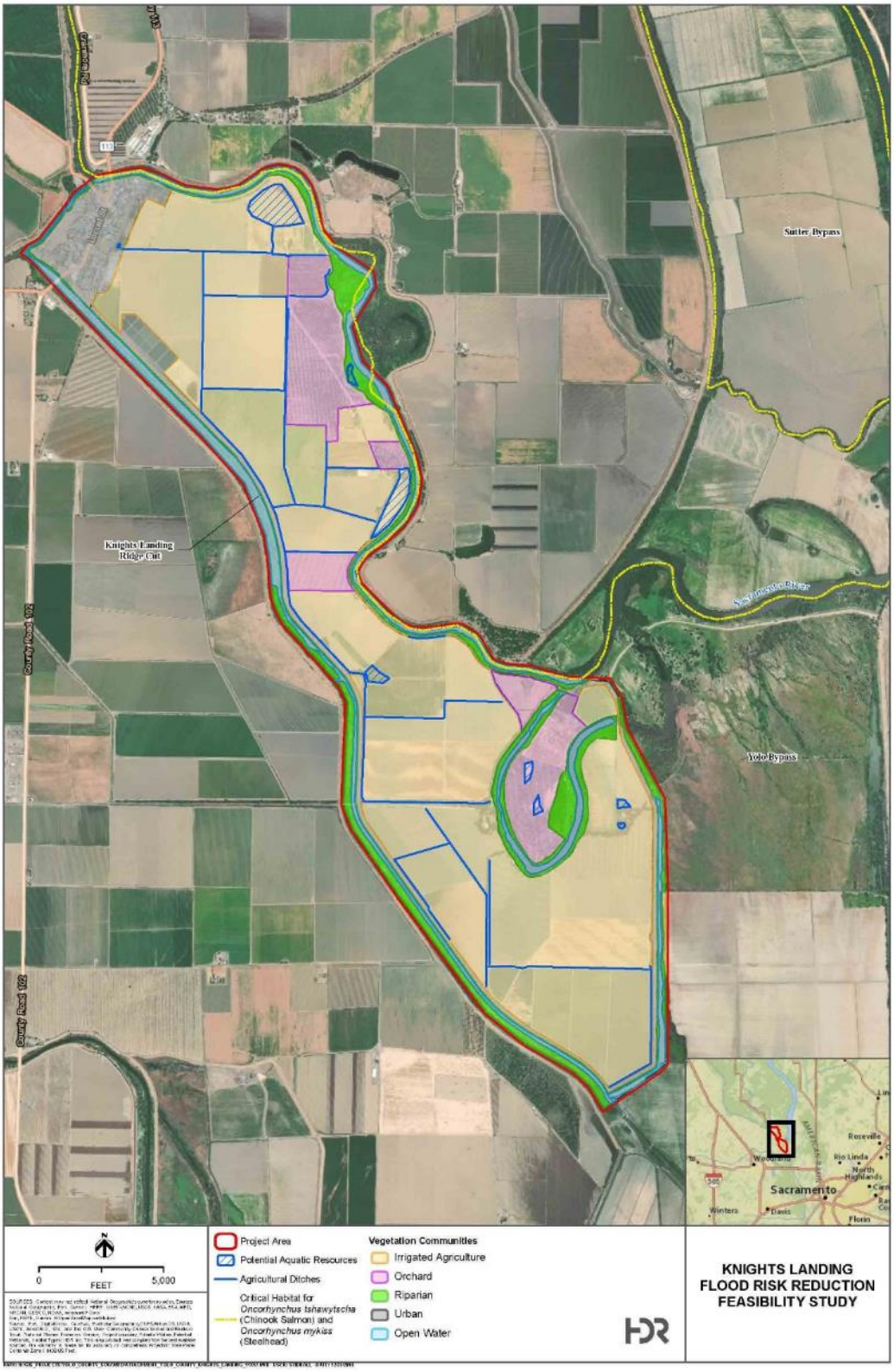

Figure 3 Spatial Distribution of Vegetation Communities in Knights Landing Study Area

Giant Garter Snake, valley elderberry longhorn beetle, tricolored blackbird, Swainson's hawk, Western Yellow-billed Cuckoo, and least Bell's vireo. Appendix D summarizes these special status species and their associated vegetation communities.

2.1.6.1 *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 (Appendix D: Environmental Constraints Analysis, Attachment C: Biological Resources Analysis). 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 the project area being located outside of known species ranges.

One aquatic species, the Giant Garter Snake, is included in Appendix D despite no known populations of this species occurring in the vicinity of the project area (CDFW 2018). Although this species is not expected to occur in the project area, it is included here due to the likelihood of the species needing to be addressed in any future consultation with U.S. Fish and Wildlife Service (USFWS). In addition, the Yolo HCP habitat model maps the project area as potential movement and overwintering habitat.

2.1.6.2 *Critical Habitat*

There are two USFWS-designated Critical Habitat Units that intersect the project area. The portion of the Sacramento River that is adjacent to the project area is designated as critical habitat for the Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*; Unit V08) as well as the California Central Valley steelhead (*Oncorhynchus mykiss irideus*; Unit V01.

2.1.6.3 *Cultural Resources*

According to information received from the Northeast Information Center, Knights Landing was founded in 1843 and was important as an early steamboat landing and point of communication between the people east and west of the Sacramento River. The Southern Pacific Railroad was completed in 1890, and bridges across the river were constructed shortly after. A historical map review indicates that, in addition to the community of Knights Landing, there were multiple residences in the eastern and northern portions of the project area scattered throughout what is now cultivated farmland. Therefore, sensitivity for historic archaeological sites and historical built environment resources is moderate-to-high throughout the proposed project area but concentrated within the community of Knights Landing and in the immediate vicinity of the historic residences.

A records search identified 34 previously recorded archaeological and built environment resources within the project footprint and an additional 12 recorded resources within 0.25 mile. Most of the previously recorded structures are in and around Knights Landing. Fifty-four previous investigations have been conducted, most of which were archaeological and/or historical field investigations. None of the previously recorded resources have been determined eligible for listing on the National Register of Historic Places (NRHP) or California Register of Historical Resources (CRHR).

Archaeological and built environment sensitivity within the project footprint and 0.25-mile buffer is highly variable and contingent on the type of resource (prehistoric vs. historical) and geography (proximity to the river). Today the area is generally low and topographically flat. A review of nineteenth-century General Land Office (GLO) maps confirms that much of the interior of the Project footprint was prone to inundation before the twentieth-century water control and flood management systems were constructed. These land management practices have almost totally obscured the original topographic landscape and have, undoubtedly, eliminated many near-surface archaeological sites.

2.1.7 Tribal Cultural Resources

Tribal Cultural Resources (TCRs) as defined by Public Resources Code (PRC) Section 21074 are either: (1) sites, features, places, cultural landscapes, sacred places, and objects with cultural value to a California Native American Tribe that is either on or eligible for inclusion in the CRHR or a local historic register; or (2) the lead agency, at its discretion and supported by substantial evidence, chooses to treat the resource as a TCR. Additionally, a cultural landscape may also qualify as a TCR if it meets the criteria to be eligible for inclusion in the CRHR and is geographically defined in terms of the size and scope of the landscape. Other historical resources (as described in PRC 21084.1), a unique archaeological resource (as defined in PRC 21083.2(g)), or nonunique archaeological resources (as described in PRC 21083.2(h)) may also be TCRs if they conform to the criteria to be eligible for inclusion in the CRHR.

Knights Landing was constructed on top of former Native American mounds which were typically located along the historic waterways. Previous investigations in the area have encountered prehistoric sites – including burials, buried hearths, and habitation sites – across the proposed project area, as well as sites within the levee itself. Accordingly, there is a low-to-moderate potential for near-surface unrecorded prehistoric or Native American sites within the un-surveyed portions of the project area; as well as a moderate-to-high potential for buried archaeological sites throughout the entire project area.

2.1.8 Water Supply

Water services in Knights Landing are provided by the Knights Landing Community Services District. The water system was constructed in the 1970s and the distribution consists primarily of 6-inch diameter pipes. It includes three wells:

- School Yard/Railroad Street well (Well 3) constructed in 1971 – capacity of 500 gpm
- Ridge Cut well (Well 4) constructed in 1981 – capacity of 1,000 gpm
- Third Street well (Well 5) constructed in 1999 – capacity of 1,500 gpm

The combined pumping capacity from the wells (3,000 gpm) meets both residential and commercial fire flow requirements (1,500 gpm residential, 2,500 gpm commercial), as well as the existing maximum use per day (408 gpm).

2.1.9 Funding Sources

Federal programs are currently provided under the USACE, FEMA, and the United States Department of Agriculture (USDA). Cost sharing percentages can vary widely based upon project specific attributes. The USACE has historically been the major financial contributor in the development of flood risk reduction infrastructures in California. The process for garnering federal funding for flood risk reduction projects requires that a federal interest in the project be identified. Federal interest has generally been identified and evaluated within feasibility studies prepared by the USACE that evaluate various criteria and generally emphasize the cost in relation to flood damage-reduction benefits associated within a specific project. Also, as noted in the Yolo Bypass Reconnaissance study that included a reconnaissance level study of costs and benefits for the various levee improvements within the study area, no economically feasible solutions for Knights Landing exist. Although small communities and rural areas generally lack the necessary benefits to justify a significant federal interest, under programs such as SCFRRP, these communities can be served through State-lead federal funding solicitations.

The State of California carries out several programs designed to provide flood management and multi-benefit ecosystem restoration and protection objectives. While some programs are operated directly by the State, others are provided grants to local agencies for similar purposes. State flood management and multi-benefit restoration programs have been funded through general funds. Since 1996, voters have authorized several State general obligation bonds, including Propositions 1E, 1, 68, and 84. Additional State funded opportunities such as FSRP to address high flood risks in rural areas, Flood Maintenance Assistance Program (FMAP) designed to assist LMAs in catching up on deferred maintenance and regaining eligibility in PL 84-99 programs, and Deferred Maintenance Program (DMP) to assist LMAs to address inspection and repairs of system pipe crossings. Other funding programs often become available to assist locals in identifying and reducing risk.

Funding local infrastructure and services, including flood and water management projects changed 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 enactment of Proposition 13 cut local property tax revenue significantly. This led local agencies and cash-strapped 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.

Currently, CSA #6 has no funding for construction of levee improvements to bring their system up from 20-year protection to the USACE designed 60-year protection as part of the USACE Mid-Valley Phase 3 Levee Repair Project. If completed, these adjustments still would not bring the levee into compliance with FEMA's 100-year levee standard. The estimated annual budget for 2013 was $39,400.

2.2 Problems

The levees in the KLLS were originally built to protect agricultural interests and properties and were not built to our current engineering, hydrologic nor geotechnical standards. Because the system was designed with limited hydrologic data and some subsequent subsidence may have occurred, the system does not have adequate capacity to convey the system design flows. A hydraulic model simulation of a levee breach on the right bank of the Sacramento River, just downstream of the community of Knights Landing, would have the greatest amount of water enter the Knights Landing Basin. The town is slightly elevated with respect to the rest of the Basin, but the simulated breach indicates floodwaters ponding the entire basin, including the entire community of Knights Landing. From the simulated levee breach, it takes approximately 7 hours for the floodwaters to reach County Road 16 and approximately 20 hours before water overtops the old levees at Grays Bend into the "Old River" area. The maximum flood depths are between 13-18 feet in the Knights landing Basin and the floodwaters remain in the Basin due to the low topography.

The following problems were identified from site visits, stakeholder engagement, and review of existing data and reports.

2.2.1 Flood Risk

The study team leveraged numerous state and federal studies of the Knights Landing Basin and input from the community to identify flood risk problems. Several locations with underseepage, through seepage, erosion, stability, and freeboard problems were identified along the KLLS. Several segments of levee in the Knights Landing area including along the KLRC, and the Sacramento River, were found to be in either critical or serious state from FSRP Assessments. The most significant problems identified in the system by the State in 2018 were in CSA #6.

During the stakeholder engagement, residents confirmed seepage issues, specifically with ponding at 4th Street and the railroad, and flooding of the community's post office parking lot. Community members also confirmed freeboard issues at specific locations

along the Sacramento River where the water level was close to overtopping during the 1997 flood event and continue to be close to overtopping in high water events as experienced during February 2019 events. Figure 4 shows high water during the February 2019 event.

Figure 4 High Water Event at Knights Landing, February 2019

2.2.1.1 *Erosion*

Erosion has been a historical issue along the Sacramento River and there has been significant revetment placed along the channel banks. During the 2017 and 2019 high water events, there was continued erosion along the Sacramento River right bank levee.

When water reaches the USACE 1957 design WSE, there is a high likelihood that erosion problems will either result in levee failure or the need to flood-fight to prevent levee failure on the Sacramento River Right Bank and Colusa Basin Drainage Canal Right Bank (eastern portion) and a moderate likelihood that erosion problems will either result in levee failure or the need to flood-fight to prevent levee failure on the remaining levees of the KLLS. Stability and erosion problems were identified between levee mile

4.9 and 6.0 along the left bank of the KLRC. KLRDD also noted erosion along the Colusa drain.

The DWR Fall 2018 Levee Maintenance Deficiency Summary Report noted erosion problems in CSA #6 The inspection report noted urgent erosion at levee mile 2.35. Between levee mile 3.18 and 3.28 there is a history of erosion. In 2006, a short section of erosion was into the levee toe, and the rest was near the levee toe, with mass failure and fluvial erosion of depositional material. In 2011, minor new erosion was noted, and the slope continues to steepen, tree roots have become exposed, and a new eddy formed.

Between levee mile 5.67 and 5.85, Approximately 18 to 20 ft of bank has been eroding since 2006 near the levee at the corner of the levee and the Fremont Weir. The vertical bank was undercutting in 2007. In 2011, the site had become significantly worse with more of the toe and lower bank eroded. Inspection reports in 2012, 2013, 2015, and 2016 noted erosion worsening and extending upstream about 500 ft. to account for eroding bank. In 2018, the report noted multiple trees appear ready to fall into the river. However, problems along the Yolo Bypass are not addressed as part of this study as (DWR) is currently addressing them as part of larger Sacramento River Basinwide flood reduction efforts.

2.2.1.2 *Underseepage and Through Seepage*

When water reaches the USACE 1957 design water surface elevation (WSE), there is a moderate likelihood that underseepage and through seepage problems will either result in levee failure or the need to flood-fight to prevent levee failure Sacramento River Right Bank and Colusa Basin Drainage Canal Right Bank (western portion) and a moderate likelihood that through seepage problems will either result in levee failure or the need to flood-fight to prevent levee failure on the KLRC and Colusa Basin Drainage Canal Right Bank (eastern portion). The Yolo Bypass Right Bank levees currently lack sufficient data about past performance or hazard indicators to determine the risk of levee failure or flood fighting due to underseepage problems.

Along the right bank of the Sacramento River, through seepage was identified near levee mile 1.0, 2.7, 3.0 and 4.0 and underseepage was identified near levee mile 1.0 and 4.0 along with freeboard deficiency at levee mile 0.5. During 2019 high water, seepage began along the Sacramento River levee in CSA #6 when the water surface elevation was at or slightly below the levee toe. The most significant seepage in 2019 was along the right bank of the Sacramento River, within a mile of the confluence of the Yolo Bypass. Figure 5 shows the progression of seepage along the Sacramento River at approximately levee mile 4.0 between February 19, 2019 and March 1, 2019.

Figure 5 Seepage along Sacramento River at levee mile 4.0, February 19, 2019 & March 1, 2019

2.2.1.3 *Slope Stability*

When water reaches the 1955/57 design WSE, there is a high likelihood that slope stability problems will either result in levee failure or the need to flood-fight to prevent levee failure on the KLRC and Colusa Basin Drainage Canal Right Bank (eastern portion), and a moderate likelihood that erosion problems will either result in levee failure or the need to flood-fight to prevent levee failure on the Yolo Bypass Right Bank levees. The Sacramento River Right Bank has areas of apparent over-steepened slopes that may cause stability concerns during elevated water levels. Additionally, erosion of the channel banks could result in stability concerns along the waterside of the levee. There were no stability issues observed during the 2017 or 2019 high water events in CSA #6. The Colusa Basin Drainage Canal Right Bank (western portion) are currently lacking sufficient data about past performance or hazard indicators.

2.2.1.4 *Inadequate Freeboard*

To evaluate the existing flood risk to the community of Knights Landing, recent hydrologic and hydraulic models were used to quantify flooding. Modeling used on the newly developed Central Valley Hydrology Study (CVHS)which involves scaling historical flood patterns to represent the desired frequencies, such as the 1-percent annual chance flood event.

Historically, the Knights Landing Basin has not experienced overtopping. The study modeling confirmed that for the USACE 1957 Design WSE and the 1-percent annual chance flood through the riverine system, there was no overtopping into the Knights Landing Basin. The computed WSE for both the 100-year flow and the 1957 Design flow in the Sacramento River and KLRC Cut were compared to the California Levee

Database (CLD) to determine the levee freeboard for the Basin Though there is no overtopping, this analysis shows reaches of the levees do not have the minimum required three (3) feet of freeboard. Figures 6 and 7 show the comparison of WSE to top of levee and Figure 8 shows the reaches of levee that lack adequate freeboard for the 1-percent annual chance flood.

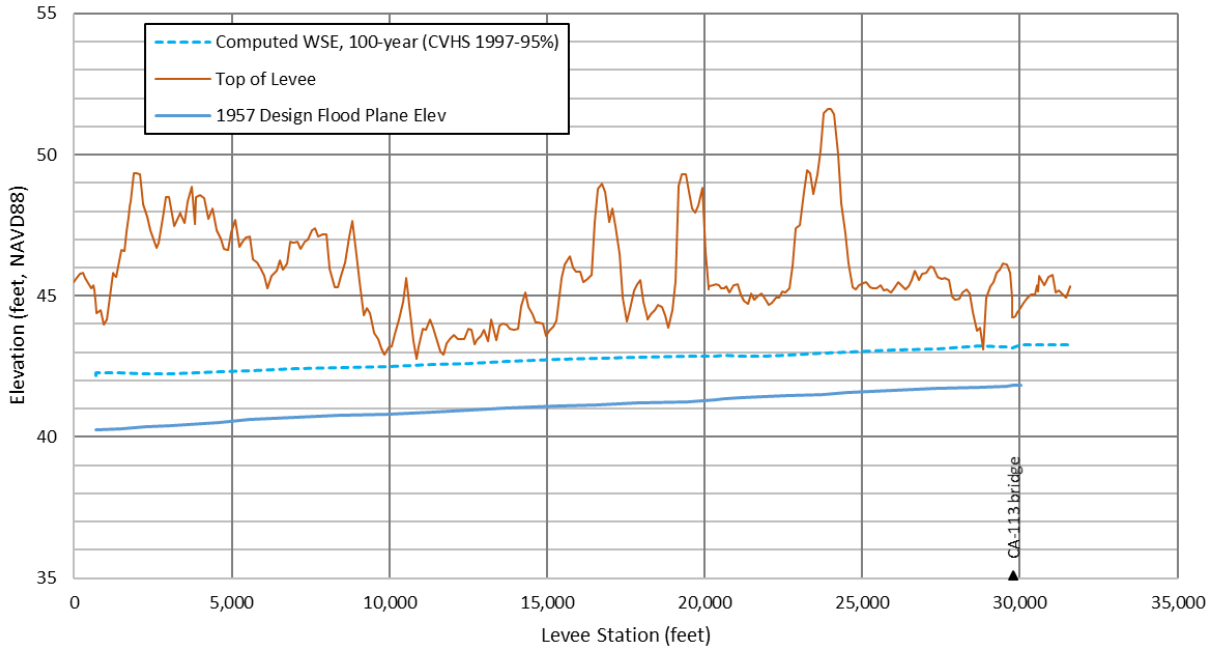

Figure 6 1-Percent Annual Chance Flood and 1957 Design Elevation for Sacramento River

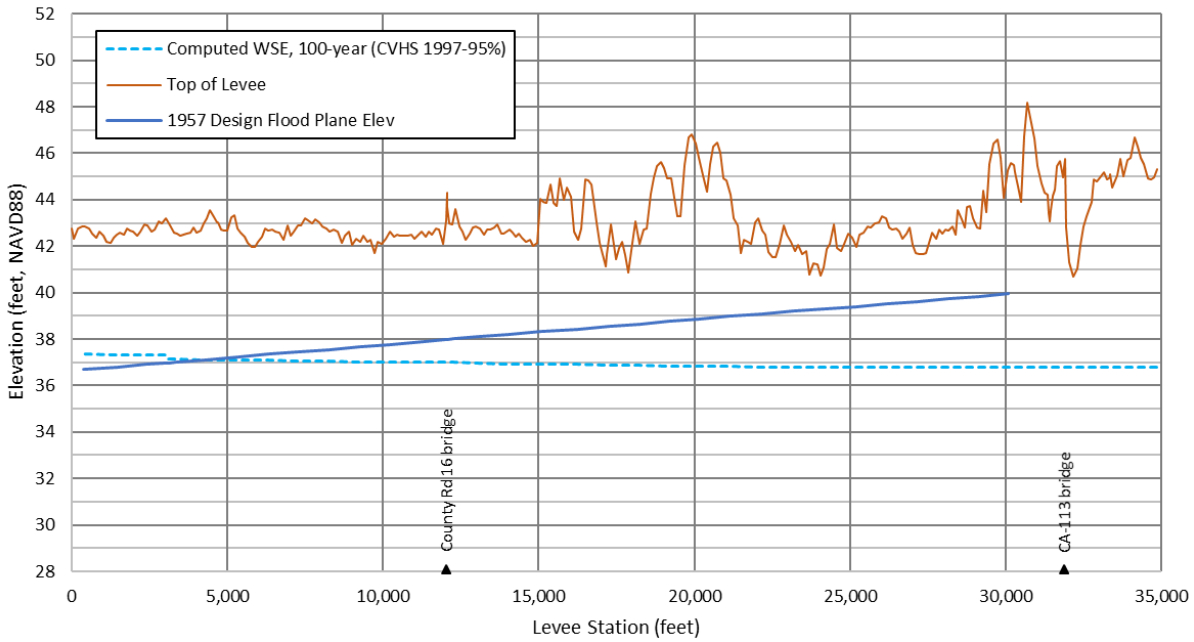

Figure 7 Percent Annual Chance Flood and 1957 Design Elevation for KLRC

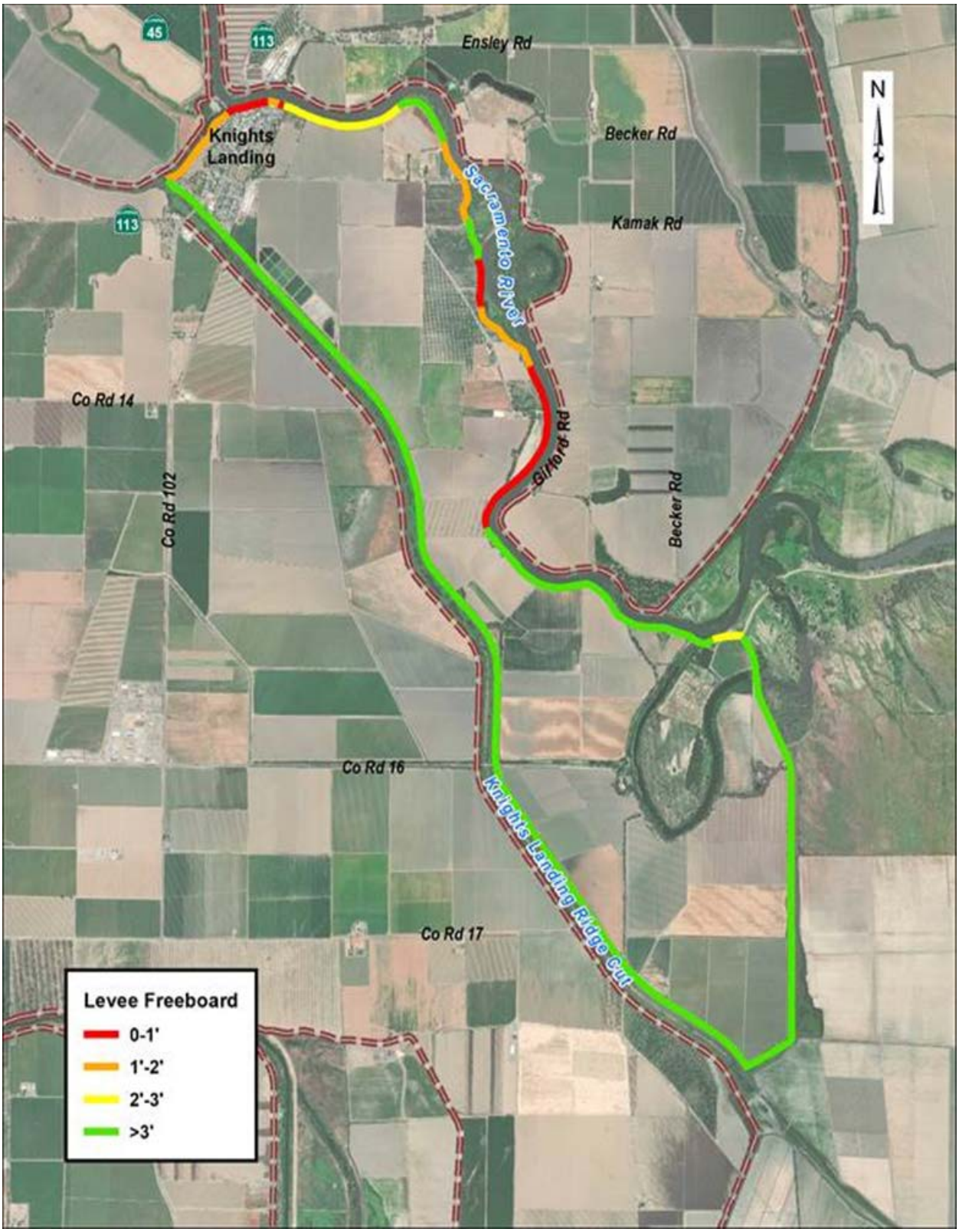

Figure 8 2-D Freeboard for 1-Percent Annual Chance Flood for Levees Surrounding Knights Landing Basin

2.2.1.5 *Expected Annual Damages*

The 2017 update to CVFPP provided a systemwide approach to improve flood risk management and ecosystem benefits for lands protected and affected by existing facilities of the SPFC. The community of Knights Landing and the remainder of the Basin are included in the SAC13 and SAC14 areas respectively in the CVFPP analyses. The CVFPP technical analysis estimated that the total structures and contents depreciated replacement value for Knights Landing Basin is approximately $105 million. As a result, the Expected Annual Damages (EAD) for the Basin is $875,000 per year (in 2014 dollars). EAD is not the estimated damages of a single flood event, rather it is the annualized damages for a given area based on the probability of flooding and the potential damages due to flooding. EAD is one of the several metrics used in the 2017 CVFPP update to evaluate proposed alternatives for improved flood protection.

In addition, the 2017 CVFPP estimated that the Knight's Landing Basin's level of protection ranges between 10 and 25 years (meaning the surrounding levees are estimated to withstand the 10 to 25-year storms).

2.2.1.6 *Future Without Project Conditions*

The future without project conditions are the current existing condition. Under existing conditions, the Knights Landing Basin faces an increased risk of levee failure which would inundate the entire basin as explained in Section 2.2. As a result, the community of Knights Landing along with agricultural areas and other key infrastructures in the basin would have flood depths of approximately 13 feet to 18 feet. Depending on the storm event, flood water would remain in the basin for a significant amount of time before draining into the Sacramento River. This could result in agricultural fields staying out of production for a season, extended residential flooding, potential loss of life, and significant damages to key infrastructure.

In addition, FEMA flood-control requirements restrict property owners from fully improving their buildings, making them more attractive to consumers, which may further constrain the potential to attract entrepreneurs and new business in Knights Landing. New housing or commercial buildings in Knights Landing are financially infeasible unless and until the existing levees are certified. If the levees fail, the depth of flooding would exceed 3 feet, with flooding much higher in some locations.

2.2.2 FEMA

The current FEMA Flood Insurance Study (FIS) for Yolo County is dated May 16, 2012 (FEMA, 2012). The current FIS maps the floodplain for the 1-percent annual chance floodplain on the Floodplain Insurance Rate Maps (FIRM) for Yolo County. The community of Knights Landing is mapped in a Special Flood Hazard Area (SFHA) Zone A due to the inability to accredit the levee system to FEMA standards (Figure 9). FEMA defines Zone A as "the flood insurance rate zone that corresponds to the 1-percent

annual chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses were not performed by FEMA or others for such areas, no base flood elevations or depths are shown within this zone." Though there is not a detailed study to provide base flood elevations (BFE), the non-compliance of the levees surrounding the Knights Landing Basin leads to the Zone A determination.

Figure 9 FEMA Flood Map for Yolo County Near Community of Knights Landing

Under current FEMA regulations and current NFIP policies, risk premiums and impractical building standards will continue to affect the existing property owners. The mandated insurance and building restrictions associated with being remapped into Zone A in June of 2010 has caused significant impacts to the Small Community and threatens agricultural sustainability. There are two primary impacts when an agricultural area is mapped into an SFHA: (1) land use requirements for elevating or flood-proofing new and substantially improved (which includes substantially damaged) structures to or above the Base Flood Elevation (BFE); and (2) a requirement to purchase a flood insurance policy through the NFIP for each structure with a federally backed mortgage (aka mandatory insurance purchase requirement). Flood insurance is only effective at reducing residual risk if the community is willing and able to purchase insurance and if the NFIP allows sustainable agriculture operations in the floodplain. Further, insurance rates are very high in deep floodplains like Knights Landing making these policies difficult to afford

2.2.2.1 *FEMA Levee Accreditation*

In order to be accredited, a levee or a levee system must meet minimum standards listed in the NFIP Code of Federal Regulations (CFR) at Title 44, Chapter 1, Section 65.10 (44 CFR Section 65.10), including design, operation plans, maintenance plans, and certification. If an earthen levee in not accredited, it is assumed to fail. Therefore, the floodplains in the area of such an inadequate levee reflect flood conditions as if this flood-control structure did not exist. The FEMA criteria used to evaluate protection from the 1-percent annual chance flood, as depicted in 44 CFR 65.10, are (1) adequate design, including freeboard, (2) structural stability, and (3) proper operation and maintenance. Levees that cannot be certified to provide protection from the 1 percent annual chance flood are not considered in the hydraulic analysis of the 1-percent annual chance floodplain. The levees protecting Knights Landing have not been certified and, therefore, are not considered in the FEMA hydraulic analysis.

As a result of remapping Knights Landing into a SFHA Zone A, the community is now subject to strict requirements for building in flood zones and purchasing flood insurance. These building requirements mandate that the lowest floor elevation for living areas must be “at or above the BFE”, which could range from 7.5 to 13.5 feet above ground.

2.2.2.2 *Escalating NFIP Insurance Premium Rates*

On July 23rd, 2018, Yolo County hosted an open house in Knights Landing and one landowner indicated that flood insurance rates went up drastically around 2012 and subsequently, he dropped his NFIP coverage all together and has not had any since. As previously stated, flood insurance is only effective at reducing residual risk if the community is willing and able to purchase insurance and if the NFIP allows sustainable agriculture operations in the floodplain.

The Biggert Waters Flood Insurance Reform Act of 2012, which attempts to recover the recent debt accrued by the NFIP as a result of damages incurred by major hurricanes and super storms, established an increasing rate structure to eventually result in an actuarial based system. These rating changes being implemented will greatly increase rates for existing structures in the SFHA over time. The current insurance pricing trends are greatly burdensome, further stifling community and agricultural development in the region, and as a designated Disadvantaged Community (DAC), Knights Landing does not have the tax base to support such rates. Approximately 194 policies are in place in Knights Landing at an average cost of $940 per year and will continue to rise as actuarial rates are implemented through the NFIP. The preferred premium flood insurance cost is $400 per year. Effective April 1, 2019, FEMA increased the annual insurance premium an additional 8.2%.

2.2.3 Agricultural Sustainability

Agricultural sustainability is a large part of the economic health of the Knights Landing community. Yolo County efforts to improve agricultural sustainable and viability include incorporation of new technology into farming, diversifying crops, growing organic produce, exploring ag-tourism options, improving marketing, and investing in sustainably agricultural practices[6]. As a result of the area being mapped in the FEMA base floodplain as described above, such modernization efforts may be suspended until Knights Landing adopts more flood protection.

Because of the benefits of agricultural operations and relatively low residual risk of agriculture in the leveed floodplain, members of the AFOTF have sought to change FEMA and NFIP's administration of agricultural areas in ways which will be less financially distressing for rural communities like Knights Landing that are at risk of flooding.

A review of FEMA's mapping procedures, insurance requirements, insurance rates, and policies indicates that agricultural facilities in leveed areas of the Sacramento Valley are beginning to bear a disproportionately large share of the financial burden of the NFIP. The financial burden is substantially greater than the risk exposure as a result of the following practices and policies:

- Insurance premiums are based on the assumption that a non-accredited levee provides no flood protection, when in fact most non-accredited SPFC levees in the SRFCP provide a substantial amount of flood protection that can be quantified and recognized. Since agricultural areas can rarely afford to meet current accreditation standards, the effect is that many leveed agricultural areas pay insurance premiums that are much higher than the actual flood risk.
- Insurance premiums for agricultural structures are generally the same as for retail business and industrial structures, which are thought to be more vulnerable to flood damage than agricultural structures.
- Fully wet flood-proofed structures which are designed to minimize damages from flood waters are required to pay insurance premiums as if they had no flood-proofing.
- Each structure on a parcel is required to have an individual policy with a $250 annual surcharge. Farms typically have far more structures than other types of businesses.
- Low-value detached agricultural structures such as sheds and pole barns are required to have flood insurance coverage when similar structures associated with a residence would not.

[6] http://www.yolocounty.org/home/showdocument?id=14351

- Insurance premiums for structures in areas protected by well-studied sound reaches of non-accredited levee are charged at higher Zone A rates, the same as areas of undetermined flood risk.

The mandated insurance and building restrictions associated with remapping into Zone A in June of 2010 has caused significant impacts to the Small Community and threatens agricultural sustainability. There are two primary impacts when an agricultural area is mapped into an SFHA: (1) land use requirements for elevating or flood-proofing new and substantially improved (which includes substantially damaged) structures to or above the BFE; and (2) a requirement to purchase a flood insurance policy through the NFIP for each structure with a federally backed mortgage (mandatory insurance purchase requirement). Flood insurance is only effective at reducing residual risk if the community is willing and able to purchase insurance and if the NFIP allows sustainable agriculture operations in the floodplain.

2.2.4 Habitat/Ecosystem Restoration

Riverine habitats and ecosystem functions have degraded over time. The geographic extent, quality, and connectivity of native habitats in the Central Valley have all declined.

2.2.5 Recreation

Safe public access to the river, especially near the community and along the Sacramento River near the Fremont Weir is not readily available. Currently, public access to the Sacramento River is limited to downstream near the Old River oxbow and on the right bank portion of the levee in Sutter County. In CSA #6, foot traffic on the levee has caused erosion at levee mile 3.41 and the levee slope has been damaged by vehicle traffic at levee mile 3.59 and 5.18, contributing to an Unacceptable Overall Maintenance Rating in 2018.

2.2.6 Operations and Maintenance and Local Governance

The responsibility for the existing perimeter levees of KLLS is split between three different LMAs, which complicates its operation and maintenance by creating the opportunity for lapses in practical coordination.

2.2.7 Water Supply Reliability

As explained in Section 2.1.8, three wells with a combined pumping capacity of 3,000 gpm provided water to meet residential, commercial, and fire flow demand. However, inadequate pipeline diameter sizing of 6 inches throughout most of the water distribution system constrains the delivery of these flows. Therefore, existing non-residential fire flows do not meet current requirements.

The existing pumps have not been reliable, resulting in failure to meet drinking water quality standards. Two of the three wells failed in 2015 requiring residents to restrict outdoor watering and implement in-home conservation measures. One well was

recently repaired and placed back into service, but repair of the second well may cost more than $1 million with no funding available.

2.2.8 Ability to Pay

The KLLS is unable to meet requirements of 44 CFR 65.10 for levee accreditation. Currently, CSA #6 has no funding for construction of levee improvements to bring their system up from 20-year protection to the USACE designed 60-year protection as part of the USACE Mid-Valley Phase 3 Levee Repair Project, and additional improvements would be required to meet FEMA accreditation. Agricultural areas generally do not have the financial means to improve levees sufficiently for accreditation, so it is not possible in most cases for agricultural areas to avoid being mapped into an SFHA or to perform the levee investigations and repairs required for being mapped out of an SFHA. Further, many agricultural areas were developed prior to the NFIP or after original FIRMs showed these agricultural areas as low-risk areas protected by levees (Zone X). Although development was basically unrestricted, these areas continued to maintain low risk agricultural development. It was not until FEMA's Map Modernization began in 2001 and the requirement in 2005 for communities to document that these levees meet rigorous engineering standards that these areas began to be mapped as SFHAs and were forced into strict building provisions and expensive flood insurance premiums that greatly impact the sustainability of agriculture.

2.3 Opportunities

2.3.1 Agricultural Sustainability

As described above, the levees protecting Knights Landing have not been certified and, therefore, are not considered in the FEMA the hydraulic analysis of the 1-percent annual chance floodplain. Opportunities to address agricultural sustainability in the basin include changes to the NFIP to support agricultural operations in the floodplain and structural flood risk.

2.3.2 Habitat/Ecosystem Restoration

There are opportunities to improve the quality and quantity of shaded riverine aquatic (SRA), improve habitat connectivity, and to restore key habitat and ecosystem function.

2.3.3 Recreation

There are opportunities to provide access to the Sacramento River by adding parking and ramps where levees are widened to address the seepage and erosion in areas with direct connectivity to publicly owned or public trust land areas along the river. These areas include upstream of Highway 45 and areas along County Road 116B. The Knights Landing Revitalization study proposes a riverfront promenade overlooking Sacramento River east of 113 and along Front Street and includes parks, public spaces and another boat launch and features of that plan could be incorporated in levee

projects. Additionally, there is currently no public access point to the Fremont Weir Wildlife Area and there may be opportunities to provide access through the private property if improvements are completed in that area.

2.3.4 Operations and Maintenance and Local Governance

The KLLS must be able to be operated and maintained to meet State and federal standards. Structural measures and improvements to the KLLS could reduce maintenance and repair requirements by modifying the flood management systems in ways that are compatible with natural processes, which would contribute to streamline regulatory and institutional standards, funding, and practices for operations and maintenance. The alternatives should develop stable institutional structures, coordination protocols, and financial frameworks that enable effective and adaptive integrated flood management (designs, operations and maintenance, permitting, preparedness, response, recovery, and land use and development planning). Opportunities may also exist for consolidation of local maintaining agencies, or formal cooperation agreements between the agencies to improve Operations and maintenance of the entire levee system within the basin.

2.3.5 Water Supply Reliability

To remedy the existing water supply reliability problems, additional facilities including new pumps, deeper wells, storage facilities, and distribution infrastructure would be required. Although no clear water supply reliability options were evaluated in this study, there may be the potential to include actions in combination with future flood risk reduction projects to improve water supply to the Community.

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3 Plan Formulation

The plan formulation process identifies and responds to problems and opportunities associated with the objectives and specified State and local concerns. The process provides a flexible, systematic, and rational framework to make determinations and decisions at each step so that the interested public and decision makers are fully aware of the basic assumptions employed, the data and information analyzed, the areas of risk and uncertainty, and the implications of each alternative plan. As a comprehensive feasibility study for Knights Landing, the formulation of flood risk reduction alternatives includes structural and non-structural alternatives to reduce flood risk.

3.1 Planning Goals and Objectives

The ultimate goals for this report are to identify a preferred flood risk reduction alternative that will attain a 100-year level of flood protection for the community of Knights Landing, sustain agriculture and the regional economy and will improve the riverine habitat viability.

3.1.1 Flood Risk Reduction

For small communities, 100-year protection (1% probability of flooding per year or less) is an unofficial target established by Congress' 1968 National Flood Insurance Act, under which communities that voluntarily participate in the NFIP are no longer subjected to mandatory flood insurance. While the Legislature or FEMA did not require a specific level of protection for rural-agricultural levees, DWR recommends an approach without numerical targets to repair distressed levees as needed to sustain existing land uses or consider levee setbacks to provide multiple benefits associated with different land uses. Additionally, as part of the 2017 update to the CVFPP, the CVFPB established a goal to attain a 100-year level of flood protection for Small Communities in the Central Valley including the community of Knights Landing in accordance with FEMA's guidelines pursuant to CFR Section 65.10.

3.1.2 Sustaining Agriculture

Structural alternatives that address improvements needed to reduce the risk of KLLS levee failures would promote agricultural sustainability. Although a goal is to meet the FEMA criteria used to evaluate protection from the 1-percent annual chance flood for the agricultural areas would significantly promote agricultural sustainability, it would also potentially induce additional residential development thereby increasing the residual risk in the basin. As a result, exploring alternatives that combine some structural flood risk alternatives to improve the highest risk levees with non-structural actions to promote agricultural sustainability will be key to meet both local and State objectives.

The AFOTF explored non-structural ideas for addressing both land use requirements (i.e., elevation and floodproofing of new and substantially improved structures) and insurance requirements. The recommendations included non-structural actions that require action by FEMA, and elevation and floodproofing that could improve agricultural sustainability while reducing flood risk. Many of these are policies yet to be considered and are not within the influence of the study team to address as a part of evaluating measures and alternatives to address. Of the nine recommendations, only one, Levee Relief cuts with EOP and floodplain management ordinance, can be implemented within the scope if this report. An additional non-structural alternative to promote agricultural sustainability while reducing flood risk would be agricultural conservation easements.

3.1.3 Improving Riverine Habitat Viability

Objectives to improve the riverine habitat viability are the following:

- Improve the quality and quantity of SRA habitat
- Increase and improve the quantity, diversity, quality, and connectivity of riverine aquatic to floodplain habitats
- Contribute to the recovery and sustainability of native species populations and overall biotic community diversity by restoring species habitat and ecosystem function
- Reduce stressors related to the current operations and future improvements of the Knights Landing flood protection system that negatively affect at-risk species.
- Combat non-native and/or invasive species to re-establish native riparian habitat

3.2 Alternatives Development

A CVFPP goal is to promote multi-benefit projects that integrate flood risk reduction with other resource needs including recreation and open space. Although this report was able to identify various opportunities for other benefits that may be combined with flood risk actions, it was determined that setback levees would not be viable options to meet the objectives of this study due to lack of hydraulic benefit and significant impacts to agricultural lands.

As such, the team formulated both structural and non-structural alternatives to address reducing flood risks. Then other multi-benefit concepts for restoration, recreation, and water supply were formulated separately and merged with identified alternatives. With consideration of the study objectives to improve flood risk management, enhance habitat restoration, provide recreational benefits, and support agricultural sustainability in Knights Landing, a wide array of alternatives were formulated. Concepts were developed and evaluated to improve ecosystem and riverine habitat viability, recreation and improve water supply reliability.

This section provides a discussion about formulation of potential structural alternatives. The structural alternatives are identified screened, evaluated, and a preferred structural alternative are collectively presented in Section 4. Non-structural elements and multi-benefit concepts are discussed separately in subsequent sections. In this study, flood risk reduction alternatives and ecosystem elements are not mutually exclusive. The Knights Landing SCFRR Study preferred alternative(s) can be a combination of the flood risk reduction preferred alternatives and preferred multi-objective elements.

3.2.1 Flood Risk Reduction Alternative Development Measures

Once the flood risks and problems were identified the study identified several remediation measures that could achieve the goal and objectives of the study. The structural measures considered were stability and seepage berms, cutoff walls, rock placement to address erosion, raising levees, setback levees to address erosion and seepage, and constructing a new ring levee or cross levee. These measures could be combined in various ways into alternatives for further consideration. Once flood risk reduction alternatives were identified, they were screened based on preliminary qualitative criteria. Those alternatives that were retained after the qualitative preliminary screening were then evaluated independently using the quantitative metrics described below and compared. The metrics for comparing alternatives considered implementation costs, schedules, and the local community's ability to pay. In addition to reducing flood risks to the Knights Landing Basin the alternatives also aim to sustain agriculture, the regional economy, safe and improved access to the river, and regional levee maintenance governance.

A Management Action is a structural or non-structural action, plan, or strategy that contributes towards achieving plan objectives. This study focuses on the following Management Actions to achieve the goal and objectives of this study.

- Levee Improvements
- Cross levee Options
- Non-Structural Actions

3.2.2 Evaluation Criteria and Metrics

DWR provided guidance, consistent with CVFPP goals, that small communities may use to evaluate, compare, and inform selection of a preferred alternative within each SCFRR feasibility study. DWR suggested metrics were evaluated under without-Project conditions and with-Project conditions so that changes, particularly in flood risk, could be qualitatively compared. The alternatives were evaluated to determine how well they meet the SCFRR alternative evaluation goals, criteria, and capital costs.

3.2.2.1 *Flood Risk Management*

The evaluation criteria include flood risk reduction to people and property within floodplains protected by the SPFC, flood system flexibility and resiliency, and floodplain management. The alternatives are evaluated by the following:

- Level of existing and future flood protection
- Project will not substantially increase urbanization of rural agricultural areas in deep floodplains
- Project will manage and address residual risks, particularly in areas of deep or rapid flooding
- Project will improve the ability of the flood management system to adapt to changing conditions (hydrologic, climate change, social, political, regulatory, or ecological conditions) and continue to function and recover quickly after damaging floods.

3.2.2.2 *Promote Multi-benefit Projects*

A CVFPP goal is to promote multi-benefit projects or elements that integrate other resource needs including ecosystem restoration, recreation, open space, and water supply reliability. Evaluation criteria for this include the ability to integrate the recreational component into the flood improvements, the community interest in and support for the recreational component, and the ability of the recreational component to meet unmet needs in the community.

Metrics for improving and enhancing natural dynamic, hydrologic, and geomorphic processes include:

- Inundated floodplain habitat
- Natural bank
- River meander potential

Metrics for increasing and improving quantity, diversity, quality, and connectivity of riverine aquatic and floodplain habitats include:

- Riparian habitat
- Marsh and other wetlands habitat
- Shaded riverine aquatic habitat

Restoring habitat contributes to the recovery and stability of native species populations and overall biotic community diversity. Quantifiable metrics for reducing stressors related to development and operation of flood management system that negatively affect at-risk species include:

- Revetment removed
- Levees relocated to reconnect floodplain
- Fish passage barriers removed (or in place to detour stray migrants)
- Invasive plants removal

3.2.2.3 *Capital Costs*

Costs to complete the project include planning and design, land/easement acquisitions, construction, structures, materials, equipment, and labor. The economic and practical feasibility of relocating roads, utilities, changing land use, or buildings needs to be accounted for as well.

3.2.2.4 *Financial Feasibility*

In addition to raising funds for project construction, a small community must be able to raise enough annual funding to pay for long-term Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R). Alternatives that lower flood risks to the disadvantaged community of Knights Landing and have lower local match percentage requirements and enhance OMRR&R will be deemed more feasible.

3.2.2.4.1 Tax Rate and Infrastructure Burden Considerations

In order to consider an area's ability to generate additional taxes and assessment, 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. CDIAC's Mello-Roos Guidelines (1991) suggest that jurisdictions should integrate Mello-Roos financing into the land use regulatory framework.

3.3 Constraints and Other Considerations

Study constraints are restrictions that would limit the extent to which the planning objectives can be met. For this study, will comply with all federal, state and local regulations andno other constraints were identified that would limit the identification of alternatives. However, the following were considered to ensure that the preferred plan is feasible and can be implemented. The alternatives were formulated to avoid, minimize, or mitigate to the following:

1. Residential homes, public structures, infrastructure, and business structures
2. Agricultural activities and facilities
   - During the stakeholder engagement, locals requested to include a proper egress to move their farm equipment if the potential preferred alternative included construction of a new cross levee
3. Road 116, Road 116B, and Highway 113

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4 Structural Alternatives

4.1 Alternatives Description

The study developed an array of alternatives based upon review of existing information and limited quantitative analyses. In addition to identifying the levee improvements needed surrounding the basin, hydrologic and hydraulic modeling revealed that if there is ever a levee overtop or breach from the Sacramento River right bank, water in the basin flows from north to south towards Yolo Bypass. However, due to the topography of the area, the Basin acts as a bathtub with water backing up from Yolo Bypass in the south to the community of Knights Landing in the north. In order to protect the community from these floodwaters, a cross levee South of the community was examined. Several locations were identified for this cross levee based on available historical levee performance, recommendations of previous studies, and stakeholder input.

All alternatives with cross levee options require adequate strengthen-in-place levee improvement measures on exiting features to ensure adequate protection within the new, smaller basin created by the cross-levee alternatives. In addition, it is recognized that the community thrives based on adjacent agricultural operations. Therefore, alternatives that include cross levee options also include identified structural measures to reduce the highest identified areas of risk to the remaining levees outside of the smaller cross leveed basin to ensure economic vitality of the community.

Thirteen structural alternatives were formulated, all containing improvments to existing levee systems and most all including cross levees at different locations southeast of Knights Landing. These alternatives are described below and summarized in Table 1. These thirteen alternatives were evaluated and screened preliminarily using the screening criteria described in Section 3.2.2.

4.1.1 No Action Alternative

Without-Project conditions and with-Project conditions must be considered so that changes can be quantified and compared when selecting the preferred alternative. The No Action Alternative does not include any cross levees or levee improvements or any non-structural actions and assumes current existing conditions to continue as future conditions.

4.1.2 Alternative 1

Alternative 1 is a combination of a cross levee with levee improvements along the levees encompassing the area surrounding the west side of Knights Landing; from the

beginning of the cross levee on the right bank of Sacramento River to the end of cross levee on the left bank of KLRC.

The cross levee in this alternative is immediately downstream of the community of Knights Landing and would begin in the north from levee mile 0.7 on the right bank of the Sacramento River and would run approximately 5,500 feet southerly towards levee mile 5.6 of the left bank of KLRC. It would also include improving 4,400 feet of additional non-levee embankment berms surrounding the existing wastewater treatment ponds as shown in Figure 10.

This alternative also includes applicable levee improvements from levee mile 0.2 to 0.7 along the right bank of Sacramento River for underseepage, through seepage, and freeboard deficiency and from levee mile 5.8 to 4.9 along left bank of KLRC for stability and erosion.

4.1.3 Alternative 2

Similar to Alternative 1, Alternative 2 corresponds to a combination of a cross levee along with levee improvements encompassing the area surrounding Knights Landing on the west side from the beginning of the cross levee on the north adjoining the Sacramento River Levee to the end of the cross levee to the south adjoining the KLRC.

The cross levee in this alternative would begin in the north from levee mile 0.7 on the right bank of the Sacramento River and would run approximately 7,150 feet southerly towards levee mile 4.9 of the left bank of KLRC. This new cross levee intersects County Road 116 and as a result County Road 116 would be elevated to go up and over the new cross levee.

This alternative also includes applicable levee improvements from levee mile 0.2 to 0.7 along the right bank of Sacramento River for underseepage, through seepage, and freeboard deficiency; and from levee mile 5.8 to 4.9 along left bank of Knights Landing Ridge for stability and erosion as shown in Figure 11.

4.1.4 Alternative 3

Similar to Alternatives 1 and 2, Alternative 3 corresponds to a combination of a cross levee along with levee improvements encompassing the area surrounding Knights Landing on the west side from the beginning of the cross levee to the north to the end of cross levee to the south.

The cross levee in this alternative would begin in the north from levee mile 0.9 on the right bank of the Sacramento River and would run approximately 6,800 feet southerly towards levee mile 4.9 of the left bank of KLRC. This cross levee option would follow the alignment of the preferred alternative identified in the LSDN RFMP, dated July 2014. Similar to Alternative 2, this new cross levee intersects County Road 116 and as a result County Road 116 would be elevated to go up and over the new cross levee.

This alternative also includes applicable levee improvements from levee mile 0.2 to 0.9 along the right bank of Sacramento River for underseepage, through seepage, and freeboard deficiency; and from levee mile 5.8 to 4.9 along left bank of KLRC for stability and erosion as shown in Figure 12.

4.1.5 Alternative 4

Alternative 4 also corresponds to a combination of a cross levee with levee improvements encompassing the area surrounding Knights Landing on the west side from the beginning of the cross levee in the north to the end of cross levee in the south. In addition, this alternative also includes levee improvement from levee mile 2.7 to 2.9 on the right bank of Sacramento River downstream of the community.

The cross levee in this alternative would begin in the north from levee mile 2.9 on the right bank of the Sacramento River near Mary Lake and would run approximately 4,150 feet southerly towards levee mile 4.6 of the left bank of KLRC.

This alternative also includes applicable levee improvements from levee mile 0.2 to 1.1 for underseepage, through seepage, and freeboard deficiency; from levee mile 2.7 to 2.9 for through seepage along the right bank of Sacramento River; and from levee mile 5.8 to 4.6 along left bank of KLRC for stability and erosion as shown in Figure 13. This alternative also includes additional applicable levee improvements between levee mile 1.1 and 2.7 on the right bank of Sacramento River.

4.1.6 Alternative 5

Alternative 5 also corresponds to a combination of a cross levee with levee improvements encompassing the area surrounding Knights Landing on the west side from the beginning of the cross levee to the north to the end of the cross levee to the south. In addition, this alternative also includes levee improvement from levee mile 2.7 to 2.9 and from levee mile 3.0 to 3.2 on the right bank of Sacramento River downstream of the community.

The cross levee in this alternative would begin in the north from levee mile 4.3 on the right bank of the Sacramento River and would run approximately 2,050 feet southerly towards levee mile 3.8 of the left bank of KLRC.

This alternative also includes applicable levee improvements from levee mile 0.2 to 1.1 for underseepage, through seepage, and freeboard deficiency; from levee mile 2.7 to 2.9 and 3.0 to 3.2 for through seepage along the right bank of Sacramento River; and from levee mile 5.8 to 4.2 along left bank of KLRC for erosion and stability as shown in Figure 14. This alternative also includes additional applicable levee improvements between levee mile 1.1 and 4.3 on the right bank of Sacramento River.

4.1.7 Alternative 6

Alternative 6 is very similar to Alternative 5 with the cross levee around the center part of the basin from the Sacramento River to the KLRC. This alternative includes a cross levee option along with levee improvements encompassing the area surrounding Knights Landing on the west side from the beginning of the cross levee to the north to the end of the cross levee to the south.

The cross levee in this alternative would begin in the north from levee mile 4.7 on the right bank of the Sacramento River and would run approximately 2,200 feet southerly towards levee mile 3.0 of the left bank of KLRC.

This alternative also includes applicable levee improvements from levee mile 0.2 to 1.1 for underseepage, through seepage, and freeboard deficiency; from levee mile 2.7 to 2.9 and 3.0 to 3.2 for through seepage; and from 4.3 to 5.4 for through seepage and underseepage along the right bank of Sacramento River. Levee improvements also include levee mile 5.8 to 3.0 along left bank of KLRC for stability and erosion as shown in Figure 15. This alternative also includes additional applicable levee improvements between levee mile 1.1 and 4.3 on the right bank of Sacramento River.

4.1.8 Alternative 7

Alternative 7 does not include any cross levee but corresponds to applicable levee improvements from levee mile 0.2 to 1.0 for underseepage, through seepage, and freeboard deficiency along the right bank of Sacramento River as shown in Figure 16.

4.1.9 Alternative 8

Similar to Alternative 7, Alternative 8 does not include any cross levee but corresponds to applicable levee improvements from levee mile 0.2 to 0.9 for underseepage, through seepage and freeboard deficiency along the right bank of Sacramento River as shown in Figure 17.

4.1.10 Alternative 9

Similar to Alternative 7 and 8, Alternative 9 also does not include any cross levee but corresponds to applicable levee improvements from levee mile 2.7 to 2.9 and 3.0 to 3.2 for through seepage and from levee mile 4.3 to 5.4 for through seepage and underseepage along the right bank of Sacramento River as shown in Figure 18.

4.1.11 Alternative 10

Alternative 10 is a combination of Alternatives 7 and 9. This alternative includes applicable levee improvements from levee mile 0.2 to 1.1 for underseepage, through seepage and freeboard deficiency; from levee mile 2.7 to 2.9 and 3.0 to 3.2 for through seepage; and from levee mile 4.3 to 5.4 for through seepage and underseepage along the right bank of Sacramento River as shown in Figure 19.

4.1.12 Alternative 11

Alternative 11 also does not include any cross levee but corresponds to applicable levee improvements for the entire levee system(s) surrounding the Knights Landing Basin. This would include all applicable levee improvements on the right bank of the Sacramento River from levee mile 0.0 to 5.9, left bank of KLRC from levee mile 0.0 to 6.5, and left bank of Yolo Bypass from levee mile 0.0 to 2.9 as shown in Figure 20.

4.1.13 Alternative 12

Alternative 12 is the combination of Alternatives 3 and 9. This corresponds to a combination of a cross levee along with levee improvements encompassing the area surrounding Knights Landing on the west side from the beginning of the cross levee to the north to the end of cross levee to the south along with levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4 along the right bank of Sacramento River.

The cross levee in this alternative would begin in the north from levee mile 0.9 on the right bank of the Sacramento River and would run approximately 6,800 feet southerly towards levee mile 4.9 of the left bank of KLRC.

This alternative also includes applicable levee improvements from levee mile 0.2 to 0.9 for underseepage, through seepage, and freeboard deficiency; from levee mile 2.7 to 2.9 and 3.0 to 3.2 for through seepage; and from levee mile 4.3 to 5.4 for through seepage and underseepage along the right bank of Sacramento River. This alternative also includes applicable levee improvements from levee mile 5.8 to 4.9 along left bank of KLRC for stability and erosion as shown in Figure 21.

4.1.14 Alternative 13

Alternative 13 is the combination of Alternatives 1 and 9. This corresponds to a combination of a cross levee along with levee improvements along the levees encompassing the area surrounding the west side of Knights Landing from the beginning of the cross levee on the right bank of Sacramento River to the end of cross levee on the left bank of KLRC along with levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4 along the right bank of Sacramento River.

The cross levee in this alternative is immediately downstream of the community of Knights Landing and would begin in the north from levee mile 0.7 on the right bank of the Sacramento River and would run approximately 5,500 feet southerly towards levee mile 5.6 of the left bank of KLRC. It would also include 4,400 feet of additional non-levee embankment surrounding the existing wastewater treatment ponds as shown in Figure 22.

Alternative 13 also includes applicable levee improvements from levee mile 0.2 to 0.7 for underseepage, through seepage, and freeboard deficiency; from levee mile 2.7 to

2.9 and 3.0 to 3.2 for through seepage; and from levee mile 4.3 to 5.4 for through seepage and underseepage along the right bank of Sacramento River. This alternative also includes applicable levee improvements from levee mile 5.8 to 4.9 along left bank of KLRC for stability and erosion.

Table 1 below shows the summary of all the structural alternatives and associated elements for consideration.

Table 1 Summary of the Structural Alternative Elements

Structural Alternative Elements					
Structural Alternative No.	New Cross levee			Fix-in-Place Levee Improvements: Through- and Under Seepage, Stability, Erosion, and Freeboard	
	From Right Bank Sacramento River levee mile	To Left Bank KLRC levee mile	Length (ft)	Right Bank Sacramento River levee mile	Left Bank KLRC levee mile
No Action	n/a	n/a	0	none	none
1	0.7	5.6	5,500	0.2 to 0.7	5.8 to 4.9
2	0.2	4.9	7,150	0.2 to 0.7	5.8 to 4.9
3	0.9	4.9	6,800	0.2 to 0.9	5.8 to 4.9
4	2.9	4.6	4,150	0.2 to 1.1 2.7 to 2.9 Any additional applicable levee improvements between 1.1 and 2.7	5.8 to 4.6
5	4.3	3.8	2,050	0.2 to 1.1 2.7 to 2.9 3.0 to 3.2 Any additional applicable levee improvements between 1.1 and 4.3	5.8 to 4.2

Structural Alternative Elements					
Structural Alternative No.	New Cross levee			Fix-in-Place Levee Improvements: Through- and Under Seepage, Stability, Erosion, and Freeboard	
	From Right Bank Sacramento River levee mile	To Left Bank KLRC levee mile	Length (ft)	Right Bank Sacramento River levee mile	Left Bank KLRC levee mile
6	4.7	3.0	2,200	0.2 to 1.1 2.7 to 2.9 3.0 to 3.2 4.3 to 5.4 Any additional applicable levee improvements between 1.1 and 4.3	5.8 to 3.0
7	-	-	-	0.2 to 1.1	-
8	-	-	-	0.2 to 0.9	-
9	-	-	-	2.7 to 2.9 3.0 to 3.2 4.3 to 5.4	-
10	-	-	-	0.2 to 1.1 2.7 to 2.9 3.0 to 3.2 4.3 to 5.4	-
11	-	-	-	*Entire 15.3-mile length of Knights Landing Basin Perimeter Levee System – where applicable*	

Structural Alternative Elements					
Structural Alternative No.	New Cross levee			Fix-in-Place Levee Improvements: Through- and Under Seepage, Stability, Erosion, and Freeboard	
	From Right Bank Sacramento River levee mile	To Left Bank KLRC levee mile	Length (ft)	Right Bank Sacramento River levee mile	Left Bank KLRC levee mile
12	0.9	4.9	6,800	0.2 to 0.9 2.7 to 2.9 3.0 to 3.2 4.3 to 5.4	5.8 to 4.9
13	0.7	5.6	5,500	0.2 to 0.7 2.7 to 2.9 3.0 to 3.2 4.3 to 5.4	5.8 to 4.9

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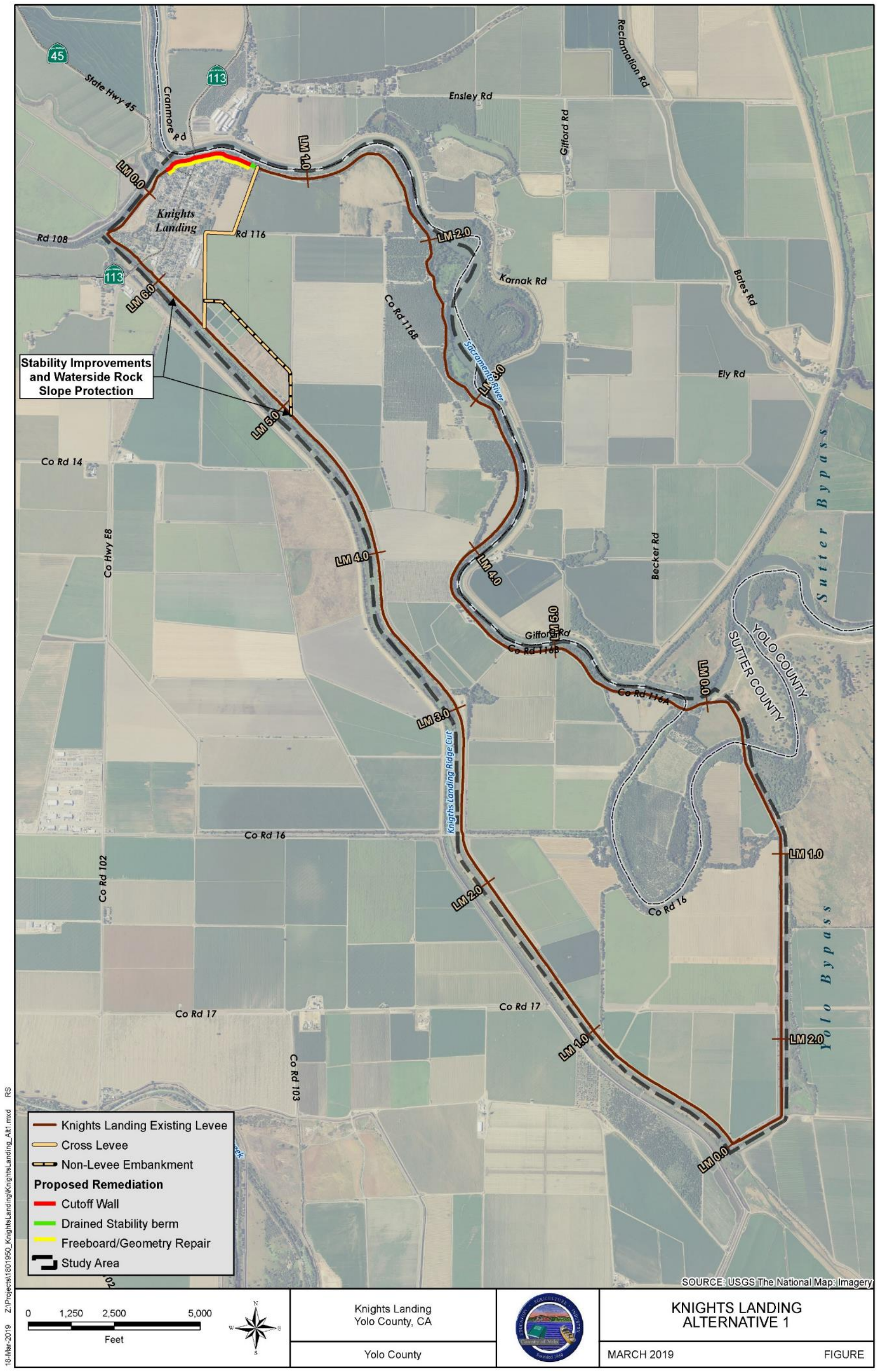

Figure 10 Alternative 1

Figure 11 Alternative 2

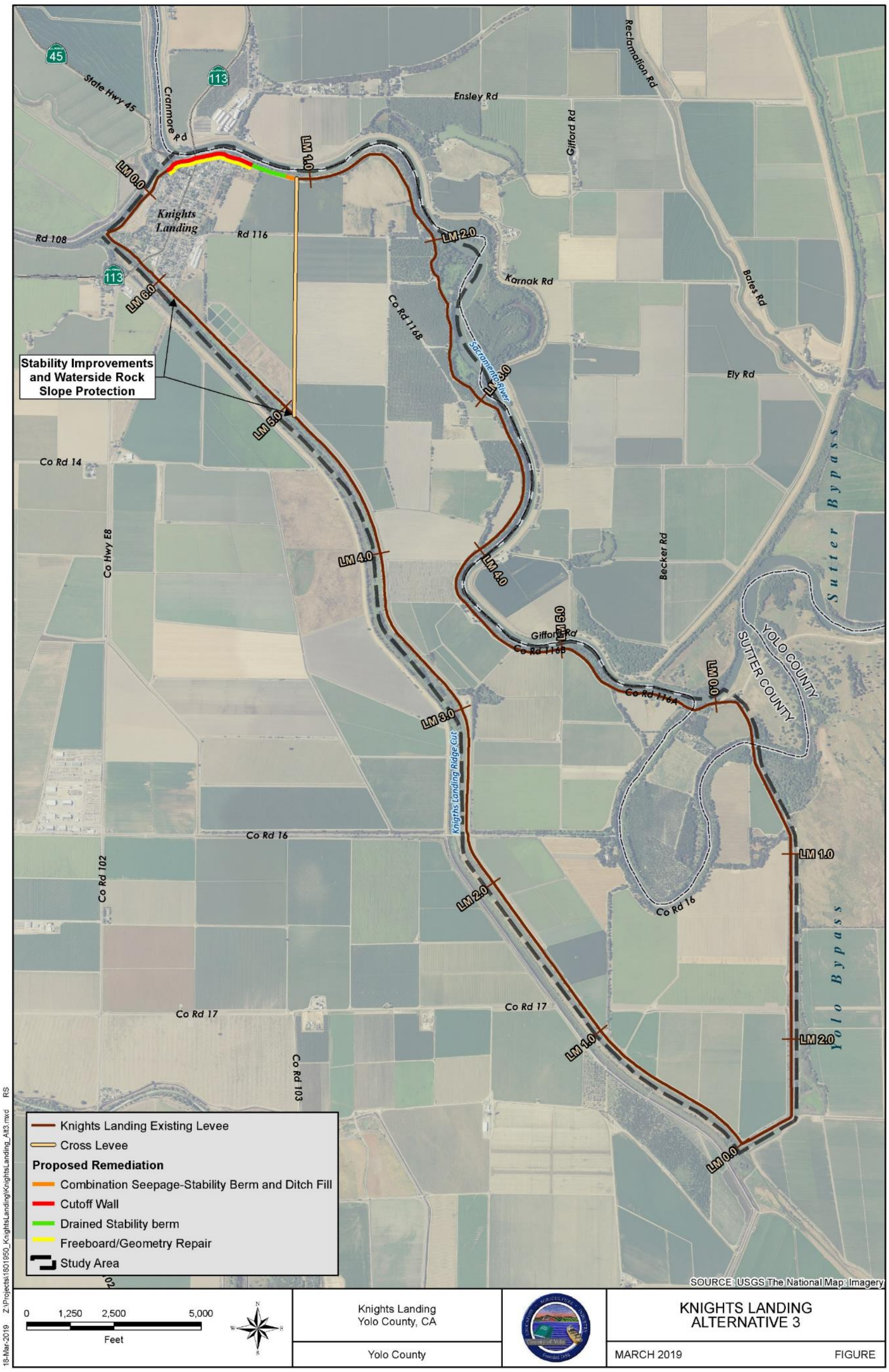

Figure 12 Alternative 3

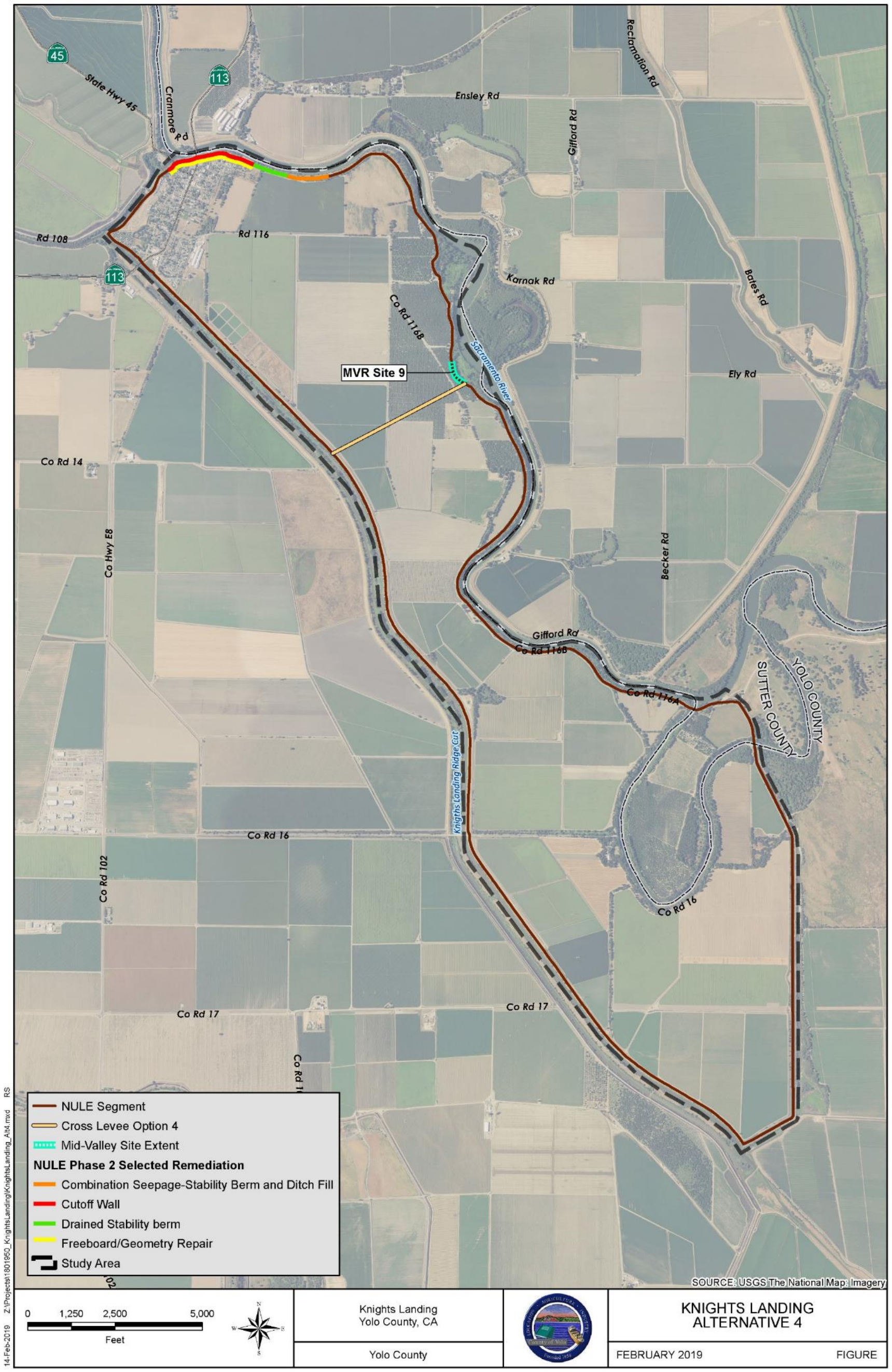

Figure 13 Alternative 4

Figure 14 Alternative 5

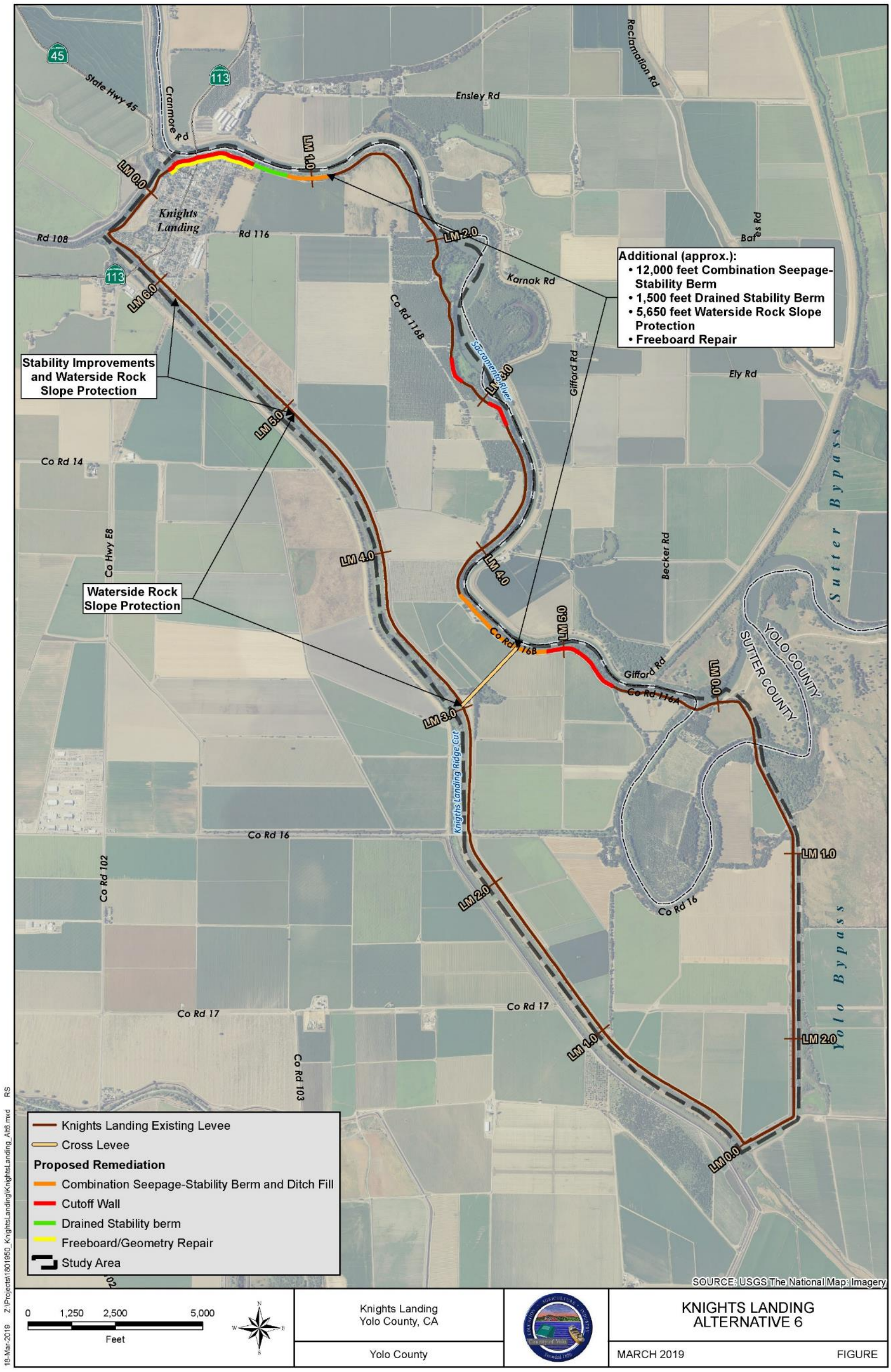

Figure 15 Alternative 6

Figure 16 Alternative 7

Figure 17 Alternative 8

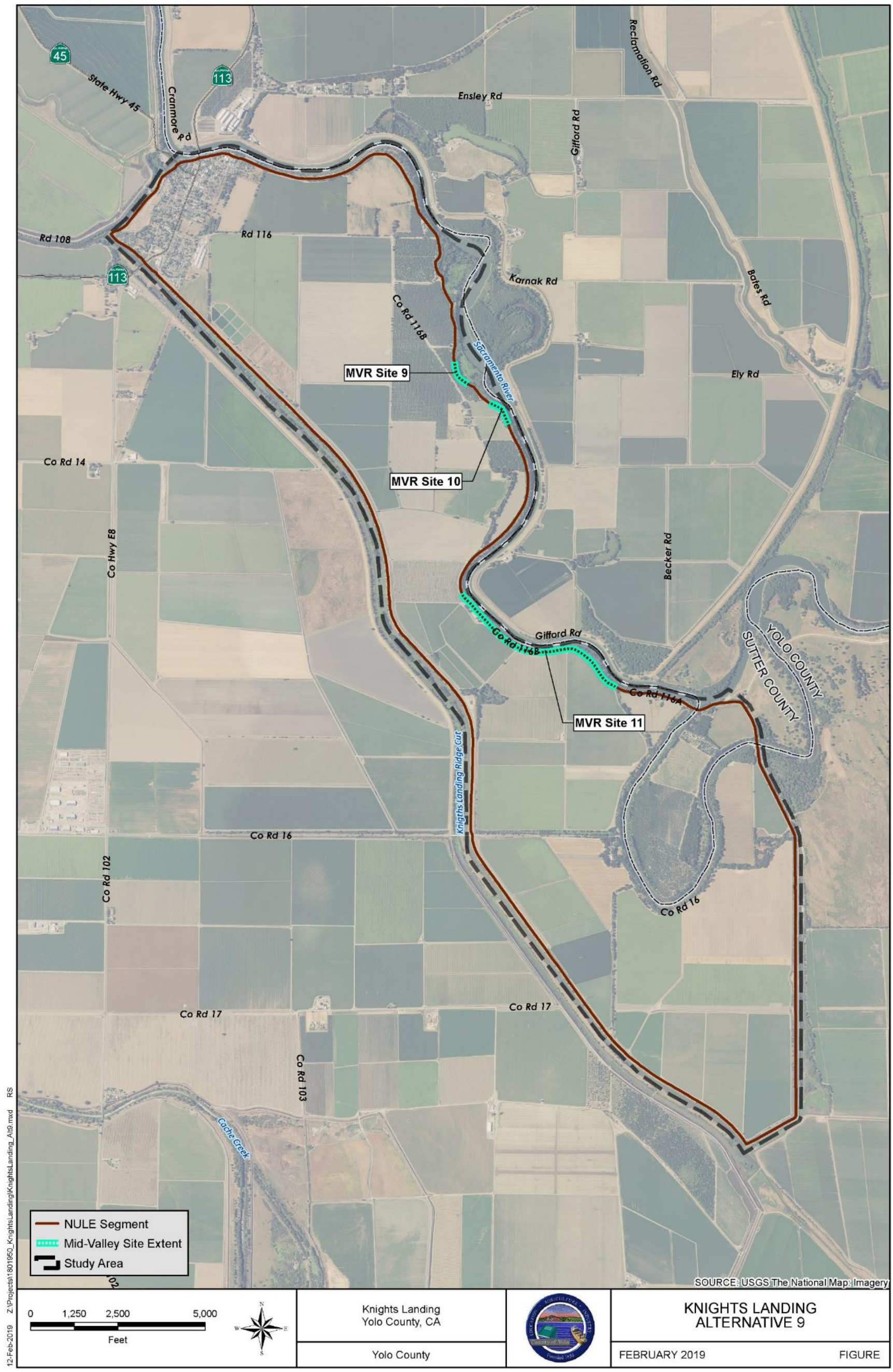

Figure 18 Alternative 9

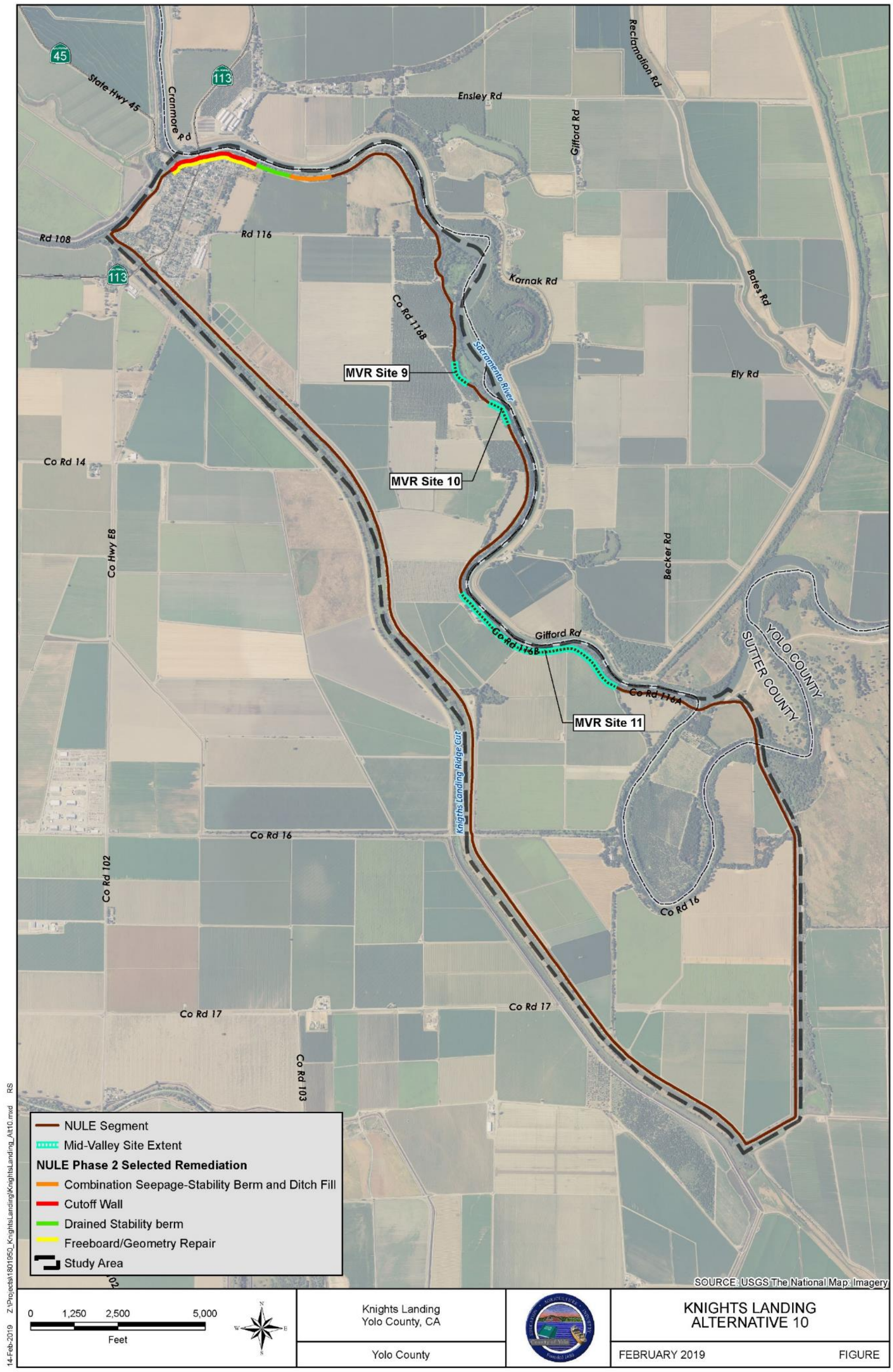

Figure 19 Alternative 10

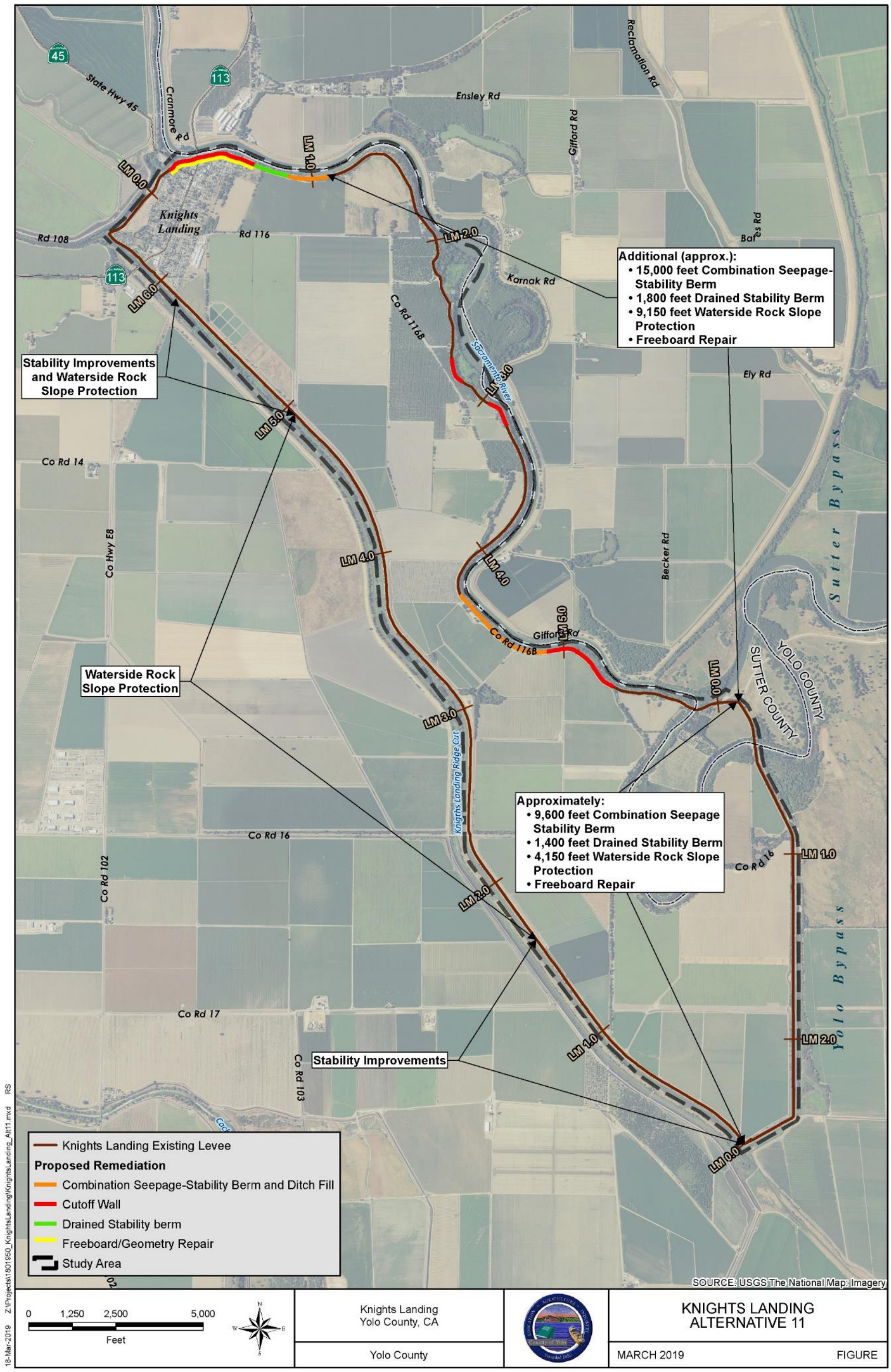

Figure 20 Alternative 11

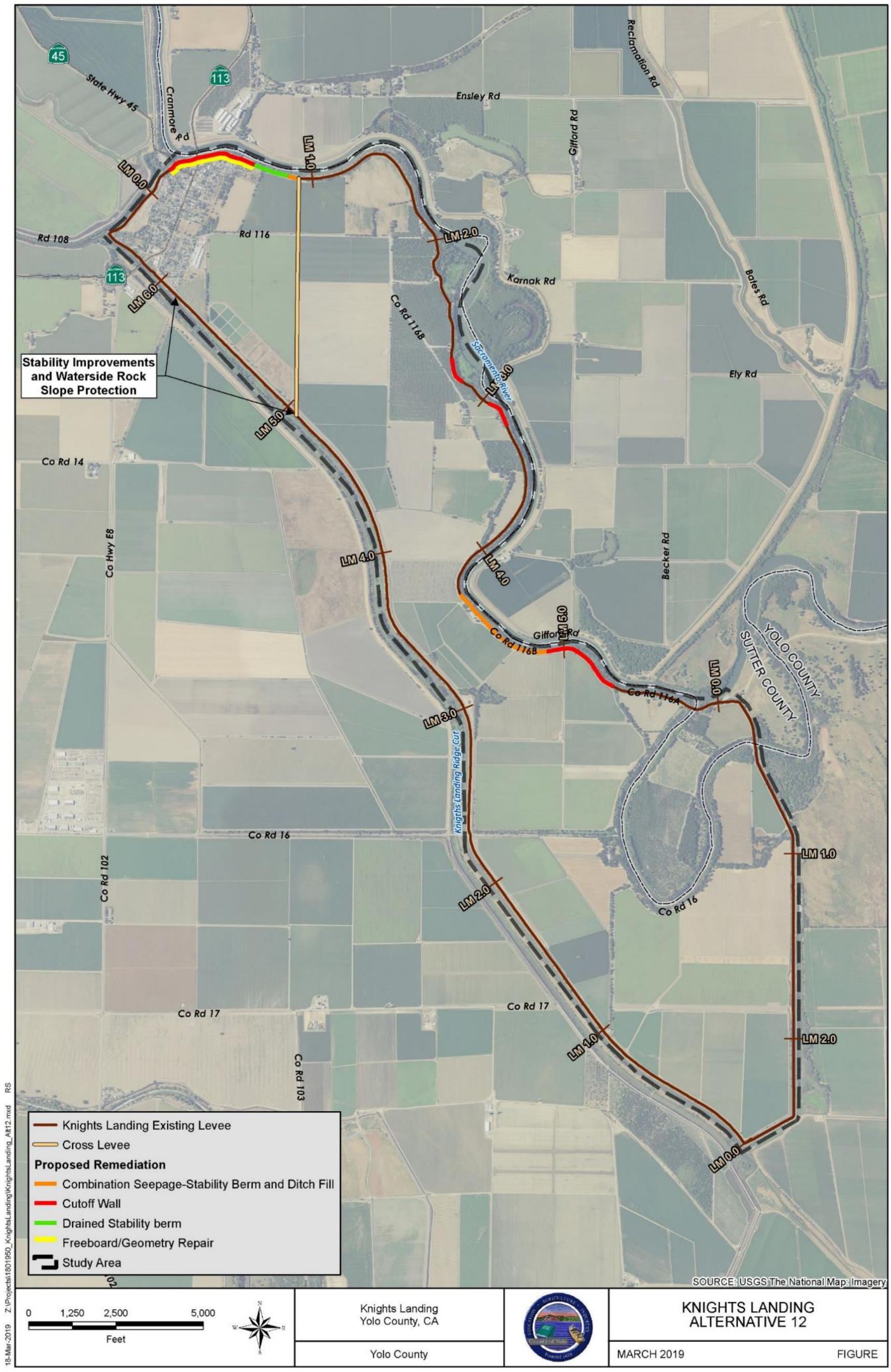

Figure 21 Alternative 12

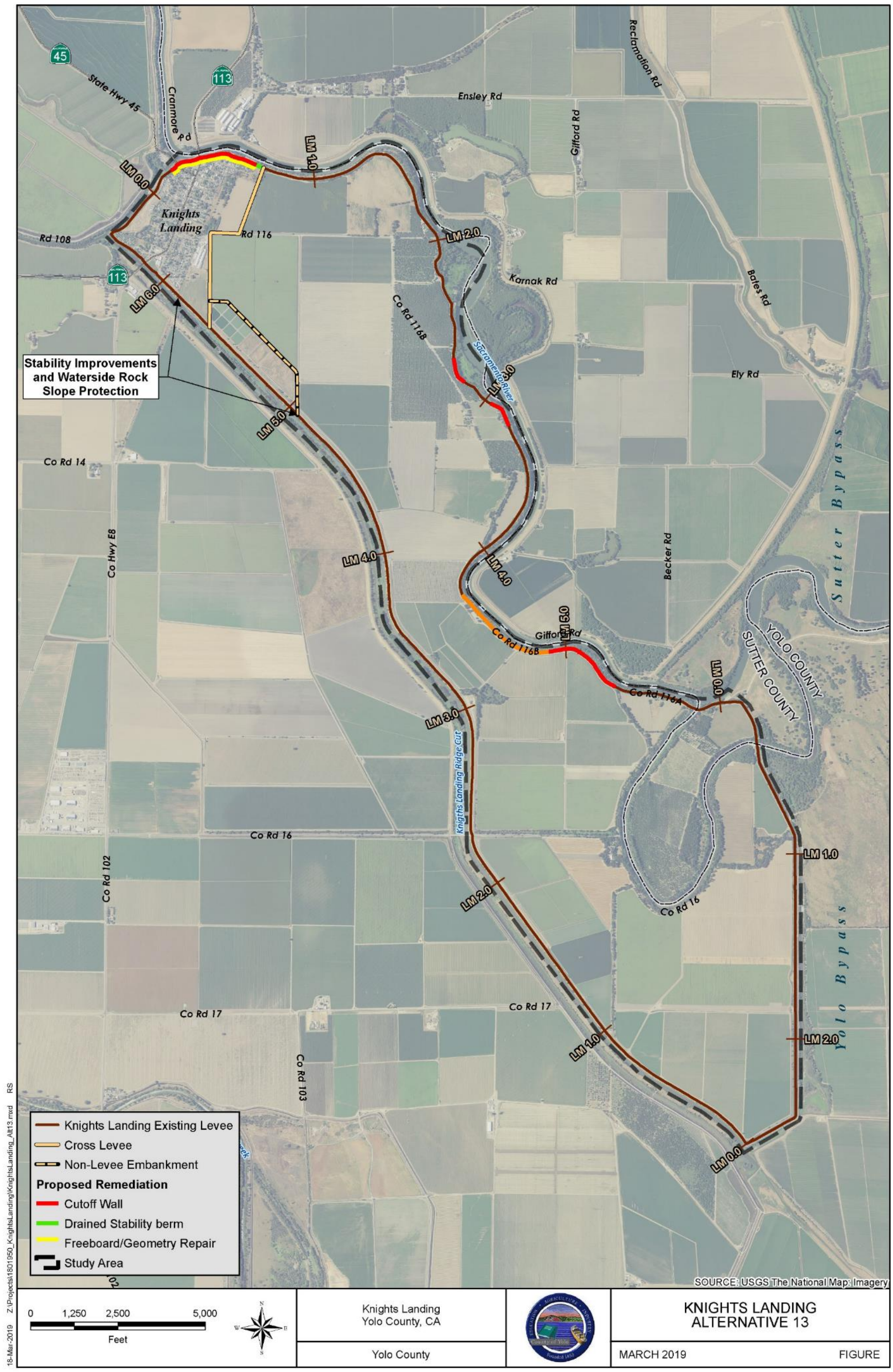

Figure 22 Alternative 13

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4.2 Preliminary Screening of Structural Alternatives

Structural alternatives described above in Section 4.1 were first screened qualitatively based on the performance measures of flood risk reduction, agricultural sustainability, costs, stakeholder acceptability, and if applicable, ability to include any multi-benefit concepts. Alternatives that provided a high level of flood risk reduction were carried forward. None of the alternatives had a low capital cost. When alternatives had a comparable level of flood risk reduction, the alternative with the lower capital cost was carried forward. Alternatives that provided a medium or high level of flood risk reduction were carried forward when the capital costs could justify the overall benefits to flood risk reduction and agricultural sustainability.

4.2.1 Flood Risk Reduction

The alternatives mentioned above were first screened qualitatively based on the performance measures such as flood risk reduction, agricultural sustainability, costs, and ability to integrate any multi-benefit concepts.

Alternatives 1, 2, 3, 4, 5, 6, 12, and 13 include combinations of various configurations of cross levee alignments along with applicable levee improvements. As a result, these eight alternatives form a ring levee to varying degrees – based on the location of the cross levee – and provide a high level of flood protection to densely populated residential and commercial portions of the Knights Landing Basin.

Alternatives 7, 8, 9, and 10 do not include any cross levees but correspond to only applicable levee improvements at several locations. As a result, flood protection provided by these alternatives would be lower when compared to remaining alternatives. Alternative 11 involves repairing the entire levee system surrounding the Knights Landing Basin and as a result would provide a high level of flood protection.

4.2.2 Agricultural Sustainability

Alternatives 1-6, 12 and 13 form a ring levee to varying degrees around the densely populated community– based on the location of the cross levee – and as a result these eight alternatives vary in the amount of area of flood protection provided to the agricultural area in the Knights Landing Basin.

Alternatives 7 and 8 correspond to applicable levee improvements at several locations along the residential and commercial areas of Knights Landing, and as a result would provide low protection to agricultural areas. Similarly, Alternative 9 corresponds to levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4 of the right bank of the Sacramento River that are adjacent to agricultural areas. Alternative 10 is a combination of cross levee and levee improvements at several locations along the community of Knights Landing and from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4 along the right bank of the Sacramento River. Since these are only levee improvements

at specific locations, these alternatives would provide lower protection to agricultural areas when compared to other alternatives.

Alternative 11 corresponds to levee improvements for the entire Knights Landing Basin and as a result would provide high level of protection to the agricultural area. However, significant risk reduction can be provided with modest improvements to areas outside of cross levee alternatives. Alternatives 6, 9, 10, 11, 12, and 13 include construction of identified seepage remediation improvements to Sites 9, 10, and 11 from the USACE Mid-Valley study. Table 2 shows the relative benefit of these alternatives for agricultural sustainability.

4.2.3 Capital Cost

Structural alternatives were formulated with a combination of cross levee and applicable levee improvements along the right bank of Sacramento River and left bank of KLRC. For a portion of these levee improvements, cost estimates provided from previous studies were available. For the cost estimations of the various cross levee alignments, it was assumed that the cost to build any of the cross levees would be directly proportional to the length of the cross levees.

Based on the cross-levee cost factor and available cost estimates for a portion of the levee improvements, a relative cost estimate was prepared for these alternatives.

4.2.4 Preliminary Evaluation

Thirteen structural alternatives were evaluated based on the performance measures identified and explained in Section 3.2.2. Table 2 below provides a summary of all preliminary alternatives for flood risk reduction, ecosystem benefits, agricultural sustainability, recreation, and costs.

Table 2 Structural Alternatives Preliminary Screening Summary by Screening Criteria

Preliminary Alternatives	Flood Risk Reduction	Agricultural Sustainability	Costs	Carried Further/Final Array
NAC	None	Low	Low	**Yes**
1	High	Low	Medium	**Yes**
2	High	Low	Medium	No
3	High	Low	Medium to High	**Yes**
4	High	Low to Medium	High	No
5	High	Medium	High	No
6	High	Medium	High	**Yes**
7	Low	Low	Medium	No
8	Low	Low	Medium	No
9	Low	Low	Medium	No
10	Low	Low	Medium	No
11	High	High	Very High	**Yes**
12	High	Low	Medium to High	**Yes**
13	High	Low	Medium	**Yes**

4.3 Proposed Remediations

Alternatives 1, 3, 6, 11, 12, and 13 were carried forward for further evaluation and screening using feasibility level cost estimates and financial ability to pay. To estimate the costs and further evaluation of these alternatives, levee remediations were proposed for the levees on the right bank of the Sacramento River and the left bank of KLRC.

4.3.1 Through Seepage Remediation

Locations that have only through seepage concerns can be remediated using a berm that is typically 15 feet wide with slope varying based on the site conditions. Water moving through the levee can be captured through the drainage layers and is then routed through drainage pipes. This remediation can also be used for stability concerns and are called stability berms. Figure 23 below shows a conceptual cross-section of a drained stability berm.

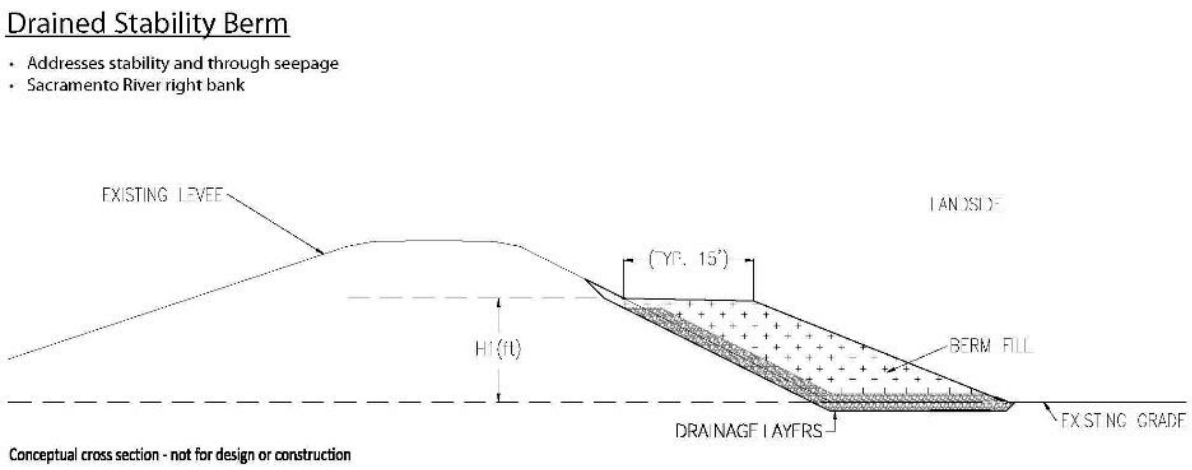

Figure 23 Conceptual Cross-section of Drained Stability Berm

4.3.2 Underseepage and Through Seepage Remediation

Locations that have underseepage and through seepage concerns can be addressed by a cutoff wall. Notably along the community of Knights Landing, where there is no space for alternative remediations, this remediation was proposed. For cutoff wall construction, a portion of the levee is typically degraded to create a working surface and from that working surface typically a 3-ft. wide cutoff wall is installed, and depth of this cutoff wall would vary depending on the site conditions. Figure 24 below shows a conceptual cross-section of a cutoff wall.

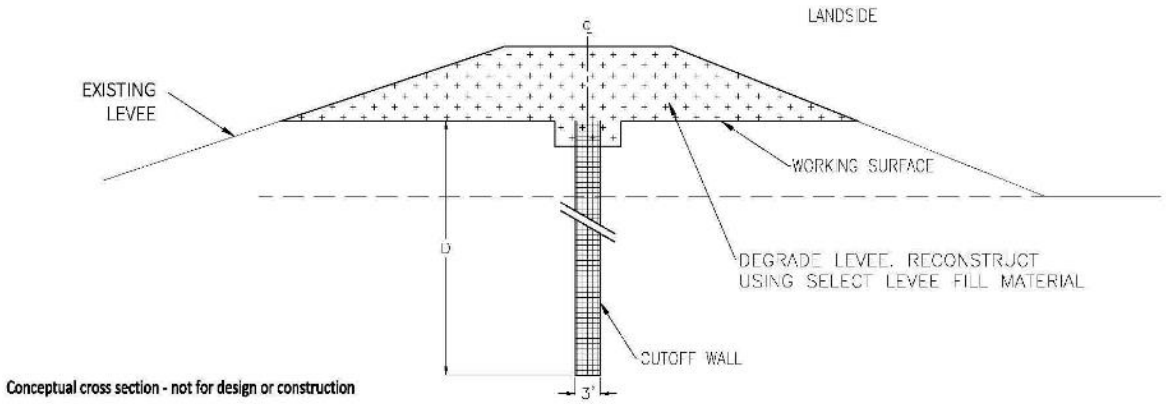

Figure 24 Conceptual Cross-section of Cutoff Wall

4.3.3 Underseepage, Through Seepage, and Stability Remediation

In areas where there is underseepage, through seepage, and stability concerns, a seepage berm can be added to a stability berm to address all three concerns. A seepage berm is typically long in width and short in height. Figure 25 below shows a conceptual cross-section of a seepage-stability berm.

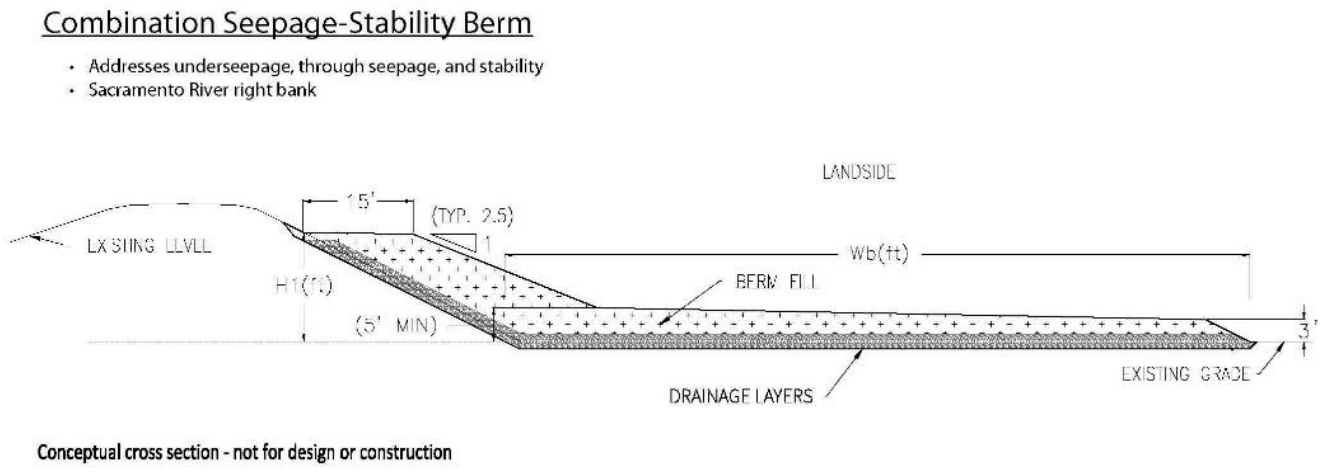

Figure 25 Conceptual Cross-section of Seepage-Stability Berm

4.3.4 Stability Remediation

As mentioned previously, few areas along the left bank of KLRC were identified for stability concerns. Some of these areas have been improved by the KLRDD with assistance from DWR. These same concepts can be included for the remaining areas on the Ridge Cut where stability was identified as a concern. Areas with stability problems can be addressed through slope flattening, building a small berm at the toe side followed by ditch fill and relocation if applicable. Figure 26 below shows a conceptual cross-section for stability improvement.

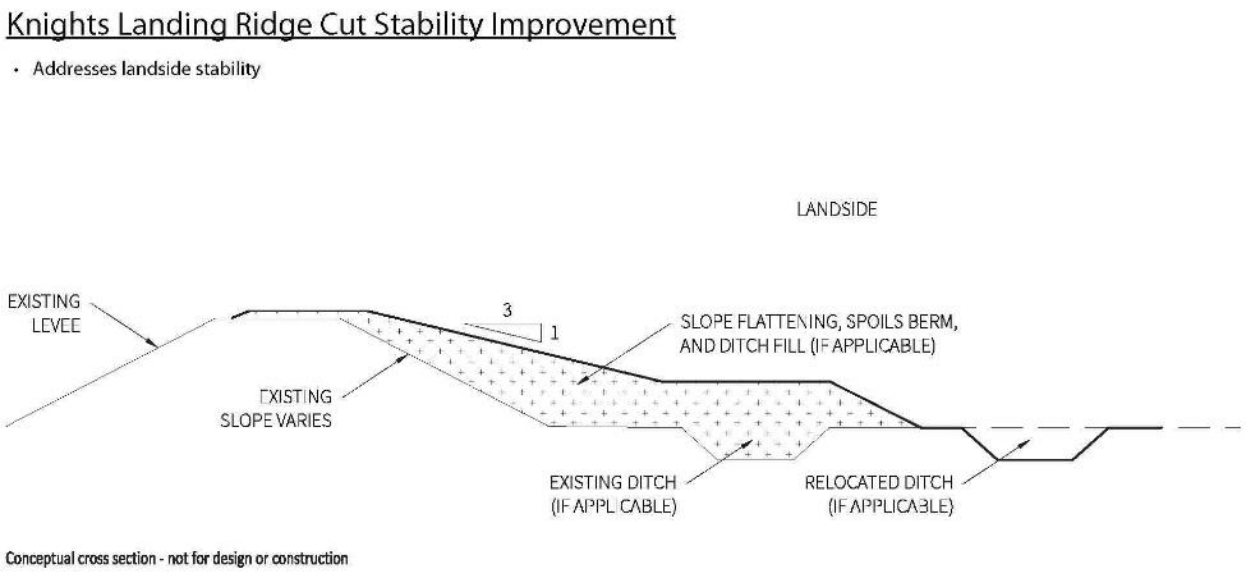

Figure 26 Conceptual Cross-section for Stability Improvements

4.3.5 New Cross levee

Most of the alternatives include construction of a new cross levee. This new cross levee would have a waterside slope and landside slope of 3:1 with 12-ft. crown width. This new levee would also include a seepage berm to address underseepage concerns based on existing foundation conditions in the Basin. The cross levee would be designed to include access ramps to move farm equipment in and out of the Basin. Figure 27 below shows a conceptual cross-section of a new cross levee.

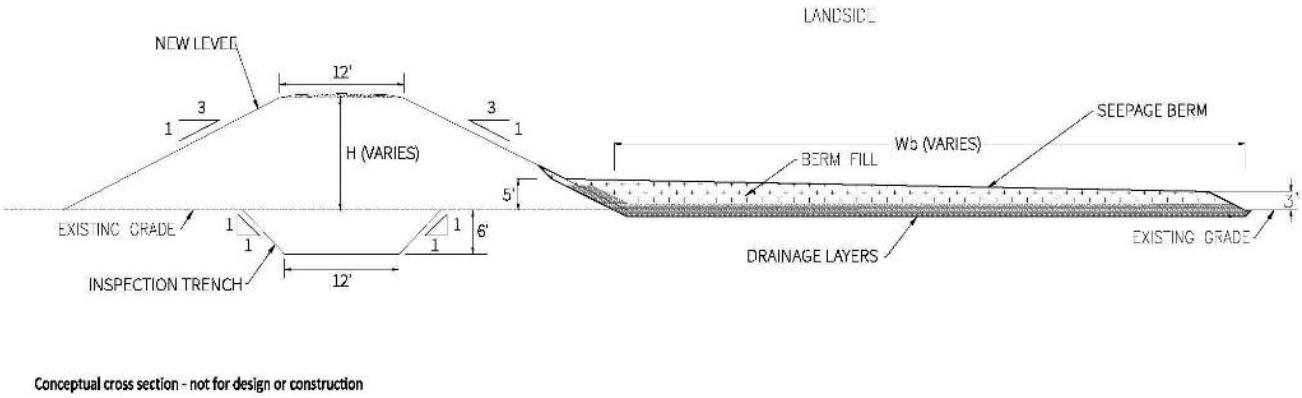

Figure 27 Conceptual Cross-section of New Cross levee

4.4 Description of Final Array of Structural Alternatives

The following section describes in detail the six final array alternatives with proposed remediations that are used for cost estimation purposes.

4.4.1 Alternative 1

Alternative 1 is a combination of a cross levee with levee improvements as needed on approximately 9,320 feet of existing levees surrounding the community of Knights Landing beginning from the start of the cross levee on the right bank of Sacramento River to the end of cross levee on the left bank of KLRC.

Alternative 1 includes approximately 5,500 feet of a new cross levee from the right bank of the Sacramento River to the left bank of KLRC along with improvements to the existing embankment berms surrounding the wastewater treatment ponds. The embankment berms surrounding the ponds include 4,400 feet of non-levee berms on the northwest and west sides of the ponds and about 3,600 feet of existing levee on the southwest side of the ponds. The non-levee embankment berms will be raised, and levee improvements will be included for the existing levee length, as discussed further below.

For evaluation purposes, the following remediations were proposed:

- Right Bank of Sacramento River
  - 240 feet of drained stability berm
  - 2,620 feet of cutoff wall

- Applicable freeboard/geometry repairs

- Left Bank of KLRC
  - 4,825 feet of stability improvements and waterside rock slope protection for erosion repair

Figure 28 shows the features of Alternative 1 with potential remediations for levee improvements.

4.4.2 Alternative 3

Alternative 3 is a combination of cross levee with levee improvements as needed on the 13,980 feet of existing levees surrounding the community of Knights Landing beginning from the start of the cross levee on the right bank of Sacramento River to the end of cross levee on the left bank of KLRC.

Cross levee includes approximately 6,800 feet of new cross levee, running roughly perpendicularly from the right bank of the Sacramento River to the left bank of KLRC.

For evaluation purposes, the following remediations were proposed:

- Right Bank of Sacramento River
  - 290 ft of combination berm and ditch fill
  - 1,010 feet of drained stability berm
  - 2,620 feet of cutoff wall
  - Applicable freeboard/geometry repairs
- Left Bank of KLRC
  - 4,825 feet of stability improvements and waterside rock slope protection for erosion repair

Figure 29 shows the features of Alternative 3 with potential remediations for levee improvements.

4.4.3 Alternative 6

Alternative 6 is a combination of cross levee along with levee improvements as needed on the 43,620 feet of existing levees surrounding the community of Knights Landing beginning from the start of the cross levee on the right bank of Sacramento River to the end of cross levee on the left bank of KLRC. Alternative 6 also includes the levee improvements at levee mile 4.2 of the right bank of the Sacramento River.

Cross levee includes approximately 2,400 feet of new cross levee running roughly perpendicularly from the right bank of the Sacramento River to the left bank of KLRC.

In the recent years, KLRDD has completed approximately 3.5 miles of landside slope stability improvements (including slope flattening, a spoils berm, and landside toe ditch

relocation where applicable) along the left bank of the KLRC levee. These improvements extend from the southern end of the wastewater ponds to approximately 18,200 feet downstream near County Road 16. Based on these levee improvements to address stability, additional stability improvements were only considered in the levee extents not covered by the district repair.

For evaluation purposes, the following remediations were proposed for levee improvements:

- Right Bank of Sacramento River next to the community
  - 1,200 feet of combination berm and ditch fill
  - 1,010 feet of drained stability berm
  - 2,620 feet of cutoff wall
  - Applicable freeboard/geometry repairs
- Right Bank of Sacramento River outside the community
  - 793 feet of cutoff wall from levee mile 2.7 to 2.9
  - 878 feet of cutoff wall at levee mile 3.0 to 3.2
  - 2,400 feet of cutoff wall and 3,157 feet of combination seepage-stability berm between levee mile 4.3 and 5.4
  - Approximately 12,000 feet of combination seepage-stability berm
  - Approximately 1,500 feet of drained stability berm
  - Approximately 5,650 feet of waterside rock slope protection for erosion repair
  - Applicable freeboard/geometry repairs
- Left Bank of the KLRC levee next to the community
  - 4,825 feet of stability improvements
  - 14,720 feet of waterside rock slope protection for erosion repair

Figure 30 shows the features of Alternative 6 with potential remediations for levee improvements.

4.4.4 Alternative 11

Alternative 11 does not include a cross levee but corresponds to applicable levee improvements for the entire levee system of approximately 80,260 feet of existing levee surrounding the Knights Landing Basin. This includes:

- 33,180 feet of levee along KLRC
- 30,530 feet of levee along the Sacramento River
- 2,740 feet of levee along the Colusa Basin Drainage Canal
- 13,810 feet of levee along the Yolo Bypass

For KLRC, as explained in Alternative 6, stability improvements were only considered for the levee extents not covered by the KLRDD repair. No levee improvements were identified for the Colusa Basin Drainage Canal levee. For evaluation purposes, the following remediations were proposed for levee improvements:

- Right Bank of Sacramento River next to the community
  - 1,200 feet of combination berm and ditch fill
  - 1,010 feet of drained stability berm
  - 2,620 feet of cutoff wall
  - Applicable freeboard/geometry repairs
- Right Bank of Sacramento River downstream of the community
  - 793 feet of cutoff wall from levee mile 2.7 to 2.9
  - 878 feet of cutoff wall at levee mile 3.0 to 3.2
  - 2,400 feet of cutoff wall and 3,157 feet of combination seepage-stability berm between levee mile 4.3 and 5.4
  - Approximately 15,000 feet of combination seepage-stability berm,
  - Approximately 1,800 feet of drained stability berm
  - Approximately 9,150 feet of waterside rock slope protection for erosion repair
  - Applicable freeboard/geometry repairs
- Left bank of KLRC
  - 12,320 feet of stability improvements
  - 20,000 feet of waterside rock slope protection for erosion repair
- Right bank of the Yolo Bypass
  - Approximately 9,600 feet of combination seepage-stability berm
  - Approximately 1,400 feet of drained stability berm
  - Approximately 4,150 feet of waterside rock slope protection for erosion repair
  - Applicable freeboard/geometry repairs (6 feet of freeboard required for Yolo Bypass levees)

Figure 31 shows the features of Alternative 11 with potential remediations for levee improvements.

4.4.5 Alternative 12

Alternative 12 is a combination of Alternative 3 and applicable levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4 along the right bank of the Sacramento River. Figure 32 shows the features of Alternative 12 with potential remediations for levee improvements.

In summary, Alternative 12 includes the following:

- 6,800 feet of new cross levee from the right bank of Sacramento River to left bank of KLRC
- Right Bank of Sacramento River next to the community
  - 290 feet of combination berm and ditch fill
  - 1,010 feet of drained stability berm
  - 2,620 feet of cutoff wall, and
  - Applicable freeboard/geometry repairs
- Right Bank of Sacramento River downstream of the community
  - 793 feet of cutoff wall from levee mile 2.7 to 2.9,
  - 878 feet of cutoff wall at levee mile 3.0 to 3.2,
  - 2,400 feet of cutoff wall and 3,157 feet of combination seepage-stability berm between levee mile 4.3 and 5.4,
- Left Bank of KLRC
  - 4,825 feet of stability improvements and waterside rock slope protection for erosion repair

4.4.6 Alternative 13

Alternative 13 is a combination of Alternative 1 and applicable levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4 along the right bank of the Sacramento River. Figure 33 shows the features of Alternative 13 with potential remediations for levee improvements.

In summary, Alternative 13 includes the following:

- 5,500 feet of new cross levee from the right bank of Sacramento River to left bank of KLRC
- 4,400 feet of new non-levee embankment on the northwest and west sides of the ponds
- Right Bank of Sacramento River next to the community
  - 240 feet of drained stability berm
  - 2,620 feet of cutoff wall
  - Applicable freeboard/geometry repairs
- Right Bank of Sacramento River downstream of the community
  - 793 feet of cutoff wall from levee mile 2.7 to 2.9
  - 878 feet of cutoff wall at levee mile 3.0 to 3.2

- 2,400 feet of cutoff wall and 3,157 feet of combination seepage-stability berm between levee mile 4.3 and 5.4

- Left Bank of KLRC
  - 4,825 feet of stability improvements and waterside rock slope protection for erosion repair

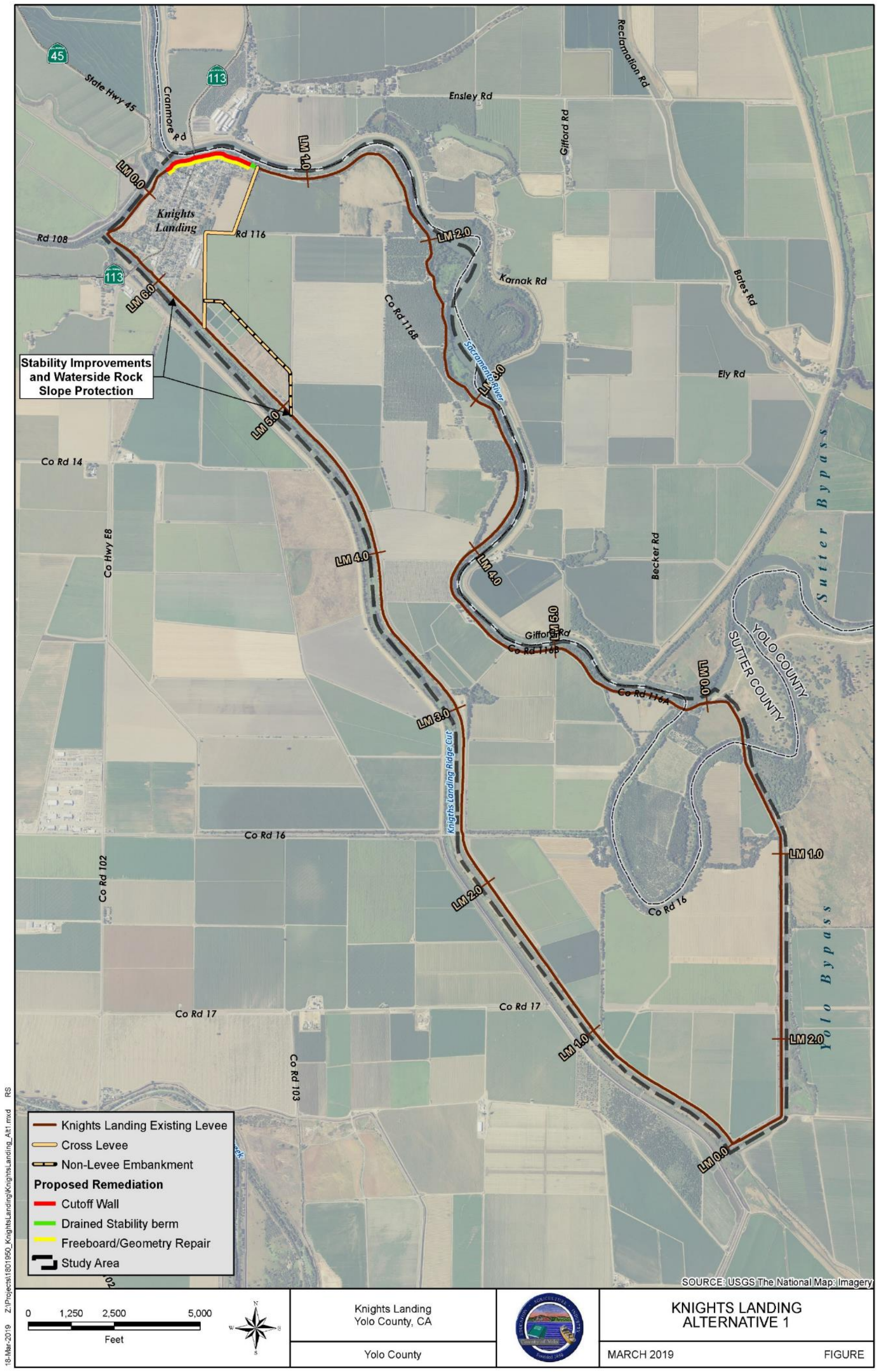

Figure 28 Alternative 1 with Potential Remediation for Levee Improvements

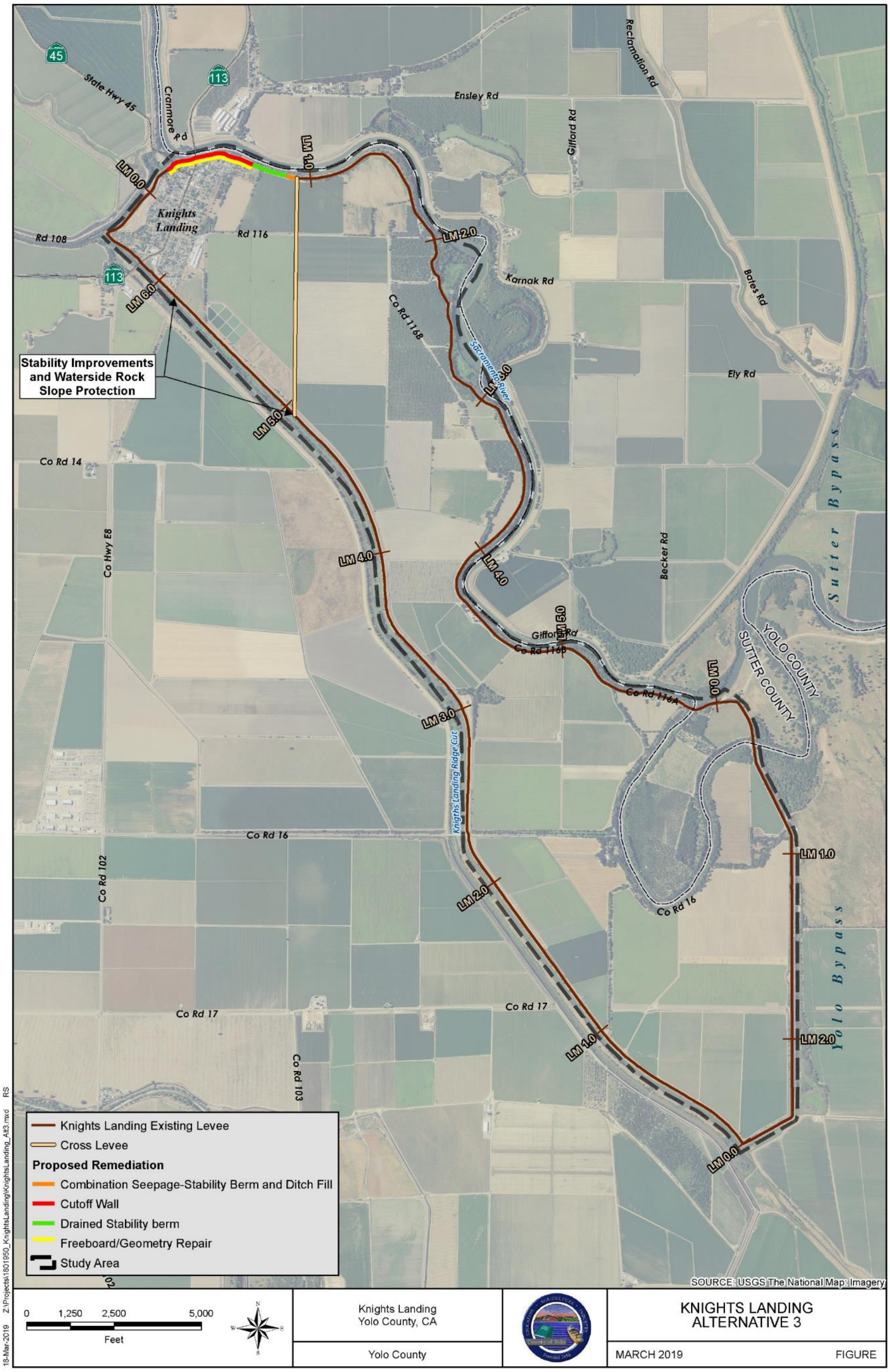

Figure 29 Alternative 3 with Potential Remediation for Levee Improvements

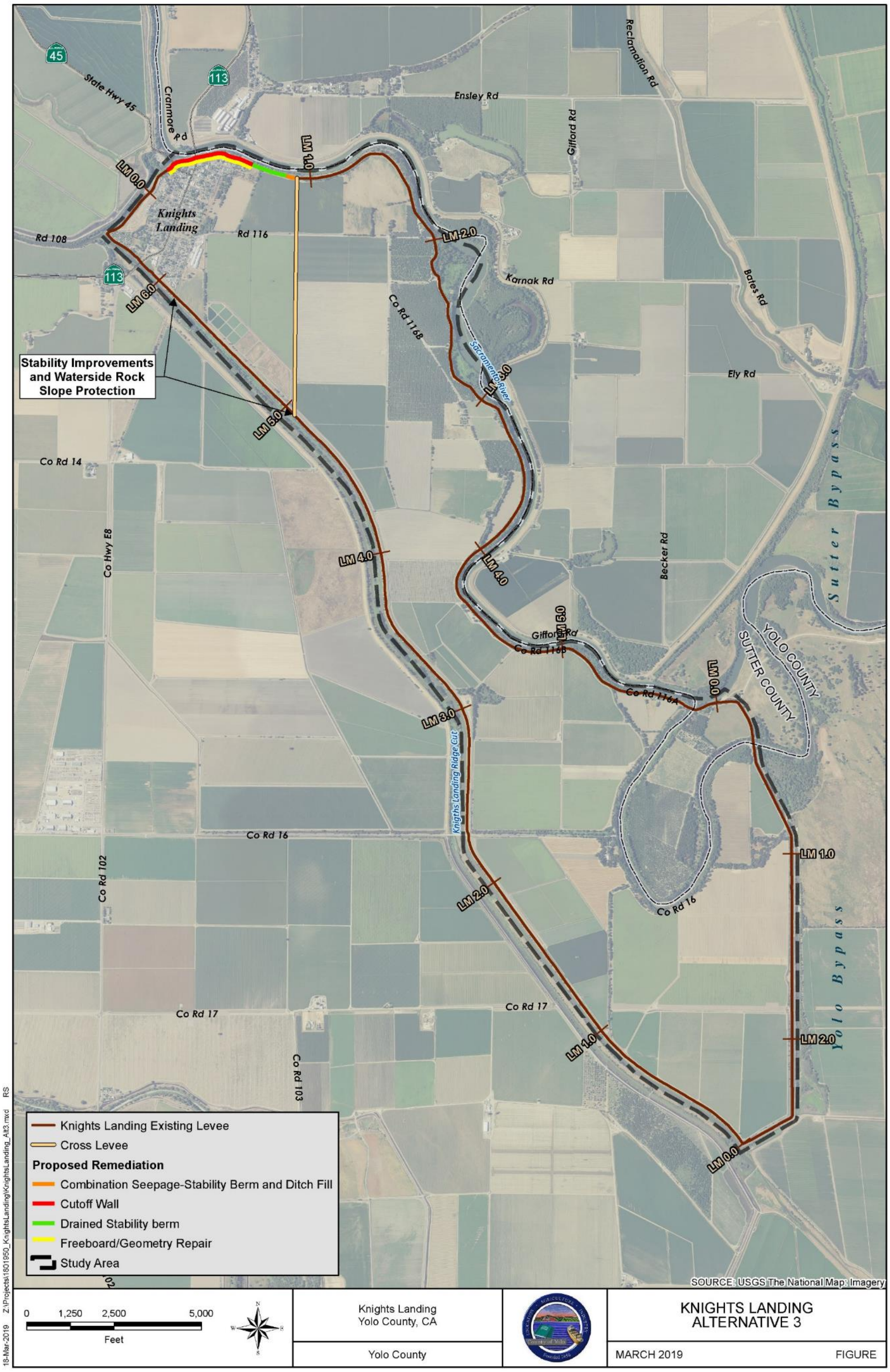

Figure 30 Alternative 6 with Potential Remediation for Levee Improvements

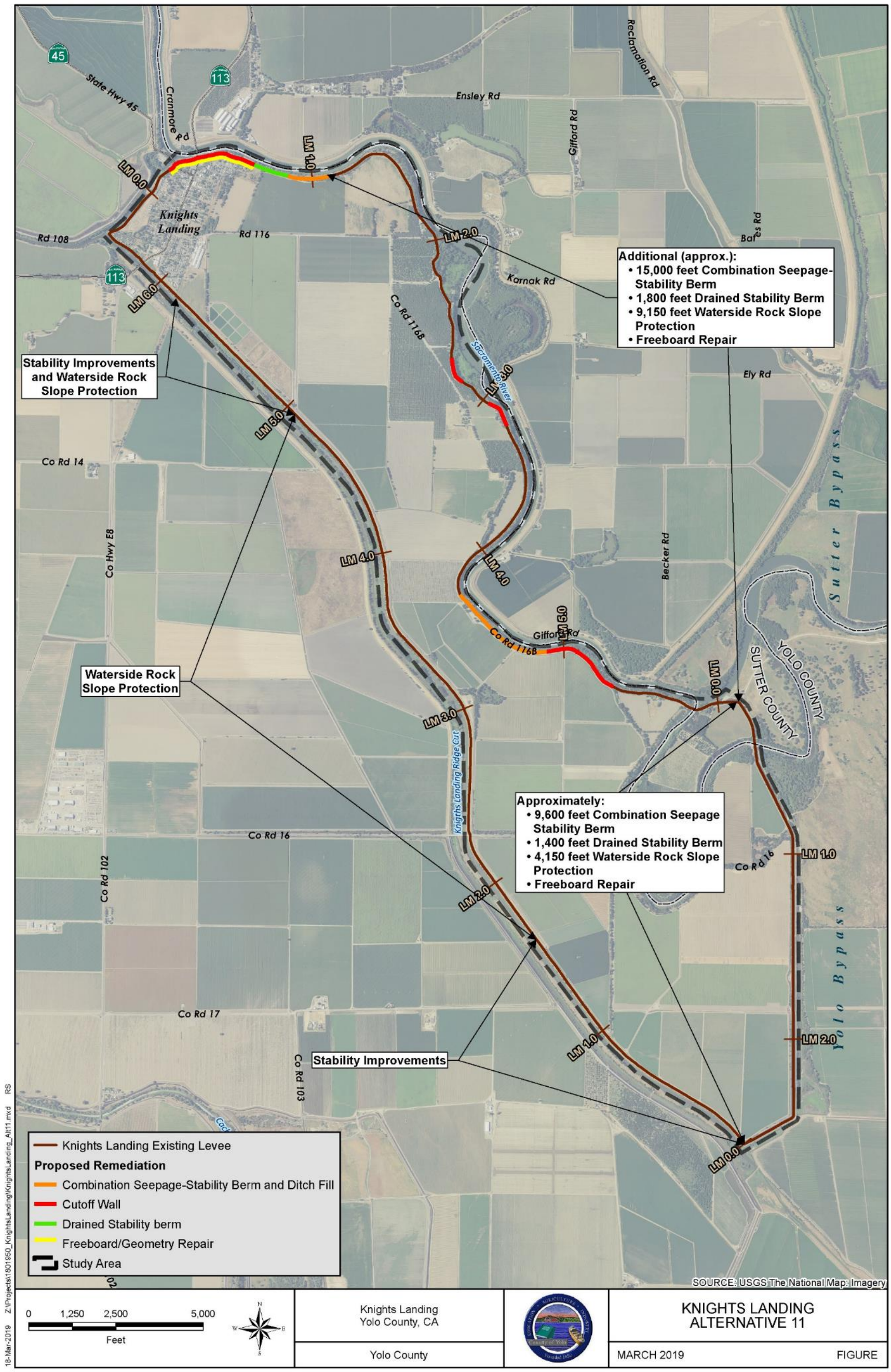

Figure 31 Alternative 11 with Potential Remediation for Levee Improvements

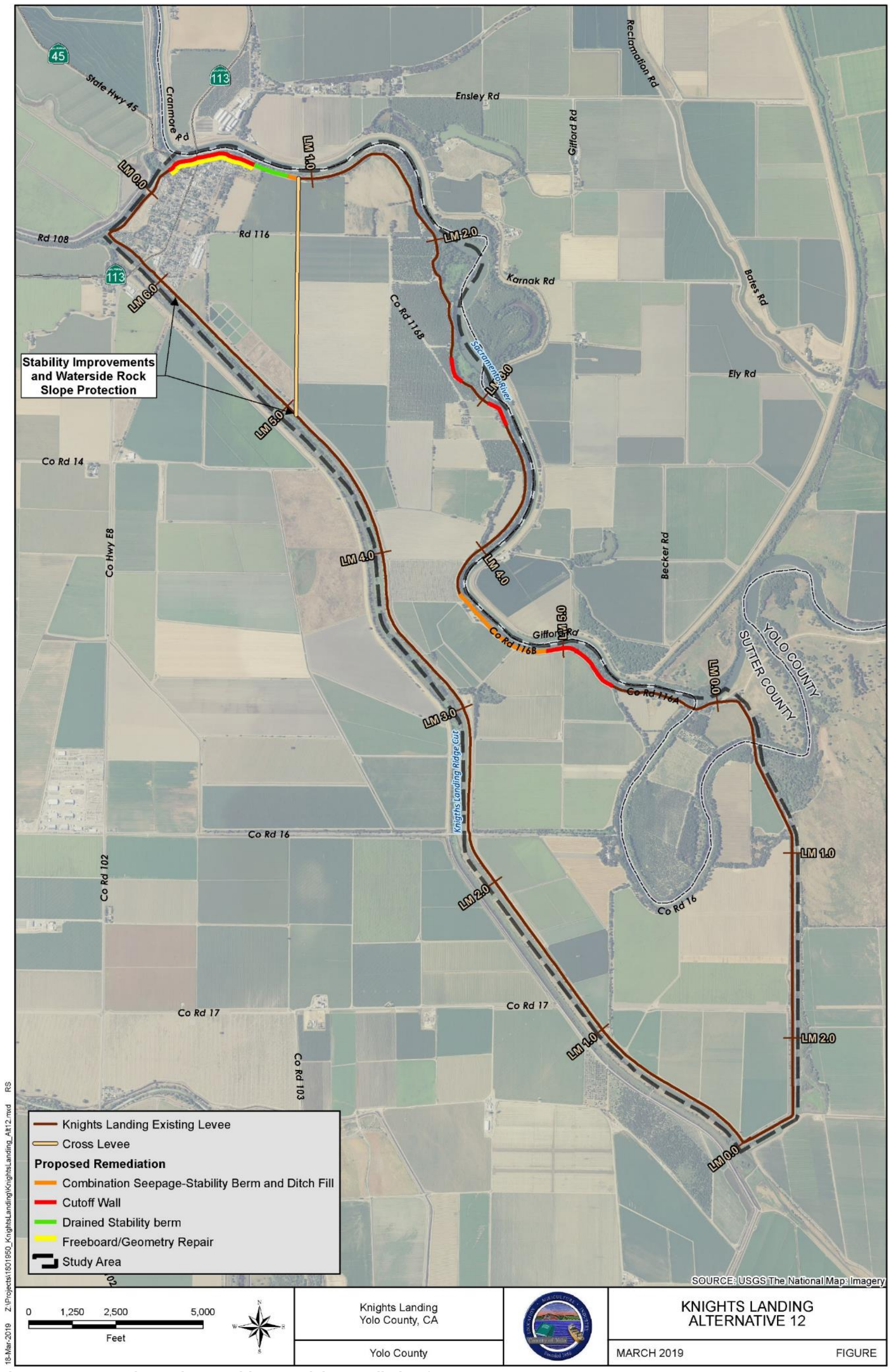

Figure 32 Alternative 12 with Potential Remediation for Levee Improvements

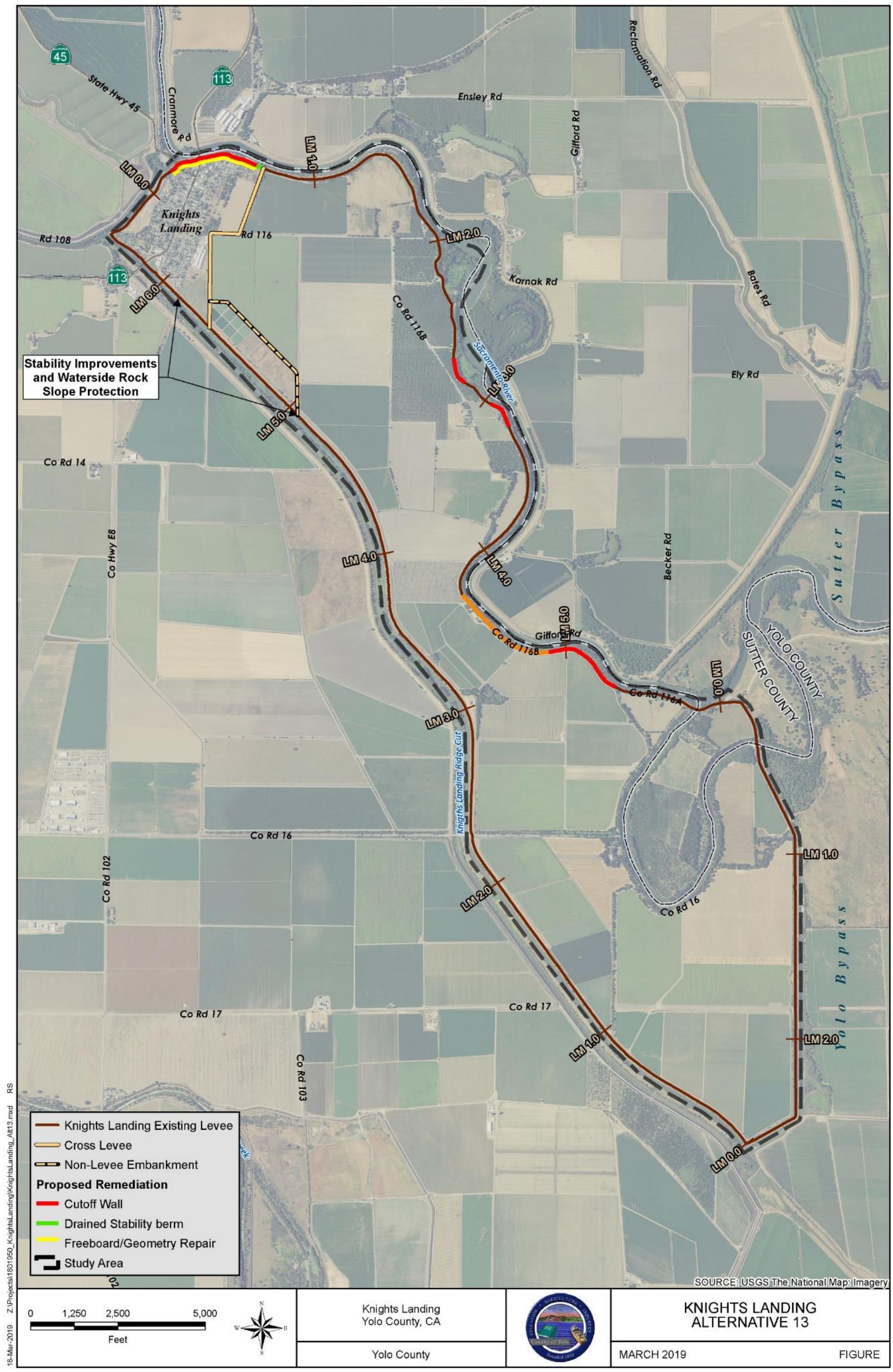

Figure 33 Alternative 13 with Potential Remediation for Levee Improvements

4.5 Capital Costs

As explained in previous sections, the structural alternatives are a combination of cross levees options and levee improvements remediations. As a result, cost estimates were prepared for each of the cross levees and levee improvements remediations. The following section provides a summary of assumptions, methodology, and results of these cost estimates. Costs are intended to be Class 4 (Feasibility Level) estimates as defined by the Association for Advancement of Cost Engineering International. Costs for all approaches are escalated to a cost basis of December 2018 using the 20 cities average from the Engineering News-Record Construction Cost Index. Further description of the development of the capital costs can be found in Appendix C: Cost Estimate Development for Final Array Structural Alternatives.

4.5.1 Cross levee

The design level of effort for the cross-levee cost estimates is considered a feasibility-study level. A feasibility-study level is defined as a paper study depending on existing reports, site visits, aerial photography review, and engineering judgment. A cost estimate was developed for each of the cross-levee alignments by applying unit costs to quantities based upon conceptual designs. Unit costs were established for construction items included within the conceptual designs.

Capital costs consist of:

- Major construction item costs (unit costs)
- Other construction costs including:
  - Unallocated items in construction costs as a percentage of the major construction item costs (percentage)
  - Mobilization and demobilization of construction equipment as a percentage of the major construction item costs (percentage)
- Other Owner Costs including:
  - Environmental documentation and permitting as a percentage of all construction costs (percentage)
  - Design and engineering costs as a percentage of all construction costs (percentage)
  - Legal costs to implement project as a percentage of all construction costs (percentage)
  - Construction management as a percentage of all construction costs (percentage)
  - Real estate capital outlay and acquisition costs (unit costs)

Levee prism geometry was assumed to meet the updated minimum non-urban levee currently under review by the CVFPB, identified in Table below. These standards are also consistent with

the Sacramento District USACE Geotechnical Levee Practice (2008) guidance. Levee geometry for all existing levees that meets freeboard design criteria is assumed to meet original project design of 20-foot crown width with 2:1 landside and 3:1 waterside slopes.

The proposed waste water pond berms in Alternative 1 protecting the Knights Landing treatment ponds would not be constructed to the same standards as the Sacramento River and the KLRC levees and any cross levee protecting the community of Knights Landing as they do not protect lives in the event of a sewage berm breach. The dimensions for these levees are also provided in Table 3. Levee heights vary between locations and levee crown elevations were established to meet freeboard requirements (three feet) above the 100-year WSE.

Table 3 Minimum Levee Dimensions

	Cross levees	Sacramento and KLRC Levees	Waste Water Pond Levees
Crown Width	12’	12-20	12’
Landside Slope	3:1	2:1	2:1
Waterside Slope	3:1	3:1	2:1
Freeboard	3’	3’	1.5’
Levee Patrol Road Width	10’	10’	10’

Potential seepage remediations for the various cross levees were analyzed by reviewing geotechnical borings along the Alternative 3 alignment. The bottom of the aquifer was not found within 65 feet of the ground surface in the northerly portion of the basin closest to the Sacramento River levee system. Thus, it was assumed that a drained, landward seepage berm would be a more viable option than a cutoff slurry wall for the cross levees. A landward seepage berm would be located on the community-side of any cross levee alignment, and it would parallel and adjoin the cross levee for a total distance as measured from the existing Sacramento River right bank levee. The seepage berm width and length dimension for the cross levee alignments associated with each final screening alternative are summarized in Table 4.

Table 4 Seepage Berm Dimensions for Northerly Portions of Cross levees

	Width of Cross levee Seepage Berm (ft)	Northerly Length of Cross levee with Seepage Berm: Distance as Measured from Sacramento River Levee - (ft)
Alternative 1 & 13	75	5,430
Alternative 3 & 12	95	3,340
Alternative 6	90	2,203

The cross levee alignment for Alternatives 1, 3, 12, and 13 intersect county road 116. To address this, a ramp for the county road would need to be constructed on both sides of the new levee. The cross levee was assumed to be 18 feet high at the intersection. The county road was assumed to be 20' wide and have a 10% grade on either side of the cross levee.

Existing GSEs along the cross-levee alignments were calculated using topography developed from the DWR Central Valley Floodplain Evaluation and Delineation Program (CVFED). An average ground surface elevation was calculated every 100 ft for Alternatives 1, 3, 12, and 13 and every 50 ft for Alternative 6. Levee heights vary depending on the alternative. Levee heights for Alternative 1 average 15.5 ft. tall, and range from 12 ft. to 17 ft. Levee heights for Alternatives 3 & 12 average 18.9 ft and range from 15 to 21 ft. Levee heights for Alternative 6 average 17.4 ft and range from 15 ft to 24 ft. Table 5 below shows the minimum, average, and maximum height of the cross-levee alignments for Alternatives 1, 3, 6, 12, and 13.

Table 5 Minimum, Average, and Maximum Height of Cross Levees

Alternative	Minimum (ft)	Average (ft)	Maximum (ft)
1 & 13	12	15.5	17
3 & 12	15	18.9	21
6	15	17.4	24

Utilizing the standard levee design, construction quantities were calculated based on the existing ground elevations for each of the segments and were summed up to calculate the quantities for each activity. The unit costs were then applied to the construction quantities to determine the estimated cost for each alternative. Table 6 shows the summary of the total cross-levee component for Alternatives 1, 3, 6, 12 and 13.

Table 6 Summary of Cross-Levee Cost Estimates

Alternative	Total Cost ($)	
	Low	High
1 & 13	$30,110,000	$39,140,000
3 & 12	$27,460,000	$35,700,000
6	$9,060,000	$11,780,000

4.5.2 Fix-in-Place Levee Improvements

The identification of remediation measures for levee improvements for the final array of alternatives are described in Section 4.3. For evaluation of the final array of structural alternatives, these remediations were used to prepare cost estimates for the specific levee improvements identified for the levee lengths. Cost estimates for the levee

improvements proposed in this feasibility study were also estimated utilizing cost estimates from previous studies when available.

Below is a summary of previous studies utilized for levee improvements cost estimates:

- Right Bank of Sacramento River next to the community – NULE Phase 2
- Right Bank of Sacramento River outside the community
  - From Levee Mile 2.7 to 2.9, 3.0 to 3.2 and 4.3 to 5.4 – USACE
  - Remaining applicable levee improvements – NULE Phase 1
- Left Bank of the KLRC levee next to the community – KLRDD Recent Construction performed in 2015

4.5.2.1 *NULE Phase 1 and Phase 2 Cost Estimates*

Costs provided in NULE Phase 1 and 2 studies were scaled based on original length of repair and the lengths identified for the repair included in the alternatives. Discussion of assumptions, methodology, and estimates are provided in Appendix B: Knights Landing Geotechnical Assessment for Final Array Structural Alternatives.

4.5.2.2 *USACE Cost Estimates*

As noted in Section 1.4.9, USACE performed a geotechnical study to determine the potential geotechnical recommendations for levee repairs in the Mid-Valley study area including sites 9, 10 and 11 along the Sacramento River, southeast of Knights Landing. These sites are referred to as levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4 respectively along the right bank of Sacramento River. Although USACE completed detailed geotechnical alternatives analysis and developed final design drawings, the cost estimates for these repairs were not made available for the purposes of this Feasibility Study. To develop a cost estimate for these repair sites, assumptions used in the cross-levee cost estimate were utilized as applicable.

The USACE recommended repair from the 2012 design document includes a cutoff wall at each site. Preliminary geotechnical analysis indicated that there are relatively shallow clay layers near levee mile 2.7, 3.0, and a southern portion of levee improvement at levee mile 4.3. However, the northern portion of levee improvement at levee mile 4.2 does not have an applicable clay layer to tie into. USACE recommended repair for this location includes a 110 foot “hanging” cutoff wall which does not tie into a clay layer.

The 2012 USACE geotechnical study of these sites also found a combination berm could address existing seepage problems. Due to the high costs of cutoff walls deeper than 80 feet, it was proposed that a seepage berm would be included as an option at levee mile 4.2 for the portion which includes deep cutoff walls. Detailed assumptions, methodology, unit costs, and detailed estimates are provided in Appendix C.

4.5.2.3 *KLRDD Recent Construction*

For levee stability improvements along the KLRC levee where remediations have not already been constructed, stability repairs are assumed similar to those recently constructed by the KLRDD based on USACE recommendations. The KLRDD reported their approximately 3.5-mile repair cost about seven million dollars in 2015 dollars. Based on uncertainty of several factors, including constructability logistics for the levee adjacent to the existing wastewater treatment ponds a contingency of 30%, typical for feasibility study estimates, was agreed to be appropriate. Escalated to December 2018 using an escalation factor of 1.12 based on the 20 cities average from the Engineering News-Record Construction Cost Index and incorporating the 30% contingency, resulted in a cost of three million dollars per mile.

Table 7 below provides a cost summary for Alternatives 1, 3, 6, 11, 12 and 13.

Table 7 Total Cost Summary of Structural Alternatives

Structural Alternative	Fix-In-Place Levee Improvements	Cross levees	Total Feasibility-level Estimate
1	$22,300,000	$39,140,000	$61,440,000
3	$24,400,000	$35,700,000	$60,100,000
6	$107,700,000	$11,780,000	$119,480,000
11	$184,700,000	$35,700,000	$220,400,000
12	$36,300,000	$35,700,000	$72,000,000
13	$34,200,000	$39,140,000	$73,340,000

Notes: All estimates include a 30% contingency on the baseline cost estimates

4.6 Financial Feasibility

The final alternatives were screened and ranked based on an overall analysis of the community's ability to provide general local matching funds as a percent of the total project cost. The financial feasibility analysis was a three-step screening process. First, a maximum annual land-based assessment was calculated using a rate analysis for the benefited area(s). Second, alternatives that protected a small community that did not raise sufficient annual funding to pay for long term OMRR&R were eliminated. Alternatives that protected only agriculture areas were screened out due to a lack of OMRR&R funding. Finally, the remaining alternatives were ranked based on their ability to raise local capital to protect Knights Landing with remaining assessment capacity. Alternatives that had lower local match percentage requirements, protected Knights Landing, and raised capital for agricultural areas to improve OMRR&R or advance levee improvement projects, were ranked higher. This ranking process is described in detail in Appendix F: Knights Landing Assessment Technical Memorandum.

A minimum amount of annual funding needed to OMRR&R each alternative was assumed to be $15,000 per levee mile. The minimum threshold was established by the Knights Landing Feasibility Study team. The existing levee system is maintained by the KLRDD, CSA #6, and DWR. Both KLRDD and CSA #6 have existing local funding sources to OMRR&R portions of the levee system. DWR on the other hand, raises funds through California Water Code 12878, et seq. The required OMRR&R funds for alternatives maintained by KLDD and CSA #6 were discounted based on an approximation of their existing funding sources for OMRR&R. The KLDD assessment district includes about $6,000 per levee mile for OMRR&R. Yolo County has an existing ad valorem tax of about $6,500 per levee mile for OMRR&R.

It was assumed current DWR funding is similar to Yolo County, or about $6,500 per levee mile for OMRR&R. New cross levee segments were assumed to require $15,000 per mile for OMRR&R. It was assumed OMRR&R funding would be required for the entire perimeter of ring levees. However, additional OMRR&R funding was limited to the geographic extent of proposed improvements outside of ring levee systems.

The ability to raise capital was determined by deducting the additional cost to fund OMRR&R from the annual assessment to estimate the remaining assessment capacity. The remaining assessment capacity was used to estimate the amount of bond proceeds, or local capital, that could be generated over a range of debt interest rates. A debt service coverage ratio of 1.1 was assumed to be required on debt underwritten by a land-based assessment. The local capital would be available to match non-local funds to construct alternatives.

The results of the financial feasibility analysis are shown in Table 8, 9 and 10. Table 8 shows the proposed, current, and increased cost per mile to OMRR&R levees maintained by KLRDD, CSA #6, DWR and for new cross levees. Table 9 provides a summary of the length of levee for each alternative and compares that to the maximum assessment to determine if sufficient funding is available to OMRR&R the newly constructed alternatives. Alternative 11 was screened out as the cost to OMRR&R the levees exceeded the maximum annual assessment. Alternatives 1, 3, 6, 12 and 13 were carried forward into the next stage of the analysis and the remaining assessment capacity was determined for these alternatives. Table 10 shows the estimate of remaining assessment capacity for Alternatives 1, 3, 6, 12 and 13 as well as a range of local capital that could be raised based on varying debt interest rates from 3 percent to 7 percent. 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 each alternative. The alternatives are ranked in Table 10 based on the percent of the project that could be paid with local capital. Projects that protect Knights Landing and raise additional funding to improve OMRR&R and provide matching funds for agricultural areas were ranked higher

Table 8 Increased Operations and Maintenance Costs per Levee Mile

OMRR&R Costs	KLRDD	CSA #6	DWR [4]	Cross Levee
Proposed ($/mi.) [1]	$15,000	$15,000	$15,000	$15,000
Current ($/mi.) [2]	$6,000	$6,500	$6,500	$0
Increased ($/mi.) [3]	$9,000	$8,500	$8,500	$15,000

Notes:
[1] Proposed cost developed by Feasibility Study Team based on budgets developed by MBK.
[2] Current Costs estimated using existing financial data from KLDD and CSA #6. Analysis assumes State is the same as CSA #6.
[3] Increased cost required to meet $15,000 per mile. All Cross levees assumed to require full OMRR&R funding.
[4] Additional information on actual OMRR&R costs and benefit zones were requested but were not received. For purposes of this feasibility level analysis, it was assumed Yolo County and DWR have the same current assessment rates.

Table 9 Operations and Maintenance Alternative Screening Analysis

Alt. [1]	KLRDD (mi.)	CSA6 (mi.)	DWR (mi.)	Cross Levee (mi.)	Total (mi.)	Maximum Assessment ($) [2,3]	Increased OMRR&R Cost ($) [4]	Remaining Assessment Capacity [5]	Screening Result
1	1.7	0.7		1.9	4.30	$109,000	$49,750	$59,250	Pass
3	1.7	0.9		1.3	3.90	$111,000	$42,450	$68,550	Pass
6-KL	3.6	4.6		0.4	8.60	$114,000	$77,500	$36,500	Pass
6-Ag	3.1	1.3	2.6		7.00	$42,000	$0	$42,000	
11	6.7	6	2.6		15.30	$112,000	$133,400	($21,400)	Fail
12-KL	1.7	0.9		1.3	3.90	$111,000	$42,450	$68,550	Pass
12-Ag	5.0	5.1	2.6		12.70	$78,000	$0	$78,000	
13-KL	1.7	0.7		1.9	4.30	$111,000	$49,750	$61,250	Pass
13-Ag	5.0	5.3	2.6		12.90	$45,000	$0		

Notes:
[1] KL denotes projects with benefit areas that protect all of Knights Landing. Ag denotes agricultural benefit areas that do not protect Knights Landing.
[2] Maximum Single Family Assessment assumed to be $200/parcel.
[3] Maximum Agricultural Assessment assumed to be $25/acre.
[4] Increased OMRR&R cost developed by multiplying the levee mile lengths by the marginal cost increase in Table 8.
[5] Remaining Assessment Capacity is the difference between the Max. Assessment and the Increased OMRR&R Cost.

Table 10 Local Funding Analysis

Alt. [1]	Rem. Ass. Capacity $	Low Int. Rate (Millions $) [2,3,5]	High Int. Rate (Millions $) [2,3,5]	Project Cost (Millions $)	Local Range		Non-Local Range		Fund Capacity Ranking
					High %	Low %	High %	Low %	
1	$59,250	$1.06	$0.67	$61.40	1.7%	1.1%	98.9%	98.3%	4
3	$68,550	$1.22	$0.77	$60.10	2.0%	1.3%	98.7%	98.0%	2
6-KL	$36,500	$0.65	$0.41	$113.60	0.6%	0.4%	99.6%	99.4%	5
6-Ag	$42,000	$0.75	$0.47	$5.90					
12-KL	$68,550							98.0%	1
12-Ag	$78,000					7.4%	92.6%	88.3%	
13-KL	$61,250			1.4	1.8%	1.1%	98.9%	98.2%	3
13-Ag	$0		$0.00	$11.90	0.0%	0.0%	100.0%	100.0%	

Notes:
[1] For Two Benefit Zone Alternatives KL denotes improvements protect Knights Landing and Ag denotes improvements protect Agricultural land
[2] Assumes 1.1 Debt Coverage Ratio
[3] Low interest rate for debt issuance assumed to be 3%
[4] High interest rate for debt issuance assumed to be 5%
[5] Term for bond repayment assumed to be 30 years

Federally backed home loans on property mapped into a 100-year flood zone require mandatory flood insurance. Alternatives that present property owners with an economic incentive to pass a land-based assessment are preferable. For example, a property owner would be more likely to support a land-based property assessment for a project that would alleviate the need to pay for mandatory flood insurance or reduce the cost of their flood insurance policy. Yolo County estimates Knights Landing has approximately 194 flood insurance policies in place. The average cost of NFIP flood insurance in Unincorporated Yolo County is approximately $940 per policy annually (FEMA, Sept 2018). NFIP preferred premium flood insurance cost is currently $400 per policy annually. Alternatives that achieve a minimum 100-year level of protection for Knights Landing and reduce, or eliminate, the cost of NFIP flood insurance are preferred.

4.7 Trade-off Analysis

A Trade-off analysis was conducted to evaluate and compare the six structural alternatives described in Section 4.4 based on the following performance measures:

- Attain a 100-year level of flood protection for the community of Knights Landing
- Flood risk reduction to key infrastructure outside the community but within the Basin

- Flood risk reduction for the remainder of Basin to improve agricultural sustainability
- Capital costs
- Stakeholder acceptability

4.7.1 Alternative 1

This alternative provides 100-year level of flood protection to the community of Knights Landing along with increased flood protection to the wastewater ponds. As the proposed levee improvements and the cross levee alignment are closer to the community of Knights Landing, the remainder of the Basin will have minor improvement in flood protection when compared to existing conditions. As explained in Section 3.1, the primary goal of this Study is to identify a preferred flood risk reduction alternative that will not only attain a 100-year level of flood protection but also sustain agriculture and the regional economy in the Knights Landing Basin. This alternative does not include levee improvements outside the community from levee mile 2.7 to 2.9, 3.0, to 3.2 and 4.3 to 5.4, where the greatest risk of failure is known to occur. Not addressing these levee improvements would also pose a significant threat to the agricultural economy of the Basin. As a result, this alternative has low acceptability from the stakeholders. The cost of this alternative was estimated to be $61.4 million.

4.7.2 Alternative 3

Alternative 3 also provides 100-year level of flood protection to the community of Knights Landing. However, due to the alignment of the cross levee, this alternative also provides 100-year level of flood protection to the wastewater ponds. Similar to Alternative 1, as the proposed levee improvements and the cross levee alignment are closer to the community of Knights Landing, the remainder of the Basin will have minor improvement (low) in flood protection when compared to existing conditions. Similar to Alternative 1, this alternative did not include levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4 and as a result has low acceptability from the stakeholders. The cost of this alternative was estimated to be $60.1 million.

4.7.3 Alternative 6

Similar to Alternative 3, Alternative 6 also provides 100-year level of flood protection to both the community of Knights Landing and the wastewater ponds. As the proposed cross levee alignment is in the middle of the Basin, the agricultural area between the community and the cross levee will also have 100-year level of flood protection. This alternative also includes levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4 that are highly anticipated by the local community and a result has high acceptability from the stakeholders. The cost of this alternative was estimated to be $119.5 million.

4.7.4 Alternative 11

Alternative 11 provides 100-year level of flood protection for the entire Knights Landing Basin as this includes applicable levee improvements for the entire levee system surrounding the Basin. Similar to Alternative 6, this alternative includes levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4 and as a result has high acceptability from the stakeholders. Based on all these levee improvements, the cost of this alternative was estimated to be $220.4 million; the most expensive of all alternatives.

4.7.5 Alternative 12

As explained previously, Alternative 12 is very similar to Alternative 3 with levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4. As a result, this alternative provides 100-year level of flood protection to both the community of Knights Landing and the wastewater ponds. In addition, this alternative also provides moderate improvement in flood protection for the agricultural lands downstream of the community because of the levee improvements proposed from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4. The cost of this alternative was estimated to be $72 million.

Even though the cost of this alternative is higher than Alternative 3, Alternative 12 was ranked higher than Alternative 3 because of the increased flood protection to the agricultural lands downstream of the community and the stakeholder acceptability of levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4.

4.7.6 Alternative 13

As explained previously, Alternative 13 is very similar to Alternative 1 with levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4. As a result, this alternative provides 100-year level of flood protection to the community of Knights Landing, increased level of flood protection for the wastewater ponds and a moderate level of flood protection for the agricultural lands downstream of the community because of the levee improvements proposed from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4. The cost of this alternative was estimated to be $73.3 million.

Even though the cost of this alternative is higher than Alternative 1, Alternative 13 was ranked higher than Alternative 1 because of the increased flood protection to the agricultural lands downstream of the community and the stakeholder acceptability of levee improvements from levee mile 2.7 to 2.9, 3.0 to 3.2, and 4.3 to 5.4.

4.7.7 Trade-off Analysis Summary

Table 11 below provides a summary of final screening of alternatives.

Table 11 Summary of the Trade-off Analysis

Structural Alternative	Flood Protection			Capital Costs ($, millions)	Stakeholder Acceptability
	Knights Landing Community	Wastewater Treatment Ponds	Agricultural Lands		
1	100-year	Increased	Low	$61.4	Low
3	100-year	100-year	Low	$60.1	Low
6	100-year	100-year	Medium	$119.5	High
11	100-year	100-year	High (100-year)	$220.4	High
12	100-year	100-year	Medium	$72.0	High
13	100-year	Increased	Medium	$73.3	High

4.8 Preferred Structural Alternative

As explained in Section 4.7, Alternatives 1 and 3 have low stakeholder acceptability and as a result were eliminated. Alternatives 6 and 11 include levee improvements that are highly anticipated by the stakeholders but were eliminated because of their high capital costs. Alternatives 12 and 13 provide similar level of flood protection to the community and the Basin for the most part. However, Alternative 12 provides 100-year level of flood protection to the wastewater ponds whereas alternative 13 provides only an increased level of flood protection. Also, Alternative 12 is slightly at a lower cost when compared to Alternative 13. In addition, Alternative 12 alignment of the cross levee follows the alignment of the preferred alternative identified in the LSDN RFMP. Based on all these factors, Alternative 12 ranks higher than Alternative 13 and as a result is selected as the Preferred Alternative.

Alternative 12, the Preferred Alternative, is a combination of a cross levee and applicable levee improvements on the Sacramento River and KLRC. Figure 34 shows the features of the Preferred Alternative with potential remediations for levee improvements.

In summary, the Preferred Structural Alternative includes the following:

- 6,800 feet of new cross levee from the right bank of Sacramento River to left bank of KLRC

Levee Improvements along the Right Bank of Sacramento River –

- 290 feet of combination berm and ditch fill at levee mile 0.86 to 0.90 to address underseepage, through seepage, and landside stability concerns
- 1,010 feet of drained stability berm from levee mile 0.67 to 0.86 to address through seepage concerns
- 2,620 feet of cutoff wall from levee mile 0.13 to 0.67 to address underseepage concerns
- 793 feet of cutoff wall from levee mile 2.7 to 2.9 to address through seepage concerns
- 878 feet of cutoff wall from levee mile 3.0 to 3.2 to address through seepage concerns
- 2,400 feet of cutoff wall to address through seepage concerns and 3,157 feet of combination seepage-stability berm to address underseepage and through seepage concerns between levee mile 4.3 and 5.4
- Applicable freeboard/geometry repairs

Levee Improvements along the Left Bank of KLRC –

- 4,830 feet of landside stability improvements and waterside rock slope protection for erosion repair of the levee and slope bank from levee mile 4.9 to 5.8

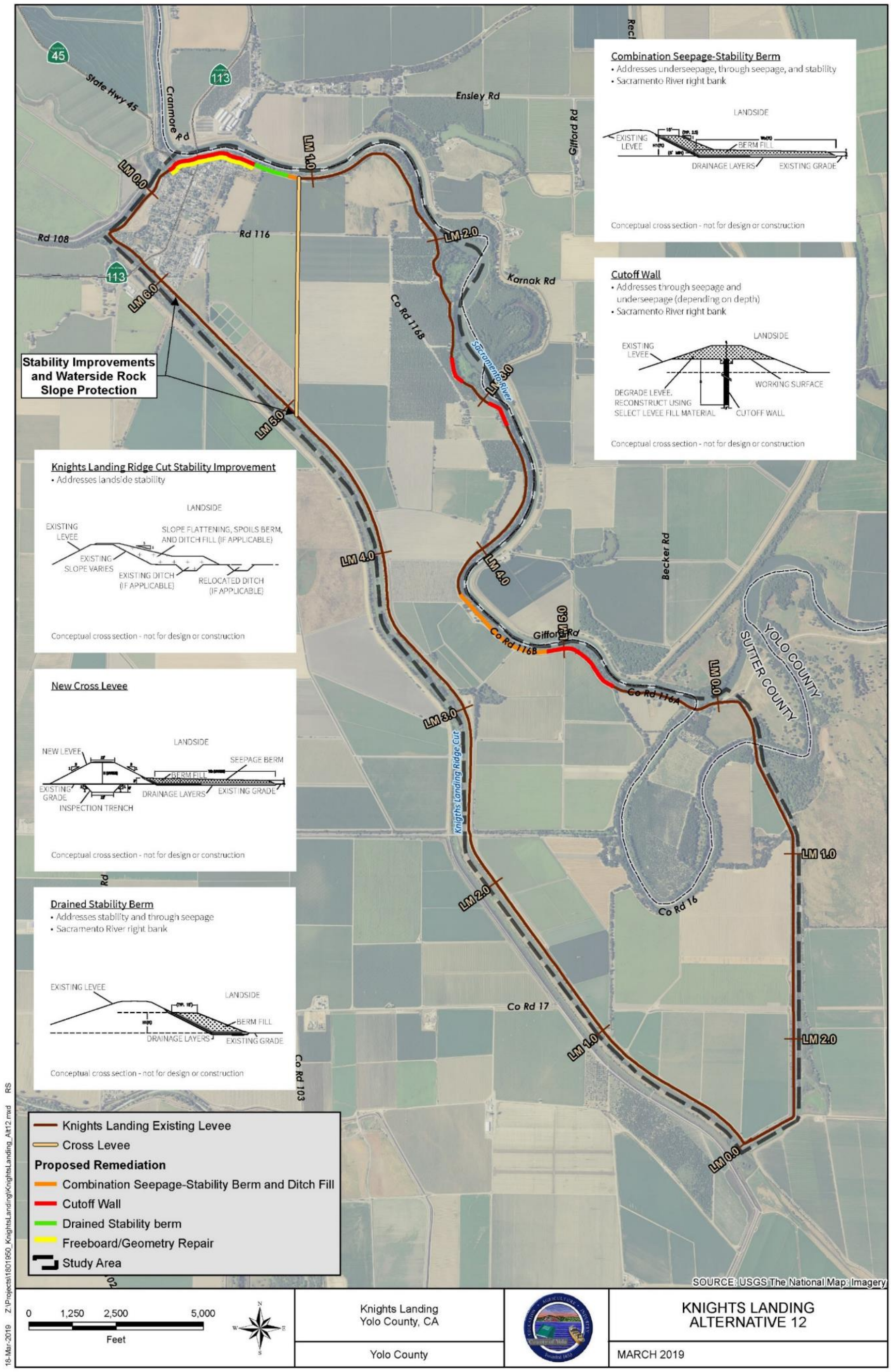

Figure 34 Preferred Alternative (Alternative 12) with Potential Remediations for Levee Improvements

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5 Non-Structural Alternatives

Non-structural solutions can be considered and combined with structural alternatives. Non-structural flood risk management solutions include a wide range of measures which limit the risk of property damage and loss of life from flood water. These actions minimize damages primarily by reducing the exposure to flood waters rather than by confining those flood waters with hydraulic structures. These elements include raising structures so that they will be above anticipated flood levels; floodproofing structures to make them more resistant to flood waters; purchasing and relocating at-risk structures; limiting development in floodplains through zoning or through the acquisition of agricultural conservation easements, open space easements, regulatory constraints, and incentive programs; the purchase of flood insurance to mitigate damages; and/or developing robust emergency operations, evacuation, and flood warning systems to evacuate persons and property in advance of devastating flood water.

Below is a list of potential Non-Structural Solutions under consideration for the community of Knights Landing:

- Relief Cut with Flood Preparedness Actions
- Voluntary Raising of Structures
- Voluntary Flood Proofing
- Refinements to the National Flood Insurance Program via Agricultural Floodplain Ordinance Task Force
- Improve NFIP Community Rating System for Yolo County/Knights Landing
- Knights Landing Levee System Emergency Operations Plan – Basic Plan Implementation, Inclusive of Flood Emergency Trigger Elevations & Response Actions
- Knights Landing Mapping of Flood Depths, Timing, Duration, and Evacuation Routes
- Improved OMRR&R Governance Between CSA #6, and KLRC Drainage District

5.1 Descriptions & Evaluations of Potential Non-Structural Solutions

5.1.1 Relief Cut with Flood Preparedness Actions

Levee relief cuts are not normally recognized on FIRMs nor considered when floodplain administrators issue permits for construction in Zone A. The AFOTF recommends that FEMA recognize levee relief cuts that are properly planned and adopted by a

community as part of an Emergency Operation Plan and Floodplain Management Ordinance. Although FEMA has not yet proposed changes to the NFIP to recognize reduced risk from relief cuts, the reduced flood depths resulting from relief cuts make them good practice for most leveed basins. Yolo County revised the Basic Emergency Operations Plan in 2013. The Knights Landing Levee System Emergency Operations Plan Basic Plan 2018 includes elements needed for Regional Flood Emergency Preparedness, Response, and Recovery (FEPRR) status. A relief cut, and Floodplain Ordinance could be combined as a non-structural alternative, provided the relief cut for any subject basin nets a definitive reduction in flood stages and/or substantially reduces duration of flooding.

A relief cut along the Yolo Bypass at the lowest end of the Knight Landing Basin was analyzed as an effort to reduce the WSE and flood duration time in the basin. The results of the relief cut analysis showed a minimal reduction in resulting WSE (about 0.3 feet) over the existing depths that are approximately 10 feet and greater. With the Basin located so close to where the Sacramento River spills into the Yolo Bypass causing significant backwater effects around the basin, the large flood flows in the system make a relief cut infeasible for this low-lying Basin. Thus, a relief cut for the Knights Landing Basin has been eliminated as non-structural solution for the community of Knights Landing

5.1.2 Voluntary Raising of Structures

Raising of existing structures to an elevation which is at least equal to or greater than the computed WSE's resulting from a levee breach can be a common and effective way of minimizing damage from floodwaters and is considered a key flood protection provision of the NFIP. The process in most cases consists of separating a building from its foundation by vertically lifting with hydraulic jacks and placing the structure onto a higher foundation of vertical walls. Structures can be elevated using various methods such as extended foundation walls, on piers, post, piles and columns and can be completed in a way to allow garage or storage space below the elevated structure. This non-structural measure is sustainable over the long term with minimal costs for operation, maintenance, repair, rehabilitation, and replacement.

Hydraulics and hydrologic modeling of the Knights Landing Basin indicates that the structures in the community of Knights Landing would require raising between 3 and 12 feet to be elevated to or above the maximum floodplain.

Reported in the 2012-2017 CVFPP there are approximately 321 total structures within the densely populated area of the Knights Landing, consisting of approximately 276 residential structures, 32 commercial structures, and 13 public/industrial facilities.[7] The 2012 CVFPP also reported an estimated cost of approximately $100,000 (in 2011

[7] 2012 -2017 CVFPP Flood Damage Assessment (FDA) Analysis input data for Knights Landing Damage Area (SAC13)

dollars) for elevating typical residential structures in known deep flood plains, and the 2014 Lower Sacramento River/Delta North RFMP identified a cost of approximately of $32.8M (in 2011 dollars) for raising all of the reported 328 structures in Knights Landing. Escalating the 2011-dollar values by 1.22 to December 2018 dollars it is estimated that raising single family residential structures could be as much as $125,000/ea. or greater. To raise all 328 total structures within the community of Knights Landing the total cost is estimated at over $40M, or possibly greater when assuming commercial, industrial and public buildings may be more costly to elevate than single family residential structures.

The cost to raise all structures to these heights may be feasible with federal and state participation but may not be desirable for the entire community, but elevating structures is encouraged on a case-by-case basis wherever feasible with Federal and state assistance. This non-structural solution would need to be voluntary for residential structures as expressed during public outreach meetings, but it could be mandatory for essential facilities in the event the preferred structural alternative elements are not fully implemented.

It is recommended that voluntary raising of structures, on a case-by-case be carried forward as a non-structural solution for reducing flood risks in the community of Knights Landing. The County should also encourage residential and business owners to participate in the voluntary raising of structures by offering potential cost-sharing incentives, (50% or greater cost-share reductions) available through federal and state cost-sharing programs.

5.1.3 Voluntary Flood Proofing

Damages to structures behind levees can be greatly reduced through effective flood proofing. Flood proofing can be cost effective for most structures where maximum depths of potential flooding are not expected to exceed five feet; however ag-related structures have been known to be flood-proofed for flood depths much greater than five feet. There are two types of floodproofing. Wet floodproofing is where structures are constructed of flood resistant materials and have openings, or vents, to allow floodwaters to pass through the structure. Any mechanical or electrical equipment must be affixed above the flood elevation or waterproofed to prevent damage. Wet floodproofing is typically appropriate for agricultural shops and buildings but are not normally practical for residential or commercial structures. Dry floodproofing is where a structure is designed to be watertight to keep flood water from entering the structure. Based on FEMA definition, dry flood proofing includes but is not limited to the following:

- installation of watertight closures for doors and windows;
- reinforcement of walls to withstand floodwater pressures and impact forces generated by floating debris;
- use of membranes and other sealants to reduce seepage of floodwater through walls and wall penetrations;

- installation of pumps to control interior water levels;
- installation of check valves to prevent the entrance of floodwater or sewage flows through utilities; and
- the re-location of electrical, mechanical, utility, and other valuable damageable equipment and contents above the expected flood level

If the flood depth at a site is above the practical height limits of available flood proofing barriers, an alternative mitigation method, such as raising of structures, should be considered.

Hydrologic and Hydraulic modeling of the Knights Landing Basin indicates that the structures in the community of Knights Landing are subject to flood depths greater than 3.5; and would require flood proof barriers of more than 3 to 5 feet, the practical limit for dry flood proofing. As a result, this non-structural solution was deemed infeasible for the vast majority of the Knights Landing Basin, particularly for the larger amount of residential and commercial structures. However, if landowners wish to pursue wet floodproofing solutions, particularly for agricultural structures in the Basin, they should be encouraged to do so, particularly if the County, State, and or federal agencies can secure cost-sharing reductions. (See AFOTF item Nos. 4 and 8 in Section 5.1.4 below that address opportunities for floodproofing agricultural structures, and the AFOTF preference to have lower NFIP insurance rates established for floodproofed agricultural structures.)

5.1.4 Refinements and Amendments to the National Flood Insurance Program (NFIP) via Agricultural Floodplain Ordinance Task Force (AFOTF) and H.R. 3167

The AFOTF, via its Technical Memorandum of December 28, 2016, has recommended nine administrative refinements of the NFIP to sustain agriculture as a wise use of the floodplain in leveed Special Flood Hazard Areas (SFHA). The NFIP administrative refinements (and amendments proposed by H.R. 3167) are focused on improving agricultural sustainability while collectively reducing flood risks in leveed agricultural basins similar to Knights Landing that are subject flooding of depths, particularly for deep SFHAs with flood depths greater than 3-5 feet. The recommendations address how rules and practices could be modified to: (1) reduce or remove elevation and floodproofing requirements for new and substantially improved agricultural structures, and (2) reduce the cost of flood insurance for agricultural structures with a federally backed mortgage to a more appropriate portion of the financial risk in the NFIP. The nine key elements include the following:

1. Levee Relief Cuts with Emergency Operation Plans and Floodplain management ordinance
2. Zone D with floodplain management ordinance and flood insurance instrument

3. Zone X (shaded) for certified levee reaches
4. Wet floodproofing rules for agricultural structures
5. Insurance rates for nonaccredited levees
6. Insurance rates for Zone D protected by sound reach of levee
7. Insurance rates for agricultural structures
8. Insurance rates for wet floodproofed structures
9. Add levee risk management activities to FEMA CRS

For the Knights Landing Basin, Item 1 was previously ruled out due to limited benefit resulting from the hydraulic backwater effects (see Section 5.1.1 above), Items 2 and 6 were determined to not be implementable due to numerous issues associated with Zone D, and the remaining recommendations were determined to be applicable to the Knights Landing Basin. These items are described in more detail below.

Item 3 - Zone X (shaded) for certified levee reaches - 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. The partial accreditation of a basin or levee reach could potentially lead to lower NFIP insurance rates as portions of levee systems are approved. This item could potentially be applied to the larger agricultural area as well as to the densely populated portion of the Knights Landing Basin.

Item 4 – Wet floodproofing rules for agricultural structures - FEMA's rules require flood vents (or openings) for entry and exit of floodwaters in all wet floodproofed agricultural structures. The Task Force recommends allowing human intervention for providing entry of floodwaters into agricultural structures in situations when large doors on at least two sides of the building could be locked open. If human intervention is authorized, appropriate conditions should be established in a Flood Emergency Operation Plan approved by the community and/or community's floodplain administrator. could allow for greater floodproofing flexibility for agricultural structures relative to stricter rules previously established for residential or commercial structures. This item is obviously most applicable to the agricultural structures in the Knights Landing Basin.

Item 5 – Insurance rates for non-accredited levees - FEMA's insurance rates for structures behind a non-accredited levee are the same as if there was no levee at all. Yet many non-accredited levees provide protection from frequent floods and significantly reduce flood risk. The AFOTF recommends that FEMA use sound actuarial science to amend its insurance rates to reflect the flood protection provided by a non-accredited levee as documented by a civil engineer, following a specific methodology and meeting specific criteria recommended by the Task Force. This item could be equally applicable to both the larger agricultural area as well as to the densely populated portion of the Knights Landing Basin.

Item 7 - Insurance rates for agricultural structures – When FEMA developed insurance rates for agricultural structures decades ago, there was not sufficient claims data to develop rates unique to agricultural structures. Therefore, agricultural structure rates are generally the same as rates for retail business and industrial structures and may be higher than necessary. The Task Force recommends that FEMA develop insurance rates for agricultural structures separately from other types of structures, update the Flood Insurance Manual with the new rates, and apply them expeditiously. Several agricultural structures including their contents, if flooded, would have significantly lower flood damages than the typical retail business or industrial structures. Thus, the NFIP premium rates should be lowered to reflect the lower flood damages associated with agricultural structures. This item is obviously most applicable to the agricultural structures in the Knights Landing Basin.

Item 8 - Insurance rates for wet floodproofed structures - FEMA's rules allow for wet floodproofing of agricultural structures by variance; however, insurance rates for wet floodproofed structures are the same as if there was no floodproofing. This recommendation would reduce NFIP premium policy rates for structures that are floodproofed. Currently, unlike dry flood proofing, insurance rates for wet floodproofed structures are the same as if there was no floodproofing. This item would be applicable to the agricultural portion of the Knights Landing Basin.

Item 9 – Add levee risk management activities to FEMA Community Rating System - FEMA's Community Rating System (CRS) provides credits that can reduce insurance premiums in CRS-participating communities. Several CRS credit categories are applicable in rural/agricultural areas. But in leveed areas of a community, the credits would be dissipated throughout the larger community, rendering them ineffective for rewarding good levee risk management in a particular leveed area of a community. This recommendation is an attempt to amend the CRS to recognize a subcommunity within a community and offer CRS credits for the following activities:

- High ground evacuation locations
- Federal levees with System Wide Improvement Frameworks (SWIFs)
- Risk-based levee system improvements
- Levee risk management plans

In addition to the nine recommendations identified above for sustaining agriculture located behind levees the AFOTF is very supportive of H.R. 3167, the "National Flood Insurance Program Reathorization Act of 2019" unamiously approved by the House Subcommittee on Economic Development, Public Buildings, and Emergency Management.

The Knights Landing Community would benefit from NFIP reform to support agricultural sustainability in areas that will not achieve 100-year base flood protection through

implementation of structural alternatives. It is recommended that the State continue to pursue recommendations made by the AFOTF and also continue to support federal legislation such as H.R. 3167 (Introduced, 06/10/2019) which proposes “To reform and reauthorize the National Flood Insurance Program” and includes several of the recommendations by the AFOTF and Congressman Garamendi’s bill, H.R. 830 introduced on 1/29/2019.

5.1.5 Improve NFIP Community Rating System for Yolo County/Knights Landing

Yolo County is an active participant/community of the NFIP and through its County-wide Flood Protection Ordinance the County strives to reduce flood risks throughout the unincorporated areas of Yolo County while also attempting to reduce NFIP premium policy rates. In addition to the above recommendations for modifying the NFIP for agricultural areas that could be applicable to the entire Knights Landing Basin and all other unincorporated areas within Yolo County that are protected by levees, there could also be opportunity for Yolo County to reduce flood insurance premiums through the FEMA CRS. As described below, the current CRS score in Yolo County is based upon the collective rating score of all the unincorporated areas combined within the County, with the exception of incorporated cities within the County having City-specific CRS scores. As of April 1, 2017, Yolo County has retained a CRS credit score, (cT) of 1,394 which places Yolo in the NFIP Community Classification Class 8. The Class 8 designation yields a 10% reduction of NFIP insurance premiums for Special Flood Hazard Areas (SFHAs) within Yolo County, inclusive of the entire Knights Landing Basin. Actions to increase the cT score would result in further reductions to insurance premiums within the County.

Yolo County’s current cT score of 1,393 is based upon several FEMA-specific activities carried out by Yolo County as identified below with corresponding Credits:

NFIP Activity	Activity Credit Score/Max Possible Score
310 - Elevation Certificates	32/116
320 - Map Information Service	70/90
330 - Outreach Projects	48/330
340 - Hazard Disclosure	5/80
350 - Flood Protection Information	57/125
420 - Open Space Preservation	620/2,870
430 - Higher Regulatory Standards	118/2,462
440 - Flood Data Maintenance	136/222
450 - Stormwater Management	141/755

502 - Repetitive Loss Category	0/n/a
510 - Floodplain Management Planning	120/622
630 – Dams (State Dam Safety Program Default Value	37/37
710 County Growth Adjustment factor 1.07 applied to 400 Series/Activities	
Total cT Score	1,394

A review of the above table indicates how the cT is score is derived based upon the County's current CRS activities, and where there may be greater opportunities to increase its current cT score from 1,394 to 1,500 which would yield an additional 5% reduction of NFIP insurance premiums throughout the county SFHAs, inclusive for the community of Knights Landing.

5.1.6 KLLS Flood Preparedness, Response and Recovery Plan Actions

A joint Flood Emergency Operations Plan for the KLLS was collectively developed in October of 2018 by the two key Local Maintaining Agencies (LMAs), namely the KLRDD and CSA #6. The plan contains the following key items and procedures for the collective LMAs that require periodic and ongoing updates specific to reducing flood risks within the Knights Landing Basin:

- KLLS LMA Flood Preparedness Procedures
- KLLS LMA Levee Patrol Procedures
- KLLS LMA Flood Fight Procedures
- KLLS LMA Flood Water Removal Procedures
- KLLS LMA Recovery and After-Action Follow-up Procedures
- Flood Contingency Map – Annex A for the Knights Landing Basin
- KLLS LMA Water Stage Monitoring of Sacramento River, Colusa Basin Drain, & Yolo Bypass

The plan provides a general approach to seasonal flood operations which includes: (1) routine preparedness and infrastructure maintenance; (2) monitoring and analysis of nearby and regional stream gages to monitor local flood warning stage, flood stage, and danger stages; and (3) a basin-specific public flood alert system for the Knights Landing Basin indicating activation and initial response actions. The noted seasonal flood operations require periodic updates to ensure continued coordination between the two LMAs

The subject flood emergency operations plan includes monitoring of river and channel stages of the Colusa Basin Drain at Knights Landing Outfall Gates (CDEC ID KLG) and the Sacramento River at Knights Landing Bridge (CDEC ID KNL). The plan also identifies additional monitoring gauges within or adjoining the Basin, with several regional gauges outside of the Basin. Some of the regional gauges are located as far as

Hwy 20 on the Colusa Basin Drain and on the Sacramento River between the Tisdale Weir and the Sacramento I Street Bridge, inclusive of the Freemont Weir stages. The subject plan defines trigger elevations for each of the monitoring gauges and various response actions for: Level I – Monitoring Stage, Level II – Flood Stage, and Level III - Danger Stage. The trigger elevations and datum elevations for each gauge are subject to change and should be revaluated and updated on a regular basis, particularly after any significant high-water events.

All of the above elements and action items associated with the KLLS Flood Emergency Operations Plan, if kept current and updated on a regular basis, will serve as a viable non-structural solution to further reduce flood risks in the Basin as well as improve the County's CRS.

5.1.7 Improved OMRR&R Governance Between CSA #6, and Knights Landing Ridge Drainage District

Flood management in Yolo County is currently carried out by 14 separate local maintaining agencies, including RDs, local municipalities and special districts inclusive of KLRDD and CSA #6. In August of 2014, during the development of the Lower Sacramento/Delta North RFMP, the UC Davis Extension Collaboration Center conducted a Yolo County Flood Governance Study which identified a preference and need to improve local governance between KLRDD and CSA #6, specifically for Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R. CSA #6 is the LMA responsible for the Sacramento right bank levee within Yolo County, and KLRDD is the LMA responsible for the left bank levee of the Knight Landing Ridge Cut adjoining the Knights Landing Basin. California DWR is the LMA responsible for maintaining the west levee of the Yolo Bypass abutting the Basin, and Sutter County is responsible for maintaining a small segment (approximately 0.53 miles) of the right bank levee of the Sacramento River immediately upstream of the of the Freemont Weir/Yolo Bypass.

The governance study clearly indicates that CSA #6 has a limited annual operations and maintenance budget of only $39,400 as of 2014, and KLRDD has a larger annual O&M budget of $100,000, both based upon property assessments for similar lengths of levee systems. Due to overlapping property assessments and CSA #6's limited ability to sustain O&M operations to levels deemed acceptable by the USACE and DWR, both CSA #6 and KLRDD could benefit from improved governance by consolidating, merging, or contracting LMA responsibilities between the two special districts.

The improved governance between the noted entities could also enhance capital improvement assessments to construct and O&M any new levee improvements, inclusive of a new cross levee identified in the preferred structural alternative for Knights Landing.

5.1.8 Agricultural Conservation Easements

The Knights Landing Community would benefit from agricultural conservation easements that would provide agricultural interests financial consideration for agreeing to keep their property in agricultural uses in perpetuity while minimizing residual risk in the higher rick portion of the basin, particularly east of the proposed cross levee. Agricultural conservation easements for the Knights Landing Basin would be designed to offset potential loss in property value for agricultural areas that aren't provided FEMA base 100-year flood protection. The agricultural easements would also preclude future residential or commercial development from taking place, further enhancing agricultural sustainability in the Knights Landing Basin.

5.2 Recommendation of Non-Structural Solutions

As explained in the previous section, some of the non-structural solutions identified have been deemed infeasible or undesirable for the community of Knights Landing However, several solutions are recommended for inclusion to further reduce flood risks to the community and also provide opportunities to reduce NFIP flood insurance premiums. The non-structural solutions also include improving local governance to enhance the community's ability to sustain existing O&M obligations and enhance funding of any new levee improvements, inclusive of a new cross levee identified in the preferred structural alternative for Knights Landing.

The following non-structural solutions have been identified as recommended for implementation, some of which are already in the early stages of implementation:

- Voluntary Raising of Structures
- Voluntary Flood Proofing, particularly of Agricultural Structures
- Refinements and Amendments to the National Flood Insurance Program via Agricultural Floodplain Ordinance Task Force and H.R. 3167
- Improve NFIP Community Rating System for Yolo County/Knights Landing
- Knights Landing Levee System Emergency Operations Plan – Basic Plan Implementation, Inclusive of Flood Emergency Trigger Elevations & Response Actions
- Improved OMRR&R Governance Between CSA #6, and KLRC Drainage District
- Agricultural Conservation Easements

6 Multi-Benefit Alternatives

When viable levee setbacks, land acquisitions, and floodplain storage activities represent the most resilient means of improving system performance within or adjoining the small community footprint, they tend to limit exposure and add to system capacity rather than concentrating flows.

Sensitive habitats included are those that are of special concern to resource agencies, which may require agency consultation, or those that are protected under various state or federal regulations such as riparian areas, agricultural ditches, areas of open water, and other potential aquatic resources. Aquatic resources provide a variety of functions for plants and wildlife, including providing habitat, foraging, cover, migration, and movement corridors for both special-status and common species. In addition to habitat functions, these features provide physical conveyance of surface water flows capable of handling large storm water events.

Recreation within Knights Landing is largely water-based. On the Sacramento River side of the study area, some of the most common fish for recreation are Striped Bass and White Sturgeon, with the latter being more present in low-water years[8]. The KLRC is home to such popular species for fishing as Black Crappie, Brown Trout, Channel Catfish, and Central Valley Steelhead[9]. Additionally, Knights Landing has a boat launch and club, and is a popular destination for boaters on the Sacramento River[10].

The approach used to identify potential habitat restoration concepts for this feasibility study initially focused on what could possibly be implemented without regard for existing land use or infrastructure constraints. As an example, the geographic scope was not limited to the Knights Landing Basin in recognition of the high value habitats that are located directly outside of the Basin such as along the Sacramento River. This approach allowed the project team to initially identify opportunities with high restoration potential.

6.1 Identification of Ecosystem Alternatives

The project team identified ten preliminary habitat restoration concepts through the use of aerial maps, high-resolution topography, and local knowledge related to land-use, infrastructure, target species, and habitats. Target species included, but were not limited to, salmonids (Chinook salmon and steelhead), numerous avian species (Swainson's

[8] https://salmonsacriver.com/fishing-report/salmon/striped-bass/sacramento/river/guide/charter/northern-california/2018/2/3/sacramento-river-fishing-report-for-striped-bass-and-white-sturgeon-february-3-2018

[9] http://calfish.ucdavis.edu/location/?ds=698&reportnumber=1293&catcol=4712&categorysearch=%27Knights%20Landing%20Ridge%20Cut-180201630301%27

[10] http://delta.ca.gov/files/2017/02/RecInv_2017_RecInvReport.pdf

Hawk, Tri-colored Blackbird, Western Yellow-billed Cuckoo, etc.), and reptiles (e.g. Giant Garter Snake). The following are the ten preliminary habitat restoration concepts identified during the initial development process.

1. Sutter Bypass Triangle Property Enhancement Concept
2. Grays Bend Channel Connection Concept
3. Grays Bend Riparian Enhancement Concept
4. Grays Bend Levee Setback Concept
5. Hog Farm Levee Setback Concept
6. Sacramento River Left Bank Levee Setback Concept
7. Sacramento River Right Bank Levee Setback Concept
8. Portuguese Bend Enhancement Concept
9. KLRC Enhancement Concept
10. New Cross levee Adjacent Borrow Site Enhancement Concept

Figure 35 shows the location of these ten preliminary habitat restoration concepts. Detailed descriptions of these concepts are provided in Appendix E: Multi-Benefit Opportunities Technical Memorandum.

6.2 Preliminary Screening of Ecosystem Alternatives

Following the identification of the preliminary restoration concepts, the study included a qualitative evaluation of each concept. This evaluation process included assessing each concept's ability to provide ecological uplift, whether they include or support recreational activities, their cost to construct and operate, the estimated permitting complexity, their effects on agricultural sustainability, the overall feasibility of implementing the improvements, and their contribution to reducing flood risks. The review focused on identifying realistic and feasible restoration concepts that would merit more detailed review due to their potential ability to be planned and implemented in the near future in connection with the identified flood improvement alternatives. Categories were scored Low, Moderate, or High representing potential or relative values associated with each category.

Using this screening process, the preliminary habitat restoration concepts were narrowed to those that would have at least a moderate feasibility of implementation. Five of the ten concepts met this criterion. Of these five concepts, the Yolo Bypass Triangle Property Enhancement Concept (Concept 1) was eliminated from more detailed review due to its low flood risk reduction benefit and its high permitting effort

due to its location in the Sutter Bypass. The Cross levee Riparian Corridor Concept (Concept 10) was also eliminated from more detailed review due to potential concerns regarding its local acceptability. The three remaining concepts included the Grays Bend Riparian Enhancement Concept (Concept 3), the Portuguese Bend Enhancement Concept (Concept 8), and the KLRC Enhancement Concept (Concept 9). These concepts were identified as having the highest potential to be implementable in connection with the flood improvement alternatives identified in this study. This screening process is described in Appendix E: Multi-Benefit Opportunities Technical Memorandum.

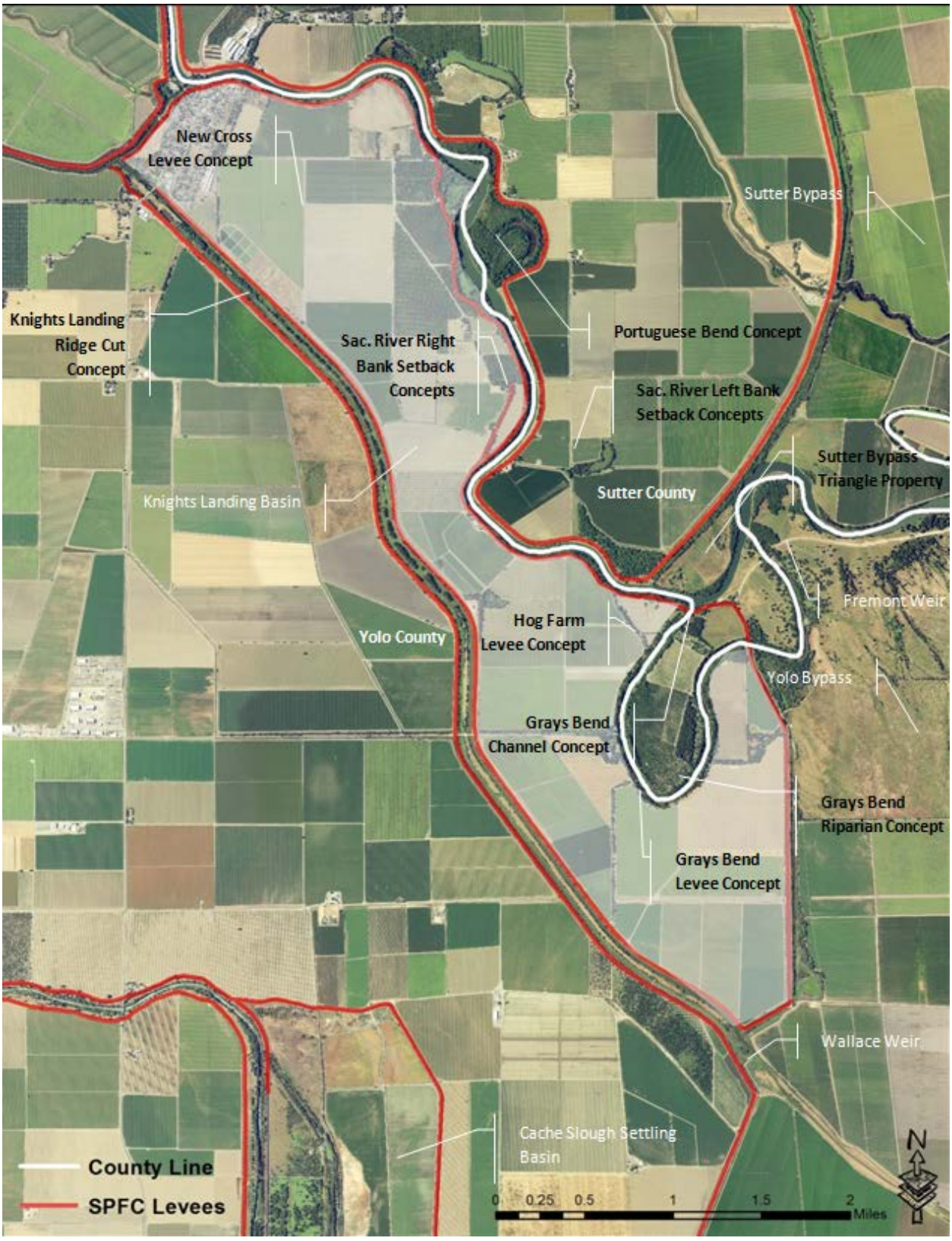

Figure 35 Preliminary Restoration Concepts

6.3 Description of Final Array of Ecosystem Alternatives

Three ecosystem concepts that are implementable in connection with the flood risk reduction alternatives identified above include the Grays Bend Riparian Enhancement Concept, the Portuguese Bend Enhancement Concept, and the KLRC Enhancement Concept. These three ecosystem concepts are described below. In addition, recreational opportunities that are implementable in connection with the flood risk reduction alternatives identified above are also described below.

6.3.1 Grays Bend Riparian Enhancement Concept

The Grays Bend project area sits at the confluence of the Sacramento River, Yolo Bypass, and Sutter Bypass, and encompasses an entire oxbow feature which was historically the alignment of the mainstem of the Sacramento River. The oxbow channel forms the county line between Yolo and Sutter counties with the oxbow area located within Sutter County. The property is privately owned, and direct landowner engagement will need to be initiated if this concept is considered for integration with any of the flood improvement alternatives evaluated in this study.

The objective of this concept is to improve the quality and quantity of SRA habitat along the left bank of the oxbow channel by widening both the area of inundated riparian habitat and expanding the width of the riparian fringe forest. At the conceptual design level, this would be accomplished by creating a narrow inset floodplain bench and laying back the banks, as well as widening the riparian corridor through active planting with native riparian species.

The width of riparian enhancements is estimated to be approximately 100 feet from the existing left edge of bank (except for one wider area adjacent to the existing forested patch in order to connect with this area), and the enhancement footprint encompasses approximately 35 acres. The target species for this enhancement concept are birds dependent on healthy riparian habitat including Western Yellow-billed Cuckoo, least Bell's vireo, and tricolored black bird, as well as other native species such as giant garter Snake and western pond turtle. The length of riparian enhancements would be refined based on a more detailed evaluation and landowner interest.

The excavated soil could be used as a source material for construction of one of the cross levees being contemplated within the Knights Landing Basin. Also, the habitat creation would potentially offset any riparian habitat impacts that may occur due to levee repairs along the Sacramento River.

The cost to implement this restoration concept is roughly estimated to be $4.9 million. This cost estimate was prepared purely for comparative purposes and should not be

relied upon for funding decisions without further refinement of the permitting requirements and the concept details.

6.3.2 Portuguese Bend Enhancement Concept

The Portuguese Bend area is located southeast of the Knights Landing community within a wide area of the Sacramento River. The area includes Mary Lake, which is an oxbow feature that is intermittently inundated by high flows within the Sacramento River. This area is located entirely within the floodplain between the existing levees of the Sacramento River and includes lands on both the west side and east side of the river. The lands on the west side of the river are in Yolo County and the lands on the east side are in Sutter County. The property is privately owned.

The objective of the restoration concept is to improve connectivity to existing riverside off-channel lands on both sides of the river in order to create a larger area of more frequently inundated floodplain habitat to benefit salmonids. In addition, active riparian restoration of poorly vegetated areas on the west bank of the river would enhance riparian habitat conditions through this corridor and provide additional shaded riverine aquatic habitat.

Targeted excavation would connect low-lying areas to the river so that they inundate earlier and more frequently. Restoration would consist of targeted excavation in five areas comprising approximately 25 acres. Riparian restoration would occur in two areas comprising approximately 28 acres. Increasing the area of inundation through targeted excavation is also expected to enhance the ability of this area to contribute to localized groundwater recharge.

The excavated soil could be used as a source material for construction of any of the cross levees being contemplated in this study. Also, the habitat creation would potentially offset any riparian habitat impacts that may occur due to levee repairs along the Sacramento River.

The cost to implement this restoration concept is roughly estimated to be $6.4 million. This cost estimate was prepared purely for comparative purposes and should not be relied upon for funding decisions without further refinement of the permitting requirements and the concept details.

6.3.3 KLRC Enhancement Concept

The KLRC was constructed in 1930 by USACE and the State of California to transport agricultural drainage water from the Colusa Basin Drain into the Yolo Bypass. Maintained by the KLRDD, the KLRC extends approximately 6 miles southeast from its confluence with the Colusa Basin Drain near the western edge of the unincorporated community of Knights Landing to the recently reconstructed Wallace Weir. The levees

on both sides of the KLRC provide flood protection for the community of Knights Landing and for the surrounding agricultural lands to the northeast and southwest.

The KLRC includes two parallel channels that were excavated to provide the material necessary to construct the adjacent levees. A linear mid-channel island was formed during construction (due to dredger arm length constraints) that extends along the length of the KLRC. Within the upper portion of the KLRC, much of the mid-channel island is densely vegetated whereas in the lower portion, much of the island is regularly mowed with only very narrow strips of shrubby vegetation along the island's edges. The vegetation along the levee toes is relatively sparse. The relatively dense vegetation growth on the upper portion of the island has likely reduced the channel's original conveyance capacity.

In addition, the island has eroded in some areas resulting in the formation of narrow cross channels that divert flows directly toward the levees, resulting in some scouring of the levee toe. Over time, this scouring could degrade the levee integrity.

The concept includes excavating the mid-channel island within the KLRC to increase channel capacity, to reduce cross channel erosion, and to provide a material source to construct a cross levee. Some of the excavated material would also be used to reinforce both of the KLRC levee toes and to provide a base for planting riparian vegetation, which would aid in stabilizing the levees. Although the riparian vegetation would somewhat reduce the additional conveyance capacity that would be achieved with channel excavation, it would provide the ancillary benefit of helping to achieve the State's objectives of restoring species habitat and ecosystem function. Specific species that could benefit include Giant Garter Snake, valley elderberry longhorn beetle, tricolored blackbird, Swainson's hawk, Western Yellow-billed Cuckoo, and least Bell's vireo.

The concept includes several assumptions, the primary of which is that the material excavated out of the KLRC would be suitable for cross levee construction. Additional analysis will be necessary to verify this assumption. Also, the island is assumed to be excavated along its entire length down to its lowest point and a two-step bank is assumed to be constructed on each side of the channel using available cut material. Using simplified geometry to estimate the cross sectional cut/fill areas for ease of calculation, the total estimated remaining volume of material available for construction of a cross levee would be approximately 1,680,000 cubic yards.

The riparian enhancement along the levee toes is proposed to be implemented in a two-step design that is based on the existing hydrology, which showed stage variation of only approximately 4 feet for the period of available data (December 2017 – December 2018). The elevations of the two steps were chosen based on this hydrology (roughly 22.5 feet and 20 feet). The lower-elevation step would be inundated year-round and the higher step would be an intermittently inundated feature, with vegetation planting

palettes chosen to match the hydrology and target wildlife species. An additional design consideration includes the placement of woody material from trees removed from the excavated island along the restored levee banks to provide cover and habitat complexity.

The cost to implement this restoration concept is roughly estimated to be $23.8 million. The majority of the cost associated with this concept, or approximately $17.2 million, is associated with the material excavation and transport activities. A substantially scaled-back version of this concept that focused on strategically filling the cross channels that may be contributing to bank erosion by using material from the existing center island is estimated to cost approximately $3.7 million. These cost estimates were prepared purely for comparative purposes and should not be relied upon for funding decisions without further refinement of the permitting requirements and the concept details.

Table 12 identifies how these three restoration concepts would contribute to achieving the habitat objectives identified in the Conservation Strategy for the Central Valley Flood Protection Plan 2017 Update. The second column of this table identifies the Conservation Strategy objectives for ecosystems processes, habitats, and stressors for the entire Lower Sacramento/Delta North Regional Flood Management Plan Area. The subsequent columns identify how each of the three restoration concepts would contribute to these objectives. For the ecosystem processes, the restoration concepts can achieve multiple-benefits within the same project footprint.

Table 12 Contributions of Ecosystem Concepts to CVFPP Conservation Strategy Habitat Objectives

	Conservation Strategy Habitat Objectives[1]	Grays Bend Riparian Enhancement Concept[2]	Portuguese Bend Enhancement Concept	Knights Landing Ridge Cut Enhancement Concept[3]
Ecosystem Processes				
Floodplain Inundation: major river reaches (acres)	7,650	-	41.4	-
Floodplain inundation: bypasses/transient storage areas (acres)	7,500	29	-	125
Riverine geomorphic processes: natural bank (miles)	4	2.4	1.1	13
Riverine geomorphic processes: river meander potential (acres)	1,300	29	41.4	125

	Conservation Strategy Habitat Objectives[1]	Grays Bend Riparian Enhancement Concept[2]	Portuguese Bend Enhancement Concept	Knights Landing Ridge Cut Enhancement Concept[3]
Habitats				
SRA cover: natural bank (miles)	4	-	-	-
SRA cover: riparian-lined bank (miles)	3	2.4	1.1	13
Riparian habitat (acres)	1,900	29	41.4	157
Marsh/other wetland habitat (acres)	3,500	-	-	-
Stressors				
Fish passage barriers: channel-wide structures	4	-	-	-
Invasive plants: prioritized species (infested acres)	363	-	-	-

[1]Habitat objectives in acres, river/bank miles (or removal of fish passage barriers) as identified in the CVFPP Conservation Strategy for the Lower Sacramento/Delta North Regional Flood Management Plan Area.
[2]Assumes 100-foot wide enhanced riparian corridor along 2.4-mile interior length of Grays Bend.
[3]Assumes a 100-foot wide riparian corridor would be planted along both banks of the Ridge Cut. Also assumes the lowering of the 160-foot wide central island, which would increase the area for inundated floodplain habitat and river meander potential.
CVFPP = Central Valley Flood Protection Plan (2017 Update)
SRA = Shaded Riverine Aquatic

6.4 Recreation Alternatives

The Knights Landing Revitalization Study focused on three recreational enhancements within the community including establishing a new public park on a portion of the Sci-Tech Academy Charter School site, establishing a promenade overlook on the Sacramento River, and improving the Knights Landing boat launch area. The Revitalization Study also separately identified recreational opportunities along the levee that extends along the northwestern edge of the community adjacent to the Colusa Basin Drain and parallel to Reed Street. In addition, as part of this study, additional recreational opportunities were explored that could be integrated with the proposed flood improvement alternatives. The following describes the three recreational opportunities identified in the Revitalization Study and the additional recreational opportunities identified in Appendix E: Multi-Benefit Opportunities Technical Memorandum. Figure 36 shows the location of these recreational opportunities.

6.4.1 New Public Park at Sci-Tech Academy Charter School

The Sci-Tech Academy Charter School (Sci-Tech) occupies approximately 14 acres of land in the center of the community adjacent to State Route 113. Sci-Tech is an Elementary School (Kindergarten through 6th Grade) that was established as a Charter School in 2011. Approximately 5-acres of open space play area on the school property were identified in the Revitalization Study as a potential soccer field/public park. Converting this area to a soccer field/public park would require the installation of an irrigation system. The local school district has no plans to use or maintain the area as a public park (Wahlstrom & Associates 2016).

6.4.2 Sacramento River Promenade

The development of a promenade on the Sacramento River would represent a substantial recreational amenity for the community that would be directly connected to alternatives evaluated in the Feasibility Study. Therefore, the integration of this promenade should be considered in any levee improvement planning and/or design along the Sacramento River between State Route 113 and Railroad Street.

6.4.3 Knights Landing Boat Launch Improvements

The Knights Landing Boat Launch (Boat Launch) is located on four acres at the confluence of the Sacramento River and the Colusa Basin Drain, just northwest of the Knights Landing community. Access is provided to the Boat Launch from State Route 113. The Boat Launch includes a parking area and a boat ramp that provides access to the Sacramento River for boating, water skiing, and fishing for local residents and visitors. The Boat Launch site is operated and maintained by Yolo County Parks Department staff (Wahlstrom & Associates 2016).

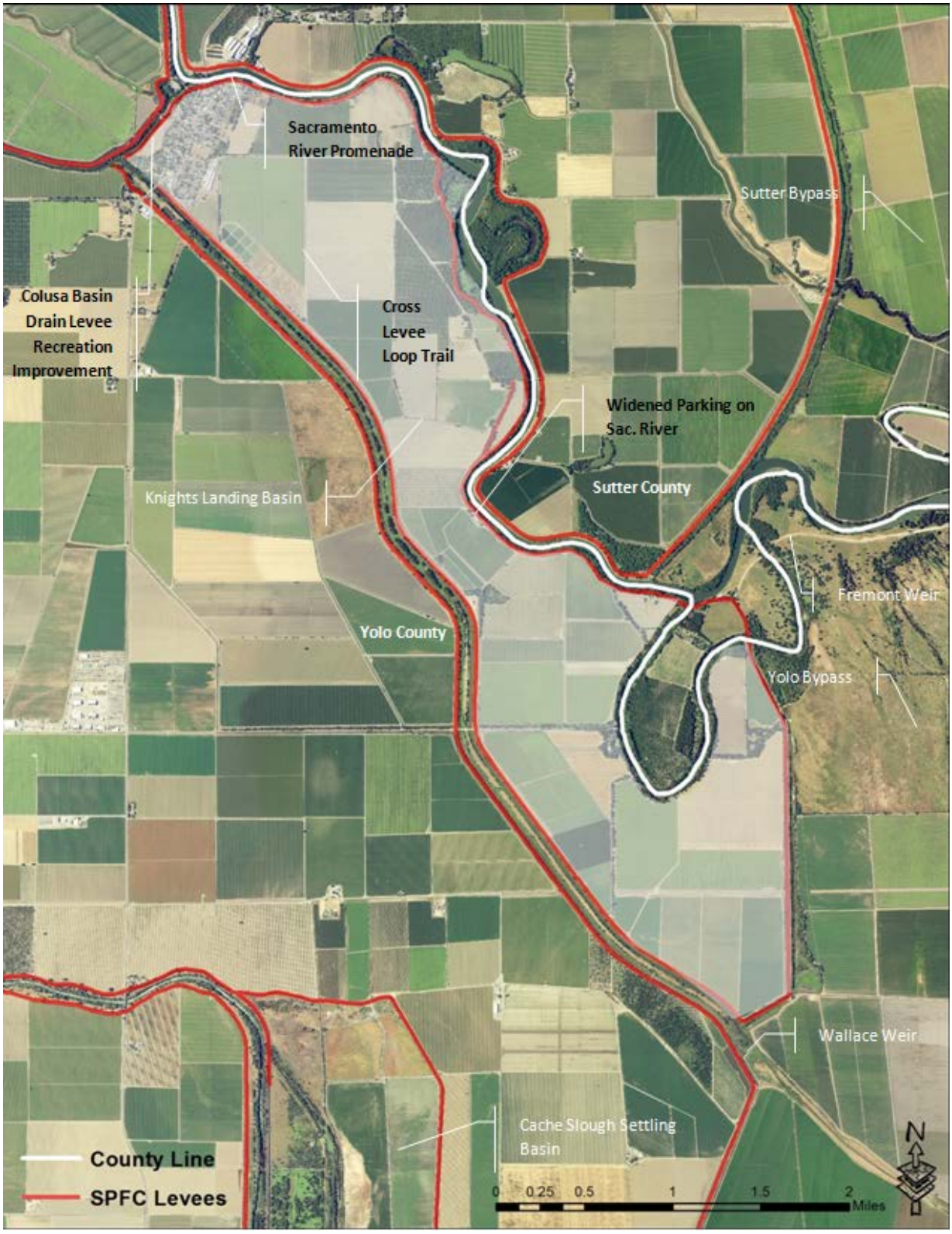

Figure 36 Preliminary Recreational Opportunities

The County recently acquired a $1.6 million grant from the California Wildlife Conservation Board to expand the Boat Launch from one to two lanes, improve the parking lot and picnic area, and recruit a full-time park host to manage the facility (Wahlstrom & Associates 2016). The County has completed the design plans and is working through the necessary permitting with the goal of starting construction on these improvements in the summer of 2019 (Marchand, pers. com., 2019).

In addition to the Boat Launch improvements that are anticipated to be constructed in 2019, the Revitalization Study identified the creation of a natural park within the densely vegetated area directly west and south of the Boat Launch area. Improvements included enhancing fishing access to the pond within the center of this area and installing trails and picnic areas. The Revitalization Study also identified the installation of a pedestrian bridge that would extend across the Colusa Basin Drain from the Boat Launch area to the Colusa Basin Drain east levee. The purpose of this pedestrian bridge would be to provide better fishing access and to connect the community to the waterfront and Boat Launch. This pedestrian bridge would also connect to a trail improvement identified along the Colusa Basin Drain east levee that is described below.

6.4.4 Colusa Basin Drain Levee Recreational Improvements

The Revitalization Study identified the installation of a trail alignment along the top of the Colusa Basin Drain east levee that would run parallel to Reed Street along the northwestern edge of the community. The trail would commence at the cul-de-sac at the southern end of Reed Street and would continue northeast along the east levee to State Route 113 at the northern end of the community, at which point it would connect with the Sacramento River Promenade trail described above. This trail would also provide access to the pedestrian bridge identified in the Revitalization Study that would connect the community to the Boat Launch.

The east levee currently has a maintenance road along its top and is posted with no trespassing signage. This area includes private commercial, residential, and public/quasi-public parcels. However, it appears to be used by local residents for river access (Wahlstrom & Associates 2016). Access improvements on both the water side and land side of the levee would enhance the recreational value of this levee alignment as a walking trail and access for fishing along the Colusa Basin Drain and Sacramento River.

6.4.5 New Cross levee Loop Trail

Although the existing levees on the perimeter of the Knights Landing community are currently used by residents as walking trails, the typical use represents an out and back activity along the same route. However, if a cross levee is constructed directly east of the community, the new levee could provide a loop trail that would allow residents to walk or run completely around the community. If the cross levee in closest proximity to the community is constructed (Alternative 1), the distance of the round-trip loop would

vary between 2.5 and 3 miles, depending upon the route walked through the community. If the cross levee is constructed further east, the round-trip loop would vary between 4 and 4.5 miles. To use the new cross levee, residents would need to either walk southeast along the northern levee of the KLRC or walk east along the Sacramento River's southern levee. If trail enhancements identified in the Revitalization Study along the Sacramento River and Colusa Basin Drain are installed, the levee trail loop would almost extend around the entire community. Recreationalists would need to walk approximately 0.5 mile through the community to connect between the end of the Colusa Basin Drain levee trail at Reed Street to the start of the KLRC levee trail at the end of Locust Street.

Also, if riparian vegetation is planted within a potential borrow area adjacent to a new cross levee alignment (Alternative 1), the cross-levee trail could incorporate walking paths within the riparian corridor. Providing a walking path through an adjacent riparian corridor would provide recreationalists with an alternative walking environment that may be more enjoyable due to greater wildlife diversity and would likely be more useable during the hot summer months once the vegetation matures.

6.4.6 Widened Recreational Parking on Sacramento River

Recreationalists currently access the Sacramento River, primarily for fishing purposes, from County Road 116B near Wild Irishman Bend. Vehicles park along the roadway on top of the levee in this area although sufficient space is not currently available to safely accommodate parking. Vehicles parking in this area can cause safety hazards for vehicles traveling on this roadway and pedestrians accessing the river. These parked vehicles can also slow or completely block emergency responders. The expansion of County Road 116B in this area sufficient to safely accommodate vehicle parking would eliminate this roadway hazard and would provide an improved recreational amenity for the community. The length of the road widening necessary to accommodate the current and estimated parking demand would need to be determined prior to initiating the improvements.

6.5 Water Supply Improvement Opportunities

The 2017 Update to the Central Valley Flood Protection Plan strongly supports and encourages the planning and implementation of projects that provide multiple benefits. These benefits are not solely limited to ecosystem or recreational enhancements, they also include improving water supply and water quality. Within Knights Landing, three existing groundwater wells are used to provide water to the community. The combined pumping capacity of 3,000 gallons per minute (gpm) from the wells meets both the 1,500 gpm residential requirement and the 2,500 gpm commercial fire flow requirement, as well as the existing maximum use per day of 408 gpm. However, the diameters of the pipelines that form the community's water distribution system are too small to deliver water at the required flow rates. Therefore, existing commercial fire flows do not meet current requirements.

Also, the existing water system pumps have been unreliable, resulting in the failure to meet drinking water quality standards. Two of the three wells failed in 2015 requiring residents to restrict outdoor watering and implement in-home conservation measures. One well was recently repaired and placed back into service, but repair of the second well may cost more than $1 million. No funding source is currently available to pay this cost.

The improvements necessary to enhance the water supply system such that it meets state standards includes the installation of new pumps, the drilling of deeper wells, the construction of water storage facilities, and replacement of the undersized portions of the water supply distribution network. The integration of these water system improvements should be considered in any levee improvement planning and/or design within the Knights Landing basin, consistent with the integrated water management approach advocated for in the 2017 Update to the CVFPP.

6.6 Multi-Benefit Alternatives Recommendation

6.6.1 Ecosystem

The three concepts with the highest potential to be implementable in connection with the flood risk reduction alternatives (and described above) include the Grays Bend Riparian Enhancement Concept (Concept 3), the Portuguese Bend Enhancement Concept (Concept 8), and the KLRC Enhancement Concept (Concept 9). These restoration concepts were not narrowed further because any one of these three restoration concepts could be feasibly paired with the flood improvement alternatives identified in this report.

6.6.2 Recreation

In preparing this report, the project team concluded that the recreational opportunities were more limited than the habitat restoration opportunities. As a result, all four recreational opportunities could be feasibly paired with the flood improvement alternatives identified in this report.

6.6.3 Water Supply

The project team recommends that the integration of the identified water system improvements be considered in any levee improvement planning and/or design within the Knights Landing Basin, consistent with the integrated water management approach advocated for in the 2017 Update to the CVFPP.

7 Implementation

While levees can help reduce the risk of flooding, they are a component of a broader flood risk management approach. The alternatives presented are not limited to federal, State or local activities. The Preferred Alternative includes a preferred structural flood risk reduction alternative (identified in Chapter 4), combined with several non-structural recommendations, inclusive of HR 3167, the "National Flood Insurance Program Reauthorization Act of 2019" that includes NFIP insurance reform of leveed agricultural areas and a measure to improve operations and maintenance governance (identified in Chapter 5). Also included in the Preferred Alternative are measures for incorporating multi-benefit components for habitat enhancement, water supply improvements and recreation (identified in Chapter 6). Thus, implementation can be phased and will require the work of numerous Federal, State, local, and private agencies and organizations.

7.1 Phased Implementation of Structural Alternatives

As explained in Section 4.8, the total cost estimate for the Preferred Structural Alternative is $72 million with a proposed cross levee estimated at $35.7 million, and levee repairs/improvements at $36.3 million. Full implementation for all of the preferred structural alternative elements would likely take five years from the time that funding is secured for the project and would include project design, environmental documentation, and construction (Figure 37).

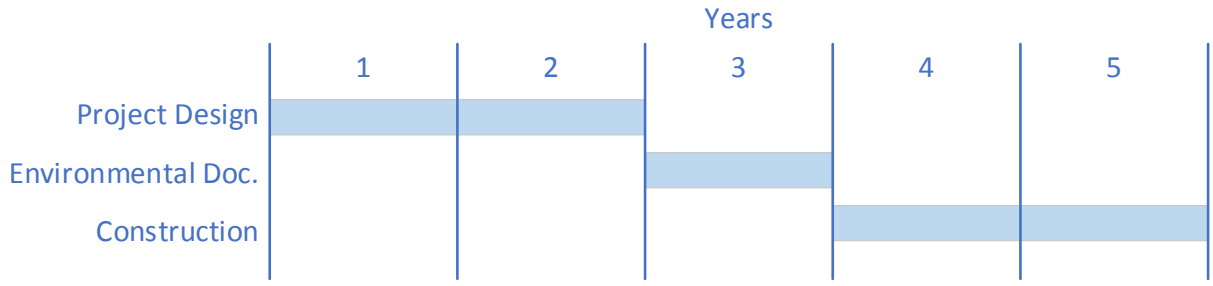

Figure 37 Potential Project Schedule

The three ecosystem concepts with the highest potential for implementation in connection with the structural flood risk reduction alternatives include the Grays Bend Riparian Enhancement Concept (Concept 3), the Portuguese Bend Enhancement Concept (Concept 8), and the Knights Landing Ridge Cut Enhancement Concept (Concept 9). Concept 3 and Concept 9 may be completed in conjunction with structural levee improvements or cross levee improvements as the excavated material associated with Concept 3 or 9 may be suitable for berm or levee fill material.

All four recreational opportunities could be feasibly paired with the structural flood improvement alternatives identified for the Knights landing Basin. These opportunities could be completed concurrently or after the preferred structural alternative.

The community of Knights Landing is largely dependent upon its limited ability to pay (ATP) for various elements of the preferred structural alternative and Yolo County is considering the following three key structural management actions to reduce flood risks within the Knights Landing Basin

7.1.1 Levee Improvements Adjacent to the Community of Knights Landing

This initial phase would consist of repairing all known levee performance deficiencies immediately adjacent to the community along the Sacramento River right bank levee and downstream of the Knights landing Outfall Gates, all northwest of a preferred cross levee alignment, just east of Knights Landing. This is a subset of KLLS repairs identified in Alternative 12, excluding: (a) repairs of the Sacramento River right bank levee downstream and east of a cross levee; and (b) the preferred cross levee. The total cost for these "No-Regrets Levee Repairs" previously identified by DWR under their Non-Urban Levee Evaluation (NULE) Phase 2 Program are currently estimated at $24.4 million including contingencies.

7.1.2 Levee Improvements Downstream of the Community of Knights Landing

This Phase would include three separate levee repairs sites totaling 1.5 miles along the right bank levee of the Sacramento River downstream and east of the community from levee mile 2.7 to 2.9, 3.0 to 3.2 and 4.3 to 5.4. These three Sacramento River right bank levee repairs (also referred to as the USACE Mid Valley Sites 9, 10, and 11) are located east and downstream of the proposed cross levee associated with the preferred alternative, Alternative 12. The full repair costs for these three collective sites, covering 1.5 levee miles are currently estimated at $11.9 million including contingencies.

7.1.3 Cross levee Phase

Pursue financing, design, and permitting and construction of the cross levee in the preferred alternative, Alternative 12. This includes financing and construction of not only the cross levee to meet FEMA accreditation (pursuant to 44 CFR Section 65.10), but also includes repairs/enhancements to the KLRC levee, adjoining the Knights Landing sewer ponds. The preferred cross levee alignment and repairs to the KLRC adjoining the Knights Landing sewer ponds is currently estimated at $35.7 million including contingencies. This amount does not include full FEMA 100-year accreditation (pursuant to 44 CFR Section 65.10) for the remaining portions of the existing perimeter levee system along the KLRC between the existing sewer ponds and the Knights Landing Outfall Gates. Management actions required for full FEMA 100-year

accreditation of the existing Knights Landing Basin perimeter levee system levee system west of the proposed cross levee are further described below in Section 7.2.

7.2 Additional Management Actions for Levee Accreditation

For the purposes of the NFIP, FEMA will only recognize those levee systems that meet minimum design and operation standards that are consistent with the level of protection sought through the comprehensive floodplain management criteria. The preferred alternative identified in this study provides flood risk reduction to the community of Knights Landing. However, in order to obtain FEMA 100-year accreditation for the levees surrounding the community, additional management actions are required pursuant to 44 CFR Section 65.10. Attaining FEMA 100-year accreditation will result in lower insurance costs which would provide immense economic benefit to the disadvantaged community of Knights Landing.

The following section provides a brief summary of steps required to attain FEMA levee accreditation. Cost estimates for these phases were not estimated as part of this study as these phases require additional studies.

7.2.1 Identify Remaining Levee Improvements

Evaluate the entirety of the perimeter levee system of the KLLS as a whole northwest of the cross-levee alignment in the preferred alternative and determine any residual repairs/improvements that are required to accredit and certify the perimeter levee system pursuant to 44 CFR Section 65.10 northwest of the final cross levee. This initial evaluation element should be done in tandem and simultaneously with initial structural phase of levee improvements adjacent to the community of Knights Landing as described above in Section 7.1.1. The identification of all perimeter levee repairs/improvements and costs thereof west of the preferred cross levee should be identified as early as possible, as the community and supporting LMA's may need a greater understanding of the total costs to repair and enhance the levees to meet FEMA 100-year accreditation criteria for areas northwest of the preferred cross levee alignment.

7.2.2 Design and Construction of Remaining Levee Improvements

Design and construct the residual repairs and enhancements identified and evaluated above in Section 7.2.1 for the perimeter levee system northwest of preferred cross levee alignment to meet FEMA 100-year accreditation certification criteria (44 CFR Section 65.10), not previously identified within DWR NULE investigations/repairs in the initial structural phase further described above in Section 7.1.1.

7.2.3 Submit Letter of Map Revision

Prepare and submit a Letter of Map Revision (LOMR) to FEMA requesting accreditation for the levee system(s) protecting the densely populated area of the Knights Landing Basin, northwest of, and inclusive of the final cross levee alignment.

7.3 Recommendations and Implementation

The KLRDD and CSA #6, acting through the County of Yolo, has the opportunity to significantly reduce flood risks to the Knights Landing Basin. They intend to accomplish this by repairing the greatest known and documented weaknesses in the perimeter State Plan of Flood Control (SPFC) levee system protecting the basin and constructing a cross levee to offer FEMA 100-year level of protection for the densely populated western portion of the basin. To achieve the noted reductions in flood risk the following recommendations include full development of the preferred structural alternative, advancing non-structural solutions, and transforming multi-benefit concepts into elements of the preferred structural alternative. They are outlined and planned to secure timely financial assistance and concurrence with the CVFPB, DWR, and the USACE to reduce known flood risks. The following recommendations can be sequenced or phased in the order as listed below or amended based upon variable funding sources. However, it is recommended the first two recommendations take priority for initiating all structural improvements, with all other recommendations, both structural and non-structural, not tied to any specific phasing or prioritization, with several non-structural solutions already partially implemented.

Recommendations:

1. CSA #6 seeks funds for the local cost-share funds for evaluating, designing, permitting, and constructing various structural levee repairs and improvements, and subsequent OMRR&R activities, particularly for a new cross levee.

2. CSA #6, acting through the County of Yolo, seeks immediate financial assistance from DWR through their Small Communities Flood Risk Reduction Program (SCFRRP) Phase 2 – Implementation Program that will be soliciting grant applications late 2019 or early 2020. The initial grant application(s) would likely seek funds for at least the two following activities:

    a. The design, NEPA/CEQA documentation, permitting and construction of the Structural “No-Regrets Levee Repairs” previously identified by DWR under their Non-Urban Levee Evaluation (NULE) Phase 2 Program currently estimated at $24.4 million including contingencies, and summarized in Section 7.1.1 above. This may include funding for a programmatic NEPA/CEQA document to cover the multitude of structural and multi-benefit activities that are contemplated with implementing all of

the preferred structural elements identified for the preferred structural alternative, Alternative 12.

b. An initial evaluation of the existing perimeter levee system west of the preferred cross levee not included with the “No-Regrets Levee Repairs”, but west of the proposed cross levee. This is needed to obtain a magnitude of costs to ultimately achieve FEMA 100-year accreditation pursuant to 44 CFR Section 65.10 for the entire perimeter levee west of the proposed cross levee, and ultimately for the proposed cross levee. Obtain funding to identify and potentially implement any of the multi-objective ecosystem and or recreation benefit concepts identified above in Section 6 that are compatible and may coincide with the perimeter levee improvements west of the preferred cross levee alignment.

3. Secure funding for design, permitting and construction of structural levee repairs downstream and east of the community of Knights Landing collectively totaling 1.5 miles along the right bank levee of the Sacramento River (also referred to as the USACE Mid Valley Sites 9, 10, and 11) currently estimated at $11.9 million including contingencies. Also, secure funding to identify and potentially implement any of the multi-benefit ecosystem and or recreation benefit concepts identified above in Section 6 that are compatible and may coincide with the repairs of the noted USACE Mid-Valley Sites 9, 10, and 11.

4. Secure funding for design, NEPA/CEQA documentation, permitting and construction of the cross levee alignment of the preferred alternative, Alternative 12, as well as repairs/enhancements to the KLRC levee, adjoining the Knights Landing sewer ponds. The noted structural elements for the preferred cross levee and levee repairs adjoining the sewer ponds is currently estimated at $35.7 million including contingencies. Also, secure funding to identify and potentially implement any of the multi-benefit ecosystem and or recreation benefit concepts identified above in Section 6 that are compatible and may coincide with the cross levee and the existing Ridge Cut levee adjoining the sewer ponds.

5. During the design and construction phases of the three structural phases outlined above (and in Section 7.1) conduct and document all activities in accordance with 44 CFR Section 65.10 meet FEMA 100-year accreditation. Concurrently or after the design and construction of the three noted structural phases, the County will have the opportunity to identify and repair, as needed, any remaining perimeter levee system of the KLLS as a whole northwest of the cross-levee alignment.

   Upon conclusion of the cross levee construction and repairing the remaining perimeter levee segment(s) west of the cross levee the County will be in a position to file a Letter of Map Revision (LOMR) to remove the densely populated

area of Knights Landing from the FEMA 100-year floodplain in accordance with 44 CFR Section 65.10.

6. Concurrently with the implementing the structural phases of the preferred alternative CSA #6, with assistance from KLRDD and others, can implement the following non-structural solutions to further reduce residual flood in the Knights Landing Basin. All of the non-structural solutions for implementation are described in more detail in Sections 5.1.2 through 5.1.8 The following non-structural solutions are highly recommended for implementation, some of which are already in the early stages of implementation:

    - Voluntary Raising of Structures
    - Voluntary Flood Proofing, particularly of Agricultural Structures
    - Refinements and Amendments to the National Flood Insurance Program via Agricultural Floodplain Ordinance Task Force and H.R. 3167
    - Improve NFIP Community Rating System for Yolo County/Knights Landing
    - KLLS Emergency Operations Plan – Basic Plan Implementation, Inclusive of Flood Emergency Trigger Elevations & Response Actions
    - Improved OMRR&R Governance Between CSA #6, and KLRC Drainage District
    - Agricultural Conservation Easements

Refinements to the NFIP are currently underway with the introduction of H.R. 3167, the "National Flood Insurance Program Reauthorization Act of 2019; and the KLLS Emergency Operations Plan developed in 2018 for the Knights Landing is currently active with improvements recommended herein in Section 5.1.6;

Yolo County in August of 2014 completed a Flood Governance Study that serves as an excellent starting point for CSA #6, KLRDD, and possibly RD 108 to improve governance that will allow for improved stable institutional structures, coordination protocols, and financial frameworks that enable effective and adaptive integrated flood management (designs, operations and maintenance, permitting, preparedness, response, recovery, and land use and development planning). The promising governance discussions between the local entities in Yolo County have been initiated and are captured in Section 5.1.8 of this feasibility study report.