DRAFT – Clarksburg Small Communities Flood Risk Reduction Feasibility Study

Yolo County

Clarksburg, CA
May 10, 2019

Contents

Tables

Figures

Appendices

Acronyms and Abbreviations

CDFW	California Department Fish and Wildlife
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CVFPP	Central Valley Flood Protection Plan
CWA	Clean Water Act
DWR	Department of Water Resources
DWSC	Deep Water Ship Channel
EIR	Environmental Impact Report
ESA	Endangered Species Act
Feasibility Study	Small Communities Flood Risk Reduction Feasibility Study
FEMA	Federal Emergency Management Agency
FEPRR	Flood Emergency Preparedness, Response, and Recovery
GAR	Geotechnical Assessment Report
GOR	Geotechnical Overview Report
IS	Initial Study
MND	Mitigated Negative Declaration
LMA	Levee Maintaining Agencies
LOI	Letter of intent
NEPA	National Environmental Policy Act
NULE	Non-Urban Levee Evaluation
NPDES	National Pollutant Discharge Elimination System
OES	Office of Emergency Services
O&M	Operations and Maintenance
PCET	Parametric Cost Estimate Template
P.L.	Public Law
RACER	Remedial Alternatives and Cost Estimates Report
RD	Reclamation District
RFMP	Regional Flood Management Plan
RWQCB	Regional Water Quality Control Board
SAFCA	Sacramento Flood Control Agency
SB	soil-bentonite
SCFRPP	Small Communities Flood Risk Reduction Program
SPFC	State Plan of Flood Control
SRFP	Sacramento River floodplain

SRL	Severe Repetitive Loss
SWIF	system-wide improvement framework
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
UCIP	Utility Crossing Inventory Program
WSE	water surface elevation
WSS	Web Soil Survey
YFB	Yolo Flood Basin

This page is intentionally left blank.

1 Introduction

Small communities are defined by the California Department of Water Resources (DWR) in the 2012 Central Valley Flood Protection Plan (CVFPP) as developed areas with populations between 200 and 10,000 residents. The Small Communities Flood Risk Reduction Program (SCFRRP) is a local assistance program with the objective of reducing flood risk to small communities protected by State Plan of Flood Control facilities. These communities must meet the Federal Emergency Management Agency (FEMA) requirement for 100-year flood protection within the flood hazard zone. The SCFRRP program supports the continued viability of small communities within the State Plan of Flood Control (SPFC) Planning Area to preserve cultural and historical continuity and important social, economic, and public services to rural-agricultural populations, agricultural enterprises, and commercial operations.

Yolo County, through the Clarksburg Small Communities Flood Risk Reduction Feasibility Study (Feasibility Study) has assessed various alternatives for reducing flood risk for Clarksburg. The recommended alternative will be studied further at future phases for implementation.

1.1 Project Setting

Clarksburg is a small rural community located along the western bank of the Sacramento River in the Delta region in southeast Yolo County. The community is composed of a small rural town and adjoining agricultural lands that extend north, west, and south of the town. About one-third of the Clarksburg population lives in the town, while the remaining two-thirds live in the surrounding areas. The Study area (Figure 1) encompasses the town of Clarksburg as well as the peripheral agricultural lands, extending east from the Sacramento River to the Sacramento River Deep Water Ship Channel and south from the South Cross Levee to Miner Slough and Sutter Slough, with Elk Slough bifurcating the basin. For the purposes of this study, the entire Project area will be referred to as the Clarksburg Area.

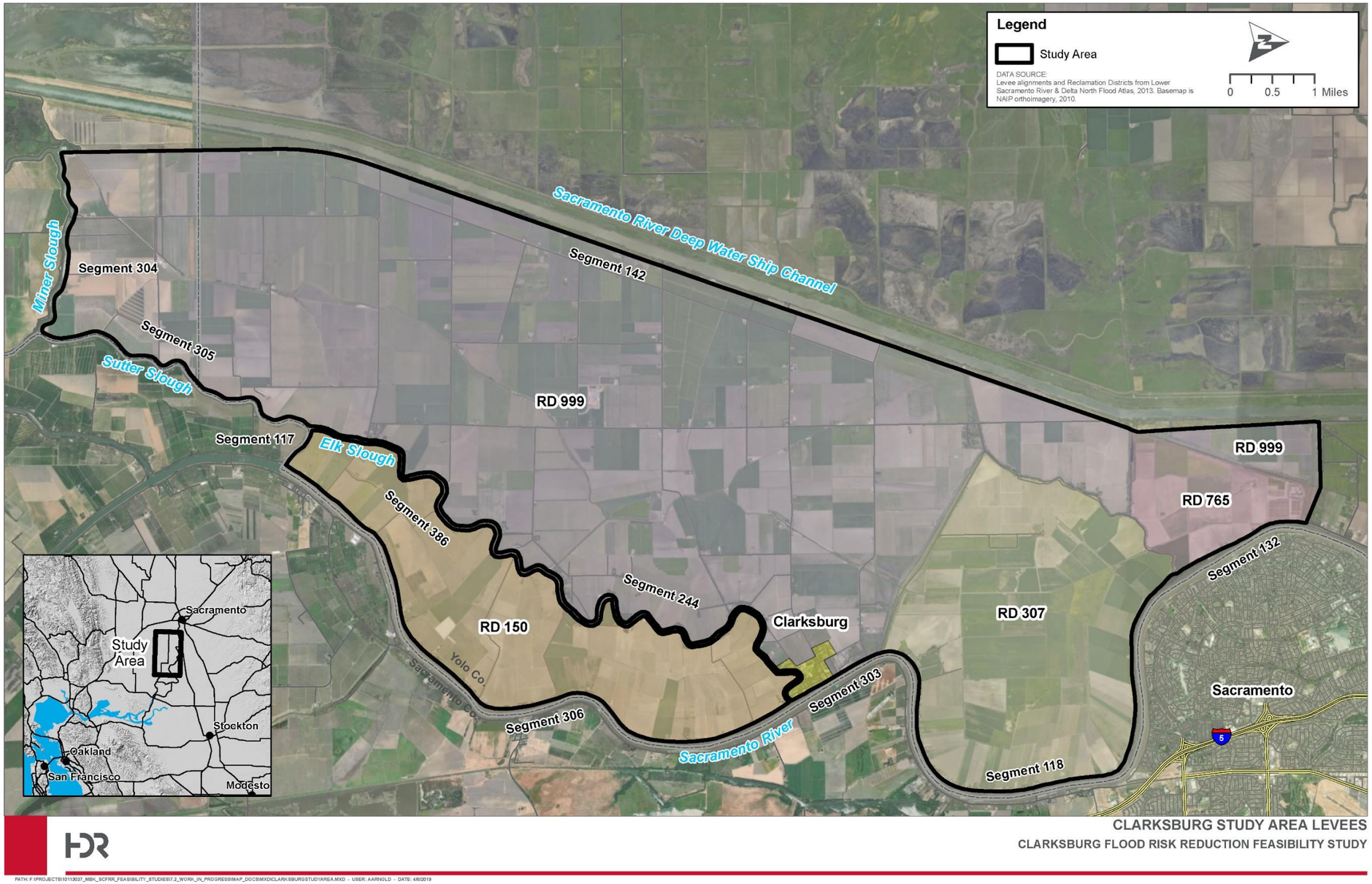


Figure 1. Study Area

1.2 Project Background/History

The Clarksburg Area has not flooded since its original levee system was constructed in the early 1900s. Levees in the Clarksburg Area are maintained by four reclamation districts: Reclamation District (RD) 999 (Netherlands), RD 307 (Lisbon), RD 150 (Merritt Island), and RD 765 (Glide). However, Clarksburg, based on attributes related to flood frequency (greater than one percent chance per year, potential flood depth (greater than 3 feet in some areas), and proximity to a river (less than 2 miles from the Sacramento River), is classified as a moderate to high hazard flood area.

1.3 Project Description

1.3.1 Purpose and Scope

The purpose of the Feasibility Study is to provide a recommended alternative to improve flood risk reduction for the Clarksburg Area. A description of the alternatives considered and method of evaluating the alternatives to produce a recommendation will be provided in this report. Development of the Feasibility Study involved:

- Defining existing resource conditions and forecasting future resource conditions
- Defining problems and opportunities
- Formulating structural alternatives
- Identifying nonstructural measures
- Identifying multi-benefit concepts
- Performing an environmental constraints analysis
- Evaluating and comparing alternatives
- Recommending an alternative for future study and implementation

1.3.2 Project Authority

The Feasibility Study is authorized under the 2012 CVFPP, which has the primary goal to reduce the chance of flooding, improve public safety, community preparedness, and emergency response; and, if flooding occurs, to reduce the amount of property damage. Supporting goals of the CVFPP are to improve operations and maintenance, promote ecosystem functions, improve institutional support, and promote multi-benefit projects.

The Disaster Preparedness and Flood Prevention Bond Act of 2006 (Proposition 1E; Pub. Resources Code, § 5096.800 et seq.) authorizes DWR to fund the SCFRRP, which will be administered by DWR in multiple phases. As part of this Phase 1, eligible communities have received funding to conduct feasibility studies to assess flood risk reduction projects. Clarksburg is one of 35 communities that received funding from Phase 1. Funding for project design and implementation will be awarded in Phase 2 and subsequent phases, as necessary.

Projects resulting from this Feasibility Study also need to be consistent with the 2014 Lower Sacramento/Delta North Regional Flood Management Plan (RFMP). The RFMP is

the regional follow-on to the 2012 CVFPP. The RFMP followed guidelines established by DWR. The overarching goal for the RFMP was to develop the long-term vision for sustainable, integrated flood management in the Lower Sacramento/Delta North Region though a collaborative process involving regional stakeholders. The RFMP identified regional solutions to flood management problems at a pre-feasibility level.

1.3.3 Agencies, Project Beneficiaries, and Stakeholders

Jurisdictions with interest in this feasibility study and potential project(s) include:

- **Clarksburg** - As described previously, Clarksburg is a small rural unincorporated community, composed of a small rural town together with thousands of acres of adjoining productive agriculture land, located on the Sacramento River within the Delta region in southeast Yolo County.
- **Yolo County** - The land use entity responsible for the Clarksburg area is Yolo County. Yolo County secured the SCFRRP Grant to develop the Feasibility Study for Clarksburg. The study team also coordinated with the Yolo County Office of Emergency Services (OES) which coordinates the county government's response to disaster or other large scale emergencies, such as flooding.
- **RD 765** – Responsible for levee maintenance and drainage in the Glide District. The 2.2 square mile district is bounded by the City of West Sacramento to the north and Babel Slough to the south. The Sacramento River and Babel Slough make up the District's eastern and southeastern boundaries, respectively. RD 999 (Netherlands) borders the District to the west. RD 765 manages 1.72 miles of levees along the Sacramento River.
- **RD 999** – Responsible for levee maintenance, drainage, and irrigation in the Netherlands District. The Sacramento River, Babel Slough, Elk Slough, and Sutter Slough form the eastern boundary of RD 999. The District is bounded by the Sacramento River Deep Water Ship Channel to the west and Miner Slough to the south. RD 999 maintains over 32 miles of levees.
- **RD 307** – Responsible for levee maintenance and drainage in the Lisbon District. Lisbon Island is bounded by the Sacramento River to the north and east, Winchester Lake and the Sacramento River to the south, and Babel Slough to the west. RD 307 maintains 6.56 miles of levees along the Sacramento River along with drainage canals and a pump station in the southeast portion of the district.
- **RD 150** – Responsible for levee maintenance, drainage, and irrigation for Merritt Island. Merritt Island is surrounded by the waters of the Sacramento River, Sutter Slough, and Elk Slough. RD 150 maintains over 17 miles of levees.

1.4 Other Related Studies and Reports

Related studies and reports that may provide further background include:

- **Yolo County Operational Area Multi-Jurisdictional Hazard Mitigation Plan -2018** The Yolo County Operational Area Multi-Jurisdictional Hazard Mitigation Plan is intended to integrate hazard mitigation strategies into the activities and programs of the local jurisdictions and special districts and to the extent practical, into the

activities of private sector organizations. The Plan identifies and evaluates specific local hazard mitigation strategies to be considered by the Yolo Operational Area and associated planning support for those strategies developed by its political subdivisions, agencies, special districts and organizations. The Plan describes strategies that government and private sector organizations may utilize as acceptable and effective mechanisms for mitigating those hazards, within the realistic constraints of capability and priority.

- **Five Year Plans, 2012**
  The RD 307, 999, and 150 prepared Five Year Plans in cooperation with the California Department of Water Resources and local agencies. The Plans are comprised of historical knowledge of each District, as well as recent findings and analysis used to describe existing conditions and future plans for the improvement of the flood protection infrastructure over the next five years.
- **Clarksburg Area Community Plan – 2015**
  The Clarksburg Area Community Plan was developed under the direction of the Clarksburg General Plan Advisory Committee and members of the Clarksburg Community. The Community Plan preserves the heritage of the Clarksburg community's past, including its small town qualities and character, its waterways, and its square miles of agricultural fields, and addresses future anticipated growth pressures through the use of new and modified goals, policies, and implementing measures.
- **Emergency Operations Plans, 2017**
  Each of the four RDs has its own Emergency Operations Plan with a Flood Contingency Map and Emergency Flood Fight Plan. RD 307, 765, and 999 have their Flood Fight Plans consolidated onto one flood contingency map and RD 150 has its own flood contingency map. The flood fight operations are to be conducted in accordance with the districts concept of operations for emergency communications, patrol, flood fight, and dewatering operations. When an actual emergency occurs, these plans should be modified as needed to meet the demands based on those specific conditions. The Emergency Flood Fight Plans include a dewatering plan, tactical plans, flood contingency options, and tactical facilities.
- **System Wide Improvement Framework**
  USACE levee systems that are eligible for rehabilitation assistance under Public Law (P.L.) 84-99 following flood or storm damage include those federally-authorized, operated and maintained by a non-federal sponsor or non-federally built, operated and maintained by a non-federal sponsor. These levees remain eligible if they are operated and maintained to acceptable or minimally acceptable standards.

  If levees are rated as unacceptable, USACE now offers non-federal sponsors a process through the system-wide improvement framework (SWIF) to remain temporarily eligible for P.L. 84-99 assistance while they correct unacceptable operation and maintenance deficiencies as part of a broader, system-wide improvement to their levee systems. Submitting a system-wide improvement framework plan is a two-step process. A Letter of Intent (LOI) is submitted followed by submission of a SWIF plan. The applicant has up to two years to develop the

plan. RDs 765, 307, 999, and 150 are working collectively on a SWIF with a LOI currently in development.

- **Elk Slough Flood Control and Habitat Improvement Project, 2019**
  RD 150 and RD 999, worked with Sacramento Flood Control Agency (SAFCA) on a reconnaissance study to make a preliminary determination for a project on Elk Slough that includes restoring a critical anadromous fish passage, enhancing shaded riverine aquatic habitat, substantially improving the slough's water quality, and implementing flood improvements through the installation of flood gates on the upper and lower ends of Elk Slough. These benefits would be achieved by more directly connecting Elk Slough to the Sacramento River, which will provide an alternative route for federally-threatened winter run and spring-run Chinook salmon migrating through the Delta. The flood gates would reduce the need to remediate known deficiencies on the Elk Slough levees as they would remain closed during high water events. RD 150 and RD 999 also applied for grant funding through the Delta Conservancy Ecosystem Restoration and Water Quality Grant Program to potentially support this project.

1.5 Stakeholder Engagement

Another important aspect to the bottoms-up development of this study has been stakeholder engagement. The engagement has involved regular communication with key stakeholders, who have the most institutional knowledge about the Area and the flood management system. Yolo County understood that public acceptance would be very important with any recommendation from this study.

Additionally, two stakeholder meetings were held. The first was held on November 26, 2018. About six key stakeholders were introduced to the study, its scope, and the preliminary alternatives. Key input was gathered about the stakeholders concerns regarding levee penetrations and encroachments, evacuation planning, and levee improvement funding. On March 19, 2019 a public meeting was held. There were over 40 attendees from the Area's stakeholders as well as the general public. The attendees learned about the study process, the recommended alternative, and the next steps. The attendees were able to provide their input to the study and recommendations.

Summaries of the stakeholder meetings are included in Appendix A.

1.6 Report Organization

The development of this feasibility study is documented in this report and organized into the following sections:

1. Introduction – This section presents background on the feasibility study and describes other related studies and reports.
2. Inventory and Forecast – This section presents an inventory of present conditions along with future conditions.
3. Problems and Opportunities – This section provides a summary of problems and opportunities facing Clarksburg.

4. Goals and Objectives – This section describes the goals and objectives of the study to address the problems and opportunities.
5. Plan Formulation - This section describes the formulation of the various alternatives considered.
6. Recommended and Implementation – This section describes the recommended alternative and its implementation.
7. Non-structural Measures – This section descries non-structural measures that could be implemented to address residual flood risk.
8. Multi-benefit Concepts – This section presents various multi-benefit concepts that could be incorporated into the recommended alternative.
9. References

2 Inventory and Forecast

2.1 Present Conditions

The following sections present an inventory of the present conditions of various resources.

2.1.1 Major Waterways

Sacramento River

The largest river in California, the Sacramento River, extends roughly 400 miles from its headwaters near Mt. Shasta to the Sacramento-San Joaquin Delta. The Sacramento River makes up the eastern border of the Clarksburg area. Rich alluvial soils deposited by rapidly flowing water of the Sacramento River and its several tributaries formed the Clarksburg community area and continue to support the many crops, vineyards, and orchards in the area (Yolo County, 2015).

Sacramento Deep Water Ship Channel

While the major features of the Sacramento River Flood Control Project, including the Yolo Bypass, were authorized by the State in 1911 and Congress in 1917, the Yolo Bypass was subsequently reduced in capacity by the construction of the Sacramento Deep Water Ship Channel (DWSC). The Rivers and Harbors Act of 1946 authorized the Sacramento River Deep Water Ship Channel to provide the Sacramento area with a deep water port. Completed in 1963, it included dredging of a 46-mile long, 200-foot wide (across the bottom of the cross section), 30-foot deep channel from the Sacramento River to West Sacramento (USACE, 2011). The ship channel was excavated adjacent to, and west of, the east levee of the Yolo Bypass. While the west levee of the ship channel functions as the east levee of the Yolo Bypass, it is not part of the SPFC and remains the maintenance responsibility of USACE (DWR, 2010a).

Elk Slough

Elk Slough drains the majority of the area around Clarksburg. Approximately 9.5 miles in length, the Elk Slough channel begins at the Sacramento River just downstream of the Clarksburg town area and extends until it connects back to the Sacramento River at Sutter Slough. RD 999 uses Elk Slough as its primary water source in the summer and it serves as the primary floodwater bypass in the winter.

2.1.2 Other Waterways

Sutter Slough, Miner Slough, Winchester Lake, Babel Slough

There are other minor waterways in the basin including:

- Sutter Slough, which borders the southeastern edge of RD 999 and the southern edge of RD150.
- Miner Slough, which borders the southern edge or RD 999.

- Winchester Lake, which is just south of Pumphouse Road located in RD 307.
- Babel Slough, which borders the western edge of RD 307.

2.1.3 Topology, Geology, and Soils

The Clarksburg District is located within the Great Valley geomorphic province (CGS Note 36), which extends through much of central California and is broadly comprised of the Sacramento Valley to the north and the San Joaquin Valley to the south, each drained by their respective namesake rivers. The project is located in the Sacramento Valley and within the Sacramento River floodplain (SRFP) and adjacent Yolo flood basin (YFB) (URS, 2011). The elevation of the Clarksburg community area ranges from 15 feet above to a few feet below sea level (Yolo County, 2015).

The SRFP flanks the Sacramento River and is comprised of overbank sediments and distributary channels of the Sacramento River. These deposits and channels are typified by mixtures of sand, silt, and clay. Surficial deposits are late Holocene in age, unconsolidated, sandy, and laterally discontinuous, with the upper 15 to 20 feet grossly similar in character. These deposits are anticipated to be highly permeable.

The adjacent YFB sits outboard of the SRFP in the adjacent broad, low-relief areas on either side of the Sacramento River. These areas are typically filled with water through sheet flows or by distributary creeks and channels during times of flooding and high flows. These depositional environments are characterized by slow moving or standing water, rather than channelized flows associated with the SRFP, and consequently are comprised primarily of silts and clays. These deposits are late Holocene in age, unconsolidated, fine grained, and are expected to exhibit low variability, low permeability, and to be laterally extensive, relatively.

2.1.4 Climate and Hydrology

The Region as a whole has a Mediterranean-like climate, with warm, dry summers and cool, moist winters. Summer temperatures are generally high during the day with fast cooling in the evenings. Variation in the summer ranges from highs in the 90 degrees Fahrenheit to lows in the 50s. Variations in temperature during the winter are much less drastic, with average highs in the 50s to 60s and lows in the 30s to 40s. Precipitation generally occurs between the months of October and March averaging about 18 inches per year.

2.1.5 Environmental Resources

Biological Resources

Six vegetation communities are identified in the project area including irrigated agriculture, orchard, riparian, urban, grassland, and open water. Additionally, agricultural ditches and potential aquatic resources were mapped. The review of the study area also evaluated the potential for special-status species to occur in in the project area. Several special-status species included in the database query results were ruled out due to absence of suitable habitat in the project area or being located outside of known species ranges. U.S. Fish and Wildlife Service (USFWS) designated critical habitat units,

conservation easements, and other protected areas located in or adjacent to the study area. Additional detail is provided in Appendix B – Environmental Constraints Analysis.

Wildlife Observed

Wildlife observed during the November 20, 2018, site visit included red shoulder hawk (*Buteo lineatus*), great egret (*Ardea alba*), red-tail hawk (*Buteo jamaicensis*), red-winged blackbird (*Agelaius phoeniceus*), American kestrel (*Falco sparverius*), double-crested cormorant (*Phalacrocorax auritus*), killdeer (*Charadrius vociferus*), and great blue heron (*Ardea herodias*). Special-status species observed include Swainson's hawk (*Buteo swainsoni*), white-tailed kite (*Elanus leucurus*), and northern harrier (*Circus hudsonius*). Over a dozen Swainson's hawks were observed perching in the riparian corridor on the north side of Winchester Lake. A white tailed kite was observed perching on a power line beside the road on Merritt Island. Lastly, a northern harrier was observed flying from a farm field in the southern portion of the project area, along Ryer Avenue. Numerous elderberry shrubs were also observed throughout the project area, which are potential habitat for the valley elderberry longhorn beetle.

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 (Attachment A). 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. Table 1 provides a description of the special-status species that have the potential to occur in each of the delineated vegetation communities. Any potential project related effects on these species or their habitats would require compliance with the California Environmental Quality Act as well as permits/authorizations from the appropriate state or federal agencies; as a result, a site-specific biological resources assessment would need to be conducted prior to project implementation to assess impacts on special-status species and their habitats.

Critical Habitat

There are three USFWS designated critical habitat units that intersect the project area. The entire project area falls within the designated critical habitat for Delta smelt. Additionally, critical habitat units for steelhead and chinook salmon include Elk Slough; as well as the Sacramento River, bordering the east side of the project area and the Sacramento Deep Water Ship Channel, bordering the west of the project area.

Sensitive Habitats and Aquatic Resources

Sensitive habitats included are those that are of special concern to resource agencies or those that are protected under various state or federal regulations. Aquatic resources provide a variety of functions for plants and wildlife including habitat, foraging, cover, migration, and movement corridors. In addition to habitat functions, these features provide physical conveyance of surface water flows capable of handling large stormwater events. Several aquatic resources and vegetation communities in the project area would be considered sensitive communities due to their unique hydrophytic vegetation and ability to support special-status species. These areas include the following communities:

riparian, agricultural ditches, open water, and other potential aquatic resources. It is recommended that a formal delineation of aquatic resource be completed prior to any work in order to determine the level of impact on sensitive communities. Consultation and permitting through the appropriate agencies would need to occur where appropriate.

Cultural Resources

A cultural resources 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. At least 166 previous investigations have been conducted in the area, most of which were archaeological and/or historical field investigations. One resource (Rosebud Ranch) is listed on the NRHP, and three resources (the Sacramento Northern Railroad, the Walnut Grove Branch Line of the Southern Pacific Railroad, and a bridge) are considered eligible for listing. The Walnut Grove Branch Line of the Southern Pacific Railroad is listed on the California Register of Historical Resources.

Archaeological and built environment sensitivity within the Project footprint and 0.25-mile buffer is variable and is primarily contingent on geography, especially with regard to the proximity to the Sacramento River and Elkhorn Slough. Native American mounds were typically located along the historical waterways, and previous investigations in the area have encountered several mounds and habitation sites in higher concentration along the river. A review of nineteenth-century General Land Office maps indicated that much of the interior of the Project footprint was swampy and prone to inundation before the twentieth-century flood management systems were constructed. Land use in the Yolo basin today is primarily agricultural and over 100 years of agricultural practices have likely leveled many prehistoric mound sites in the area, obscuring their surface expression. Most of the prehistoric sites were originally recorded from the 1930s through the 1960s and have not been revisited. In addition, historical information received from the Northwest Information Center indicates that there is a potential for deeply buried sites more than 6 feet below the surface along the waterways (CHRIS note dated February 9, 1993). Previous cultural resources investigations in the area have been focused primarily in the vicinity of the Sacramento River and therefore most of the Project footprint has not been surveyed. Therefore, there is a low-to-moderate potential for near-surface unrecorded prehistoric or Native American sites within the unsurveyed portions of the Project footprint, and there is a moderate-to-high potential for buried archaeological sites throughout the entire Project footprint and in the vicinity of the Sacramento River and the former Big Lake area.

The records search revealed that historical settlements like Clarksburg, Five Points, Freeport, and Riverview were focused along the major waterways, namely the Sacramento River and the various sloughs, and associated with transportation and trade. There was, however, sparser historical settlement away from these channels throughout the Project area, representing early efforts at agriculture. Therefore, sensitivity for historical archaeological sites and historical built environment resources is moderate-to-high throughout the proposed Project footprint, but especially high along the Sacramento River and Elk Slough and in the immediate vicinity of the historical residences.

2.1.6 Population, Land Use, and Communities

The Clarksburg community is composed of two primary land use areas: the Clarksburg town area and the adjacent Clarksburg agricultural area. As stated previously, about one-third of the community's population of approximately 1,700 people lives in the Clarksburg town area, while the remaining two-thirds live in the agricultural area (Yolo County, 2015).

The town area consists of residential, commercial, industrial, and public service uses. Land use development within the Clarksburg town area has occurred over time. The level of land use activity has also varied, including the availability of commercial services and industrial production. Residential development within the town area has predominantly occurred in the form of low density single-family homes and to a lesser and limited degree as medium density multi-family housing.

Development and land uses within the Clarksburg agricultural area have been limited to agricultural structures and activities and to residences in support of farming operations, and agricultural tourism. The Old Sugar Mill is made up of renovated buildings housing several wineries and serves as a valuable agricultural tourism draw for the county and Clarksburg.

2.1.7 Schools

The Area's high school, Delta High School, is an important community institution in that it serves all high school-age students from Walnut Grove, Courtland, Hood, and Clarksburg. There are also students that live in West Sacramento. The high school is co-located with the Clarksburg Middle School and has a total enrollment of approximately 400 students. Awareness of the student population is important, in the event of a flood emergency.

2.1.8 Fire Protection

The Clarksburg Fire Protection District which provides fire protection, basic life support, and pre-hospital emergency medical services with a staff of approximately 20 volunteer firefighters operating from a single fire station located at 52902 Clarksburg Ave., Clarksburg, CA. The Fire District is dispatched by the Yolo Emergency Communications Agency. (LAFCO, 2016)

2.1.9 Recreation

Other forms of recreation in the Clarksburg Area include recreational fishing along the levee shorelines or by boat, boating, and various walking and biking trails.

2.2 Forecast – Future Without-Project Conditions

Most likely future-without project conditions will not differ significantly from the existing conditions in the project area today. And that would also be the case if no action were taken; existing conditions would prevail. Changes expected to occur are a slight increase in population and demand for commercial, industrial and other services resulting from the agricultural tourism and agricultural industries.

3 Problems and Opportunities

3.1 General Overview of Problems

As described in the 2014 RFMP, flood management and related problems found throughout the Lower Sacramento/Delta North Region are also prevalent in the Clarksburg Area. These problems include:

- **Deficiencies in the flood management infrastructure –** There are various problems facing the Clarksburg's flood management system of levees, channels, and hydraulic structures. These problems can be attributed to poor original design and construction with substandard materials, age, deterioration, penetrations and encroachments, and obstructions. Specific instances of these problems are discussed in Section 3.2.
- **Operations and maintenance challenges –** Faced with limited funding and staffing, increasing regulatory constraints, and changing expectations for the multiple uses of the flood management system, it is increasingly difficult for local agencies in the Region to operate and maintain levees and channels. This has jeopardized eligibility for Federal levee rehabilitation funds under Public Law 84-99 (PL 84-99), administered by the USACE, and levee accreditation under the FEMA NFIP. Encroachments and penetrations are also a potential problem because they limit the ability to inspect, flood fight, and maintain levees.
- **Environmental and ecosystem sustainability and enhancement -** The ecosystem within the Central Valley has been modified by a wide variety of land use and habitat changes over more than 160 years, resulting in an overall reduction in habitat quality and function. These changes have included urbanization, agricultural conversion, historical mining activities and associated mercury contamination, water damming and diversions, channelization of streams, habitat isolation, introduction of invasive species, water quality degradation, and climate change. In addition, the construction of flood management infrastructure and ongoing flood management operations within the Central Valley have changed the ecosystem's function and processes, particularly within seasonal wetland, riparian, and river and tidal habitats.
- **Agricultural sustainability -** The loss of agricultural lands would adversely affect the economy of the Region through the loss of high-value crops and the decrease in the critical mass of agricultural production necessary to support agriculture-related industries. An additional concern for rural agricultural communities is the much higher level of flood protection provided to urban areas compared to rural areas. Due to the inherently low population base within rural agricultural areas, sufficient financial resources are typically not allocated to reducing the flood risk in rural areas. The lower level of flood protection in rural agricultural areas results in higher life safety risks for residents and agricultural enterprises within these areas when compared to urban areas. With the increase in flood insurance costs, it may diminish the ability of these agricultural areas to remain viable and sustainable over the long-term.
- **Lack of funding -** The lack of adequate funding is a common problem facing many public agencies in recent years. Levee Maintaining Agencies (LMAs) tend to rely on land owner assessments for the majority of their funding. Many times these funds

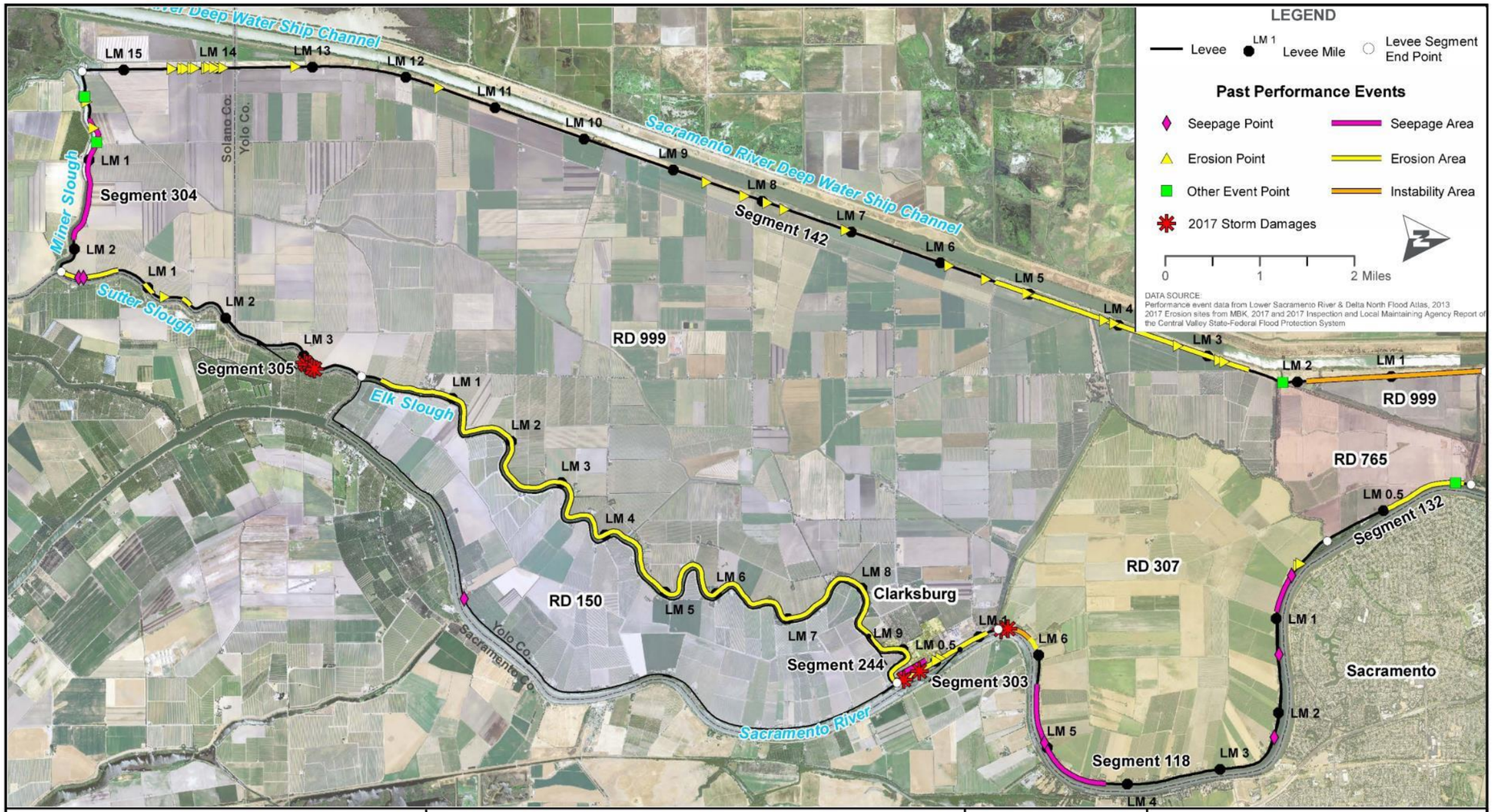
may only be sufficient to maintain normal operations. However, with the deterioration and aging of much of the flood management infrastructure, more funding will be needed to complete many of the proposed repairs to the flood management infrastructure. It will likely be difficult to secure funding to make all of the repairs and improvements that are being considered for the flood management system. Therefore, regional and State priorities must be considered to get the greatest benefit from the available funding.

- **Effects of climate change –** Uncertainty of future hydrology is another problem facing the flood management system in the Region. Earlier snowmelt and shifts from snowfall to rainfall will place increased demands on the operation of the reservoirs. Climate change also has the potential to increase the severity of storms in the Region and in wildfires in the watershed which could increase runoff and sedimentation. Also, anticipated sea-level increases of 17 to 66 inches by 2100 due to climatic changes will affect water-level stages in the Delta and the lower reaches of the Sacramento River. A rise in sea level would increase exposure to waves and wind set-up, increasing the pressure on levees currently protecting low-lying land, much of which is already below sea level.
- **Institutional barriers (including governance) –** Flood managers in the Region also face several institutional problems. Many of these problems are due to the lack of coordination among local, State, and Federal agencies with responsibilities over different aspects of the flood management system and flood risk reduction. Inconsistent policies and requirements imposed without sufficient data have put additional burdens on already challenged flood managers. Other institutional problems include LMAs struggling with permitting involving multiple agencies and varying requirements.
- **Flood Emergency Preparedness, Response, and Recovery (FEPRR) –** In response to the RFMP, in 2017 the Clarksburg, LMAs, RD 307, 765, 999, and 150 each developed Emergency Operation Plans, which included flood contingency maps, flood fight information, citizen evacuation maps, preliminary relief cut analyses, and other pertinent information. These emergency plans were adopted by Yolo County. The Districts' plans only contain detailed procedures for meeting District emergency responsibilities as stated above. Further public outreach is needed by Yolo County and similar jurisdictions with public safety responsibilities to ensure the community is aware of and involved in the development emergency operations, contact information and evacuation plans specific to the Clarksburg Area.

3.2 Flood Management Infrastructure Past Performance Events

This section presents more detailed information about past performance of the levees surrounding Clarksburg, which is documented in the NULE Geotechnical Assessment Report (GAR) (URS, 2011) and discussed in more detail in the Appendix C - Geotechnical Analysis. Past performance events include underseepage, through seepage, erosion, and slope instability.

Past performance of the levees surrounding Clarksburg is shown graphically on Figures 2 and 3 – Past Performance of Clarksburg Project Levees. In general, the levees have performed through the efforts of the RDs. However, there have been several areas of erosion documented with abundant occurrences on the waterside along the Sacramento River west levee, DWSC, and Elk Slough and underseepage documented along the Sacramento River west levee north and south of Clarksburg and along Miner Slough.



NOTES:	Clarksburg Flood Risk Reduction Feasibility Study	HDR	Past Performance of Clarksburg Project Levees – RD765, RD307, and RD999
			Dec 2018

Figure 2. Past Performance Events – RD 765, 307, and 999

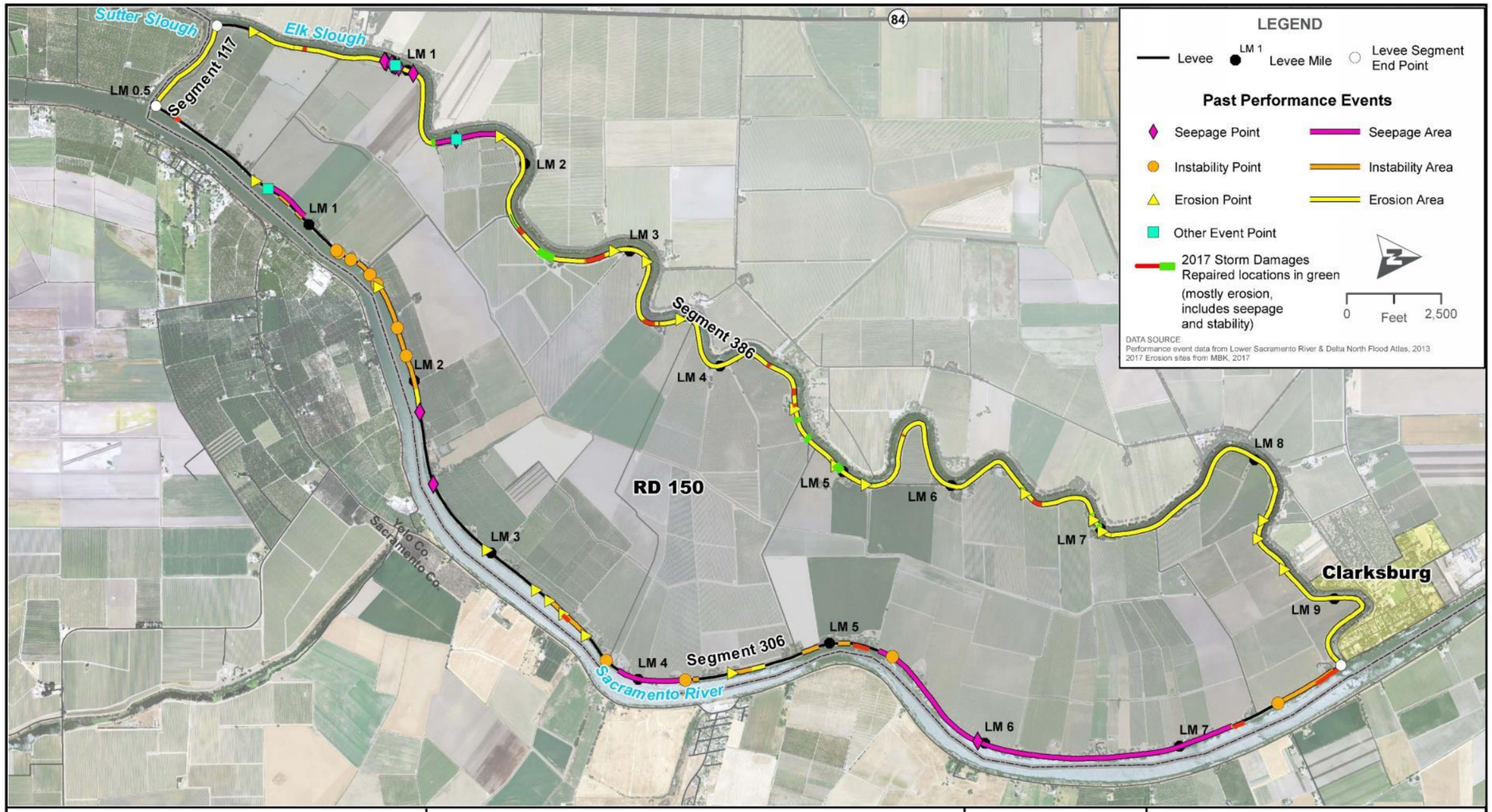


Figure 3. Past Performance Events – RD 150

3.3 NULE Program Analyses

As described in the Non-Urban Levee Evaluation (NULE) Geotechnical Overview Report (GOR) (URS, 2014), the NULE program analyzed the existing conditions of the levees surrounding the northern part of the Clarksburg Area by dividing the levee alignments into reaches, selecting analysis cross-section locations and performing seepage and stability analyses. A summary of the NULE analyses for each Reach is summarized in the Table 1, which shows the possible failure modes of each of the levees. Additional detail on this analysis can be found in Appendix C – Geotechnical Evaluation.

Table 1. Summary of NULE Program Analyses

River	Segment	Reach	NULE Stations	Levee Miles	Failure Mode (Does Not Meet Criteria for 1955/57 WSE)			
					Under seepage	Through Seepage	Stability	Erosion
Sacramento River	132	H	SACR-R 3685+00 to 3765+44	LM 1.52 to 0.00	X	X	X	
	118/132	G	SACR-R 3585+00 to 3685+00	LM 1.70 to LM 1.52	X	X	X	
	118	F	SACR-R 3505+00 to 3585+00	LM 3.23 to 1.70		X	X	
	118	E	SACR-R 3455+00 to 3505+00	LM 4.19 to 3.23	X	X	X	
	118	D	SACR-R 3337+50 to 3455+00	LM 6.45 to 4.19		X	X	X
	303/118	C	SACR-R 3262+57 to 3337+50	LM 0.00 to 6.45		X		X
Elk Slough	244	B	ELKS-R 1430+00 to 1499+63	LM 8.33 to 9.65		X		X
	244	A	ELKS-R 1412+64 to 1430+00	LM 8.00 to 8.33		X		X
Deep Water Ship Channel	142	J	SDWH-L 1691+20 to 1766+50	LM 6.43 to 5.01	X		X	
	142	K	SDWH-L 1766+50 to 1832+00	LM 5.01 to 3.77	X		X	
	142	L	SDWH-L 1832+00 to 1923+00	LM 3.77 to 2.05	X		X	
	142	M	SDWH-L 1923+00 to 1936+00	LM 2.05 to 1.80				
	142	N	SDWH-L 1936+00 to 1960+00	LM 1.80 to 1.35	X		X	
	142	O	SDWH-L 1960+00 to 1996+00	LM 1.35 to 0.67				
	142	P	SDWH-L 1996+00 to 2030+15	LM 0.67 to 0.02				

Source: URS, 2011

3.4 Flood Risk Analysis

The Clarksburg Area is surrounded by the Sacramento River, Sacramento Deep Water Ship Channel, Sutter Slough, Miner Slough, and Elk Slough. Any levee breach would fill the basin. However, due to the highest landside toe elevation any levee breaches along the Sacramento River will fill the basins with the greatest depths and no relief would be provided until the Sacramento River at the breach site draws down. To confirm this flood risk, a hydraulic analysis was performed assuming hypothetical levee breaches along the west levees of the Sacramento River. Levee breach locations along the Sacramento River were selected to breach and their breach location was based on the highest landside toe elevation. The inundation extents and flow paths were used to inform and formulate flood risk reduction project alternatives. The breaches included one directly adjacent to the town, one in RD 307, one in RD 765, along with cascading breaches of high-elevation features within the basin, such as roads embankments and channel embankments, which would likely washout as they were not intended to be flood protection features of internal embankments. An additional breach was simulated in RD 150 along the Sacramento River, to confirm flood risk on Merritt Island. More detailed information about the analysis, hydrology, and hydraulic model are presented in Appendix D – Hydraulic Analysis.

3.5 Opportunities

There are also opportunities for multi-benefits in Clarksburg in addition to flood risk reduction benefits. These potential opportunities include:

- Prioritizing repairs – It is understood that there are several identified levee deficiencies that required rehabilitation. Through this program, the community of Clarksburg will be able to shine a light on its flood management deficiencies, which may allow them to pursue funding through other sources in addition to the DWR's SCFRRP. Findings of this feasibility will be coordinated with the implementation of the RD 765/307/999 SWIF.
- Roadway improvements – Levee improvements on the Sacramento River levees could result in improved roadway safety. These roads, especially South River Road, are needed as escape routes during flood emergencies. Additionally, extending recreation trails would have the additional safety benefit of getting bikers off the road and onto a dedicated bike trail.
- Environmental benefits – Operations of the flood management system could be modified to support wildlife habitat conservation enhancement through the restoration of natural fluvial and related biological processes. Biological benefits could accrue from improving aquatic and riparian habitat, as well as water quality, by laying back the banks of the slough to where it is possible to support native vegetation. Findings of this feasibility study will be coordinated with the Elk Slough Flood Control and Habitat Improvement Project for any environmental benefits along Elk Slough.
- Recreational benefits – There are opportunities to improve recreation, particularly, bike trails. The City of West Sacramento recently completed a feasibility study that identified a way to construct a bike path on top of the maintenance road on the South Port levee. This trail will connect to the Clarksburg Branch Line Trail and provide a

continuous 10-mile loop with great recreational cycling opportunities along the Sacramento River. Additionally, this study has the opportunity to extend the Clarksburg Branch Line Trail south further into Clarksburg.

- Outreach – The development of this feasibility study has provided an opportunity to outreach to the community of Clarksburg. Though various stakeholder meetings, the project team and Yolo County have had the opportunity to describe the development of the feasibility study, the flood risk in Clarksburg, opportunities for flood risk reduction, and emergency preparedness and evacuation plans by Yolo County.

4 Goals & Objectives

The goals for this Clarksburg Area Study, which are consistent with the CVFPP goals, are to improve flood risk management, promote ecosystem functions, promote multi-benefit concepts, improve operations and maintenance, and improve institutional support.

The specific objectives of the project to achieve those goals and address the problems and opportunities include:

- Public Safety – Provide protection for the 1 percent annual exceedance probability (100-year) flood, meeting freeboard requirements for the people and property of Clarksburg.
- Multi-Benefits
    - Minimize impacts to environmentally sensitive resources, thereby minimizing permitting complexities and potential resource agency requirements.
    - Preserve or improve water supply reliability.
- Agricultural Sustainability – Minimize impacts to adjacent agricultural areas and promote agricultural sustainability.
- Preliminary Costs – Minimize first and lifecycle costs.

4.1 Other Considerations

There are other considerations that will need to be considered with any proposed project for Clarksburg, including:

- Existing infrastructure and how it might be affected, including:
    - Existing interior drainage pumps such as those operated by RD 999 and RD 150
    - Major roads in the basin, such as South River Road, which serves as a major route during emergencies
- Stakeholder support
    - Willing landowners
    - Stakeholder engagement
    - Stakeholder awareness
- Economic stability
- Institutional coordination
    - County OES
    - Schools
    - Fire Department
    - RDs
    - State DWR

- Permitability of repairs, including
  - Major levee repairs
  - Penetrations and encroachments

4.2 Constraints

Constraints are restrictions that limit the planning process. Some general types of constraints that need to be considered are resource constraints and legal and policy constraints. Resource constraints are those associated with limits on knowledge, expertise, experience, ability, data, information, money and time. Legal and policy constraints are those defined by laws, applicable policies, regulations, and other types of guidance.

In addition, federal, State, and local laws, regulations, policies, and permit requirements may constrain the study scope and range of potential solution options.

5 Formulation of Preliminary Alternatives

This section describes the formulation of the conceptual alternatives considered for this project.

5.1 Management Actions

There are several management actions that Yolo County could employ to reduce flood risk in Clarksburg. Management actions are features or activities that can be implemented at a specific geographic site to contribute to one or more planning objectives. In other words, management actions are the “tools in the toolbox” for addressing the problems and opportunities facing Clarksburg. Below are descriptions of those management actions that were considered in the developed alternatives.

5.1.1 Fix-in-Place of known problems on existing levees

Levees are strengthened to enhance their integrity by improving the embankment soil properties and geometry to resist slope and seepage failures. Improving levee’s resistance to slope failure is achieved by enlarging levees through adding material to increase the overall crown width which requires flattened side slopes and added material to the base. To improve stability, material can be added on the landside toe of a levee to increase stability. Adding material on the waterside can be used in situations where erosion is present, but is not desired because of constriction to the waterway. Methods to address seepage include landside seepage berms, impermeable barrier curtains (slurry cutoff wall) in the levee, relief wells, and toe drains. Armoring of the landside of the levees is required to improve levee resiliency during overtopping episodes. Erosion protection could be addressed by flattening the waterside slope and/or armoring with rock revetment. A vegetated bench could also be added to the waterside slope to improve resiliency.

5.1.2 Closure Structures

Closure structures, such as flood gates, are barriers that may be constructed as temporary or permanent barriers or as operational gates, closing and opening as needed to block floodwaters from a particular area. These structures could have additional benefits including, improving and preserving important riparian and aquatic habitat.

5.1.3 Constructing a training, spur, or cross levee

Subdividing a basin with a training, spur, or cross levee could limit the inundation following the failure of a primary flood control system. These levees could redirect the erosive forces of flood waters to reduce the likelihood of levee failure.

5.1.4 Ring levee

Reduction in flood risk to small communities and individual structures can be achieved by constructing a ring levee around the developed area of the community, isolating it from potential flood waters. Ingress and egress to the area protected may require long ramps to provide vehicular passage over the top of the levee.

5.1.5 Elevating or relocating structures

To raise a structure, such as a house, utilities must be disconnected and the structure must be raised off its foundation to the new height. A new permanent foundation is then built, the structure is lowered onto the new foundation, and utilities are reconnected. New stairs and landing are constructed. To relocate a structure, utilities must be disconnected and the building must be raised off its foundation and moved to its new location. The structure is then placed on its new foundation and utilities are reconnected.

5.1.6 Floodproofing, dry or wet

There are different floodproofing measures such as dry flood-proofing (keeping water from entering a structure), or wet flood-proofing (allowing water to enter the building with minimal interior damage). Dry floodproofing is effective for shallow flooding, typically less than two or three feet. Wet floodproofing is effective in reducing structural damage, due to the equalized hydrostatic pressure.

5.1.7 Relief Cuts

Relief cuts may reduce the extent and depth of flooding in leveed areas by reducing the ponding that would occur when flood water is trapped behind levees in the flood basin. Pre-planned levee relief cuts are more likely to be effective than ad hoc relief cuts.

5.1.8 Emergency Preparedness and Response:

Emergency preparedness and response can help communities with the development of emergency evacuation plans, emergency warning systems, enhancing local emergency response or flood fight plans, stockpiling flood fight materials and equipment, training and exercises, and making critical improvements.

5.1.9 Agricultural Easements

The 2012 CVFPP initially proposed DWR's interest in acquiring agricultural conservation easements to limit rural development in areas protected by the SPFC.

5.2 Preliminary Alternatives

To address the problems and opportunities and to achieve the goals and objectives, several preliminary alternatives were identified. These preliminary alternatives are made up of the management actions described previously.

5.2.1 Alternative 1 – No Action Alternative

This alternative would be to maintain the status quo and conduct no actions. This alternative is included for comparison purposes.

5.2.2 Alternative 2 – Remediation of All Known Deficiencies on All Levees

This alternative would involve remediating the existing project levees in the Clarksburg Area of all known problems and deficiencies. These deficiencies were described earlier, and identified by DWR as part of the NULE program, and by the local levee maintaining agencies. The levee system is comprised of the levees that border the Sacramento River, Sutter Slough, Miner Slough, and the Sacramento Deep Water Ship Channel and internal levees along Elk Slough.

5.2.3 Alternative 3 – Remediation of Known Deficiencies to Perimeter Levees plus Flood gates on Elk Slough

This alternative is similar to Alternative 2 in that it would involve remediation of known problems to the existing perimeter levees in the Clarksburg Area. In addition, this alternative would include the installation of flood gates on Elk Slough, at the upstream end at the confluence with the Sacramento River and the downstream end at the confluence with Sutter Slough. The flood gates would alleviate the need to remediate known deficiencies on the Elk Slough levees. The alternative would include a reconstruction of the headgate structure to allow fish passage, and construction of an operable downstream flood control gate to establish a flood protection corridor by removing 18 miles of Elk Slough levees from primary flood control, and to relocate or floodproof existing structures necessary for the establishment of this corridor. These improvements would be achieved through the acquisition of easements and strategic purchases of real property that protect or enhance the Elk Slough flood protection corridor, while preserving and significantly enhancing the wildlife habitat value of the corridor.

The alternative would also include agricultural land conservation, and wildlife habitat conservation enhancement through the restoration of natural fluvial and related biological processes in Elk Slough. Biological benefits will accrue from improving aquatic and riparian habitat, as well as water quality, by laying back the banks of the slough toward their original design profile to better support native vegetation and improve flood conveyance.

5.2.4 Alternative 4 – Remediation of Known Deficiencies on Levees on Elk Slough and Sacramento River Adjacent to Clarksburg and North to the West Sacramento Cross Levee

This alternative would involve remediation of known deficiencies of levees immediately adjacent to the town of Clarksburg (Elk Slough – portion of Segment 244) and along the Sacramento River levees to the north (Segment 303, 118, and 132) in RD 307 and RD 765. This alternative's main objective would be to improve flood risk reduction from a levee breech along the Sacramento River from the north that would send flood waters south toward the town of Clarksburg.

5.2.5 Alternative 5 - Ring Levee

This alternative would involve the construction of a ring levee around the main town. The ring levee would remove the town from the FEMA floodplain, alleviating the cost of high insurance rates. This alternative was considered in the 2012 CVFPP by DWR. The conceptual design for Clarksburg is a combination alternative that would provide a ring levee system to the north and west while also making fix-in-place repairs to portions of Levee Segments 303 and 244, on the Sacramento River. The new levees were assumed to have a 12-foot crown, with an average height of 8 feet, spanning about 1.6 miles in length total.

5.2.6 Alternative 6 – Remediation of Known Deficiencies to Levees Adjacent to Clarksburg and Construction of a Cross Levee along Pumphouse Road

This alternative would involve remediation of known deficiencies of the levees immediately adjacent to the town of Clarksburg along the Sacramento River (Levee Segment 303), the portion of Levee Segment 244 along Elk Slough, and the construction of a 3.5 mile cross levee along Winchester Lake (RD 307) and Babel Slough (RD 999), on the already elevated Pumphouse Road, up to the Sacramento Deep Water Ship Channel. This cross levee would be north of the town and along the southern boundary of RD 307. This cross levee would increase protection and increase evacuation time for the town and the southern portion of RD 999 from an upstream levee breach.

5.2.7 Alternative 7 – Prioritized Repair Program

This alternative would involve identifying all required remediations, including penetrations, along the existing levees. The needed repairs would be prioritized and phased in terms of severity, cost, and permitability. The prioritized repairs would allow for the community to identify funding opportunities and make repairs when possible and coordinate with the Systemwide Improvement Frameworks developed for each of the Levee Maintaining Agencies.

5.2.8 Alternative 8 – Remediation of Known Deficiencies on Levees Adjacent to Clarksburg and Flood Fight Plan on Pumphouse Road

This alternative would involve remediation of known deficiencies to the levees adjacent to the town (Segment 303 and 244) and the development of a flood fight plan to decrease the probability of a failure along the embankment on Pumphouse Road.

5.2.9 Alternative 9 – Remediation of Known Deficiencies of Levees Adjacent To Clarksburg

This alternative would involve fix-in-place of the levees adjacent to the town (Segment 303 and 244) only along the Sacramento River and Elk Slough, respectively.

5.2.10 Alternative 10 - Remediation of Known Deficiencies of Levees Adjacent to Clarksburg with Flood Gates on Elk Slough

This alternative would involve remediation of known deficiencies to the levees adjacent to the town (Segment 303 and 244) plus the construction of flood gates on Elk Slough as described in Alternative 3.

5.2.11 Alternative 11 – Remediation of Known Deficiencies on Levees on Elk Slough and Sacramento River Adjacent to Clarksburg and North to the West Sacramento Cross Levee with Gates on Elk Slough

This alternative would involve remediation of known deficiencies of levees immediately adjacent to the town of Clarksburg (Elk Slough – portion of Segment 244) and along the Sacramento River levees to the north (Segment 303, 118, and 132) in RD 307 and RD 765 with the construction of gates along Elk Slough.

5.3 Screening of Preliminary Alternatives

The preliminary set of alternatives were screened using the following criteria based on the goals and objectives:

- Public Safety Potential – Flood risk reduction to people and property.
- Multi-Benefit Potential – Promoting projects that improve ecosystem functions, water quality and reliability, recreation and other benefits.
- Agricultural Sustainability Potential – Promoting agricultural sustainability through flood risk reduction for agricultural lands.
- Preliminary Costs – Preliminary costs were obtained from DWR's Remedial Alternatives and Cost Estimates Report (RACER) (DWR, 2011) from the NULE Program. The RACER, included remedial alternatives for the potential levee deficiencies identified in the NULE Program and order of magnitude cost estimates. These cost (2011 Dollars) were used only for comparison purposes and categorized as follows:
    - Low - $0-$50 million
    - Moderate - $50 million - $100 million
    - High - $100 million - $400 million
    - Very High - $400 million - $700 million

The analysis of the preliminary alternatives was done qualitatively. Screening down the set of preliminary alternatives allowed the number final alternatives to be more manageable for more detailed analyses.

The following sections describe the qualitative analyses of the preliminary alternatives.

5.3.1 Alternative 1 – No Action Alternative

- Public Safety Potential: Flood Risk Reduction: This alternative would maintain the status quo and thus not improve flood risk management.
- Multi-Benefit Potential: This alternative would maintain the status quo and thus not have any multi-benefit potential.
- Agricultural Sustainability Potential: This alternative would not promote agricultural sustainability.
- Preliminary Costs: This alternative would maintain the status quo and thus not change costs.

5.3.2 Alternative 2 – Remediation of All Known Deficiencies on All Levees

- Public Safety Potential: Flood Risk Reduction: This alternative would have a high level of flood risk reduction because it would involve fix-in-place improvements to all project levees in the basin as identified in NULE. These improvements would address issues due to through seepage, underseepage, landside stability, erosion, freeboard deficiencies, and geometric deficiencies. However, there would still be residual flood risk from unidentified problems.
- Multi-Benefit Potential: Fix-in-place improvements would not allow for much potential for multi-benefits.
- Agricultural Sustainability Potential: This alternative would promote agricultural sustainability through flood risk reduction for the entire District.
- Preliminary Costs: Preliminary remediation costs from NULE for all the levees are categorized as very high.

5.3.3 Alternative 3 – Remediation of Known Deficiencies to Perimeter Levees plus Flood gates on Elk Slough

- Public Safety Potential: Flood Risk Reduction: This alternative would have a similar level flood risk reduction as Alternative 2.
- Multi-Benefit Potential: This alternative would have high multi-benefit potential due to the construction of flood gates at the upstream and downstream ends of Elk Slough. These gates, along with a connection with the Sacramento River, would improve and preserve important riparian and aquatic habitat, while simultaneously re-connecting Elk Slough and restoring anadromous fish passage.
- Agricultural Sustainability Potential: This alternative would promote agricultural sustainability through flood risk reduction for the entire District.
- Preliminary Costs: The costs for this project would most likely be less than Alternative 2. All perimeter levee improvements would be the same, but the Elk Slough levee repairs would not be required. Additional costs would be from the construction of the gates on Elk Slough. These costs are expected to be less than

the costs of repairing the Elk Slough Levees. The costs for this alternative are still expected to be very high.

5.3.4 Alternative 4 – Remediation of Known Deficiencies on Levees on Elk Slough and Sacramento River Adjacent to Clarksburg and North to the West Sacramento Cross Levee

- Public Safety: Flood Risk Reduction: This alternative would result in a moderate to high level flood risk reduction by targeting remediation of levees that if breached would cause the deepest flooding.
- Multi-Benefit Potential: Fix-in-place improvements would not allow for much potential for multi-benefits.
- Agricultural Sustainability Potential: This alternative would moderately promote agricultural sustainability through flood risk reduction for the areas north of the town.
- Preliminary Costs: The costs for this project would be less than Alternative 2 because of the reduced amount of fix-in-place that would be required and be categorized as moderate.

5.3.5 Alternative 5 – Ring Levee

- Public Safety Potential: Flood Risk Reduction: This alternative would provide low-moderate flood risk reduction to the Clarksburg Area as it would focus only on the population in the town of Clarksburg, where it would provide a high level of flood risk reduction.
- Multi-Benefit Potential: There would be minimal to zero multi-benefit potential from this alternative.
- Agricultural Sustainability Potential: This alternative would not promote agricultural sustainability as it only provides flood risk reduction for the town.
- Preliminary Costs: The 2012 CVFPP estimated the costs of the ring levee which would be categorized as low.

5.3.6 Alternative 6 – Remediation of Known Deficiencies to Levees Adjacent to Clarksburg and Construction of a Cross Levee along Pumphouse Road

- Public Safety Potential: This alternative would provide a moderate to high level of flood risk reduction. A cross levee would improve flood protection to the town of Clarksburg and all land south. However, areas north of the levee, particularly RD 307 would not have improved flood risk reduction.
- Multi-Benefit Potential: This alternative would have low potential for multi-benefits.
- Agricultural Sustainability Potential: This alternative would moderately promote agricultural sustainability for about one third of the Clarksburg Area through flood risk reduction for areas north of town.

- Preliminary Costs: The cost of the remediation of the levees adjacent to town and the estimated cost of the construction of the cross levee would produce a moderate cost.

5.3.7 Alternative 7 – Prioritized Repair Program

- Public Safety Potential: This alternative would have a moderate to high level of flood risk reduction as repairs from all over the district would be prioritized, either by this program or future efforts.
- Multi-Benefit Potential: This alternative would have the same level multi-benefit potential as Alternative 2.
- Agricultural Sustainability: This alternative would promote agricultural sustainability through flood risk reduction for the entire District.
- Preliminary Costs: Costs for this alternative would be very high but phased to allow prioritization.

5.3.8 Alternative 8 – Remediation of Known Deficiencies on Levees Adjacent to Clarksburg and Flood Fight Plan on Pumphouse Road

- Public Safety Potential: This alternative results in a moderate level flood risk compared to Alternative 2, but provides more protection than just for the town as it would slow flooding to the south of RD 999.
- Multi-Benefit Potential: Fix-in-place improvements would not allow for much potential for multi-benefits.
- Agricultural Sustainability Potential: This alternative would moderately promote agricultural sustainability through flood risk reduction for areas north of town.
- Preliminary Costs: The cost of this alternative would include the remediation of the levees adjacent to Clarksburg and the development of a flood fight plan on Pumphouse Road, which would all be a low cost.

5.3.9 Alternative 9 – Remediation of Known Deficiencies of Levees Adjacent to Clarksburg

- Public Safety Potential: This alternative would provide a lower level of flood risk reduction compared to Alternative 2 because it would only increase protection for the town from the levees in the immediate vicinity
- Multi-Benefit Potential: Fix-in-place improvements would not allow for much potential for multi-benefits.
- Agricultural Sustainability Potential: This alternative would not promote agricultural sustainability as it only provides flood risk reduction for the town.
- Preliminary Costs: The costs for this project would be the least among the fix-in-place alternatives because of the reduced amount of fixing-in-place that would be required and thus it would be categorized as low cost.

5.3.10 Alternative 10 – Remediation of Known Deficiencies of Levees Adjacent to Clarksburg with Flood Gates on Elk Slough

- Public Safety – Flood Risk Reduction: This alternative would provide a lower level flood risk reduction compared to Alternative 2, but still moderate, because it would only increase protection for the town from the levees in the immediate vicinity, but there would be added benefit from the flood gates on Elk Slough.
- Multi-Benefit Potential: Similar to Alternative 3, this alternative would have high multi-benefit potential due to the construction of gates at the upstream and downstream ends of Elk Slough. These gates, along with a connection with the Sacramento River, will improve and preserve important riparian and aquatic habitat, while simultaneously re-connecting Elk Slough and restoring anadromous fish passage.
- Agricultural Sustainability Potential: This alternative would moderately promote agricultural sustainability.
- Preliminary Costs: The costs would include the fix-in-place costs for the levees adjacent to the town. Additionally, the costs would include the yet to be determined costs for the flood gates on Elk Slough. Therefore, the costs are yet to be determined, but are most likely moderate or high.

5.3.11 Alternative 11 – Remediation of Known Deficiencies on Levees on Elk Slough and Sacramento River Adjacent to Clarksburg and North to the West Sacramento Cross Levee with Gates on Elk Slough

- Public Safety Potential: This alternative would result in a moderate to high level flood risk compared to Alternative 2, but provide more protection than just for the town.
- Multi-Benefit Potential: Because of the gates on Elk Slough, this alternative would provide the same potential for multi-benefits as Alternative 3.
- Agricultural Sustainability Potential: This alternative would moderately promote agricultural sustainability through flood risk reduction due to increased protection along the Sacramento River and Elk Slough.
- Preliminary Costs: This alternative would be similar to alternative 4, with the addition of the flood gates. Because the flood gates costs are yet to be determined, the cost of this alternative is most likely moderate or high.

Table 2 presents a summary of the preliminary evaluation of the all of the alternatives. Table 3 presents the results of the screening of the preliminary alternatives in a final array of alternatives.

Table 2. Preliminary Alternative Evaluation

Alternative	Flood Risk Reduction – People and Property at Risk	Multi-Benefit Potential	Agricultural Sustainability	Preliminary Costs
1 – No Action	Low	Low	Low	None
2 – Remediation of All Known Deficiencies on All Levees	High	Low	High	Very High
3 – Remediation of Known Deficiencies to Perimeter Levees plus Flood gates on Elk Slough	High	High	High	Very High
4 – Remediation of Known Deficiencies on Levees on Elk Slough and Sacramento River Adjacent to Clarksburg and North to the West Sacramento Cross Levee	Moderate-High	Low	Moderate	Moderate
5 – Ring Levee	Low-Moderate	Low	Low	Low
6 – Remediation of Known Deficiencies to Levees Adjacent to Clarksburg and Construction of a Cross Levee along Pumphouse Road	Moderate-High	Low	Moderate	Moderate
7 – Prioritized Repair Programs	Moderate-High	TBD	Moderate-High	Very High
8 – Remediation of Known Deficiencies on Levees Adjacent to Clarksburg and Flood Fight Plan on Pumphouse Road	Moderate	Low	Moderate	Moderate
9 – Remediation of Known Deficiencies on Levees Adjacent to Clarksburg and Flood Fight Plan on Pumphouse Road	Low-Moderate	Low	Low	Low
10 – Remediation of Known Deficiencies of Levees Adjacent to Clarksburg with Flood Gates on Elk Slough	Moderate	High	Moderate	Moderate/High
11 - Remediation of Known Deficiencies on Levees on Elk Slough and Sacramento River Adjacent to Clarksburg and North to the West Sacramento Cross Levee with Gates on Elk Slough	Moderate	High	Moderate	Moderate/High

Table 3. Screening

Alternative	Screening	Retained
1 – No Action	No benefits	No
2 – Remediation of All Known Deficiencies on All Levees	High costs	No
3 – Remediation of Known Deficiencies to Perimeter Levees plus Flood gates on Elk Slough	High costs	No
4 – Remediation of Known Deficiencies on Levees on Elk Slough and Sacramento River Adjacent to Clarksburg and North to the West Sacramento Cross Levee	Medium Alterative, but targets levees which would produce the deepest flooding	Yes
5 – Ring Levee	DWR proposed alternative	Yes
6 – Remediation of Known Deficiencies to Levees Adjacent to Clarksburg and Construction of a Cross Levee along Pumphouse Road	Similar benefits to Alternative 8 with higher costs and more uncertainty	No
7 – Prioritized Repair Programs	Phased approach to be incorporated into the recommended alternative	No
8 – Remediation of Known Deficiencies on Levees Adjacent to Clarksburg and Flood Fight Plan on Pumphouse Road	Similar benefits to Alternative 9 and flood flight plan will be incorporated into all final alternatives.	No
9 – Remediation of Known Deficiencies on Levees Adjacent to Clarksburg and Flood Fight Plan on Pumphouse Road	Minimal alternative	Yes
10 – Remediation of Known Deficiencies of Levees Adjacent to Clarksburg with Flood Gates on Elk Slough	Multi-benefit potential, but moderate flood risk reduction with higher costs	No
11 - Remediation of Known Deficiencies on Levees on Elk Slough and Sacramento River Adjacent to Clarksburg and North to the West Sacramento Cross Levee with Gates on Elk Slough	Multi-benefit potential with moderate flood risk reduction	Yes

6 Evaluation and Comparison of Final Array of Alternatives

A more thorough evaluation and comparison of the retained alternatives was completed. The retain alternatives include:

- Alternative 4 – Remediation of Known Deficiencies on Levees on Elk Slough and Sacramento River Adjacent to Clarksburg and North to the West Sacramento Cross Levee
- Alternative 5 -Ring Levee
- Alternative 9 – Remediation of Known Deficiencies on Levees Adjacent to Clarksburg and Flood Fight Plan on Pumphouse Road
- Alternative 11 - Remediation of Known Deficiencies on Levees on Elk Slough and Sacramento River Adjacent to Clarksburg and North to the West Sacramento Cross Levee with Gates on Elk Slough

6.1 Hydrology and Hydraulics

As described in flood risk, the study team performed hydrology and hydraulics analyses to support the study. These analyses are described in detail in in Appendix D. The results of the hydrology and hydraulics analyses informed the geotechnical analyses as well as the preliminary structural alternatives and non-structural measures.

6.2 Geotechnical

Geotechnical analyses and results to support the recommended alternative are included in the Geotechnical Evaluation, included in Appendix C. Analyses were performed in compliance with USACE and FEMA guidance and found that all alternative alignments would be feasible and meet the requisite criteria.

6.3 Civil Engineering Elements

6.3.1 Survey and Mapping

Topographic mapping was obtained from the Sacramento River Basin Integrated HEC-RAS 1D-2D System Model Documentation (DWR, 2017)

The mapping data is presented in the 1988 North American Vertical Datum (NAVD 88). This datum is the basis for elevations reported within this analysis. The horizontal datum is the North American Datum of 1983.

6.3.2 Top of Levee

The top of levee elevation was defined as the 100-year water surface elevation (WSE) with an additional three feet of height for freeboard and one foot of height for settlement and to accommodate for any potential wind run-up and wave setup.

6.3.3 Alignments

Alignments were created using aerial imagery and field reconnaissance and are preliminary in nature. This study provides feasibility-level recommendations for the identified alignments, with the intent that the alignment deemed to be most feasible would be modified during the preliminary design phase as needed to take into account existing features, constraints and constructability limitations supported by more detailed surveys and analyses.

6.3.4 Penetrations and Encroachments

Penetrations should be designed to comply with all applicable regulations, including USACE EM 1110-2-2902 (USACE 1998) Conduits, Culverts and Pipes. Potential penetrations through the levee that would be anticipated for the recommended alternative would include irrigation supply pipes and interior drainage for collecting runoff from the protected area and conveying through the levee.

The locations and sizes of potential penetrations will be determined during the preliminary design phase. The costs associated with such penetrations are assumed to be captured in the project contingency.

Levee penetrations are recognized as hazard elements affecting the integrity of levees. Heavily corroded, leaking, collapsed, or otherwise compromised pipes affect the structural integrity of levee embankment by creating mechanisms of internal erosion. Identification of the precise location of these crossings and documentation of their external conditions constitute important and relevant information used to assess levee vulnerability.

Utility Crossing Inventory Program (UCIP) has developed an inventory of utility crossings penetrating State-Federal Project levees. The inventory included detailed desk studies to identify the location and characteristics of documented pipes crossing Project levees and field surveys to document the external condition of the crossing structures and levee embankment. UCIP may not provide a comprehensive list of all utility crossings within the system. Also, of those listed, require field investigation to verify pipe characteristics.

While the majority of utilities penetrating Project levees are irrigation or drainage discharge pipes, there are many other types of utilities crossing levees such as pressurized gas pipelines, storm drains, sewer lines, and communication conduits.

6.3.5 Borrow Sources

Potential borrow areas for the project were located using the USDA Web Soil Survey (WSS) tool (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx). The WSS tool was used to draw areas of interest adjacent to and near the levee reaches. A soil map was obtained from the WSS tool which delineated various soil types identified within the area of interest. Along with the soil map, a range of engineering properties for each soil units used for classification was also obtained from the web tool. Comparing the typical engineering properties of each soil unit with the typical engineering properties of levee fill materials, potential borrow areas were identified and marked. Additional screening for preliminary engineering design will need to evaluate actual soil engineering properties, depth to groundwater, landowner agreement(s), potential haul routes, and

permitting requirements (e.g., erosion and sediment control, United States Army Corps of Engineers 404/401, environmental and cultural resources surveys, mining, others).

6.4 Possible Levee Remediations

The retained alternatives, 4, 5, 9, and 11 all included levee reaches which required remediation of known deficiencies. The analysis of these levees and the determination of the remediation is presented in detail in Appendix C – Geotechnical Evaluation. The possible remediations for the levees included cutoff walls, drained stability berms, combined drained stability and seepage berms. Also, included were rock slope revetment for erosion remediation. The following sections present a description of each of these remediations.

6.4.1 Cutoff Wall

Cutoff walls will mitigate underseepage by providing a seepage barrier within the levee and its foundation. Proposed cutoff walls should extend at least 5 feet into lower permeability strata. Cutoff walls could consist of conventional soil-bentonite (SB) material or if desired, interlocking sheetpiles. Penetrations through the levee would require special consideration if found to be in conflict with the cutoff wall.

For cutoff wall construction, the existing levee crown is degraded $^1/_3$ to $^1/_2$ of the current levee height to create a working platform that provides sufficient space for construction equipment. SB cutoff walls are constructed using an excavator with a long-stick boom capable of digging a trench to a maximum depth of approximately 75 to 85-feet deep. The trench width is typically 3 feet. Bentonite or cement-bentonite slurry is placed in the trench as it is excavated to prevent caving while the backfill material is mixed. The excavated soil is then mixed with the appropriate SB slurry to achieve the required cutoff wall permeability, and then backfilled into the trench. After installation of the cutoff wall, the levee is rebuilt to the pre-construction geometry using degraded levee material or imported fine-grained soils that meet requirements for levee fill. A typical SB cutoff wall cross-section is shown as Figure 4.

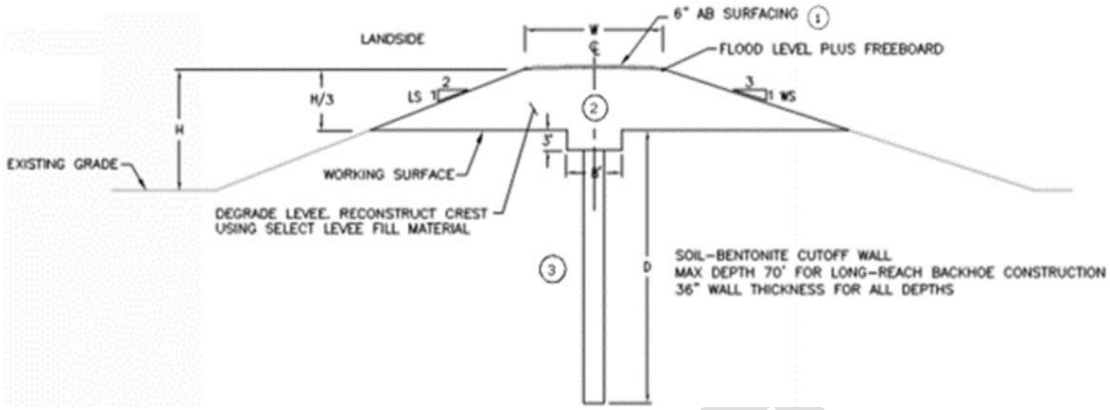


Figure 4. Typical SB Cutoff Wall (adapted from URS, 2014b)

An interlocking sheetpile system could be used in lieu of a SB cutoff wall. The interlocking sheetpile system would be installed through the levee crown with minimal levee degrade. The wall alignment along the levee crown could be trenched 2 to 3 feet to allow driving the top of the sheetpiles below the levee crown and below the all-weather road surface.

6.4.2 Drained Stability Berm

Drained stability berms will mitigate landside slope stability and/or throughseepage. In the case of mitigating landside stability, the drained stability berm will provide additional weight at the toe to resist forces that develop along a slip surface. In the case of mitigating through seepage, filter material will retain existing embankment material in place and allow seepage to safely flow from the embankment. Drained stability berms are constructed by stripping approximately 1 foot of soil from the existing ground surface, placing filter material, placing drain material, and then placing a protected layer of embankment soil. A typical drained stability berm is shown as Figure 5. For the purposes of assessing project feasibility, assume that drained stability berms extend a minimum of 40 feet (2 times the levee height) beyond the ends of the levee segment needing improvement. The extended improvement area is intended to address end-around effects. The drained seepage berm will discharge captured water at the berm toe and grading to provide positive drainage away from the levee will be required.

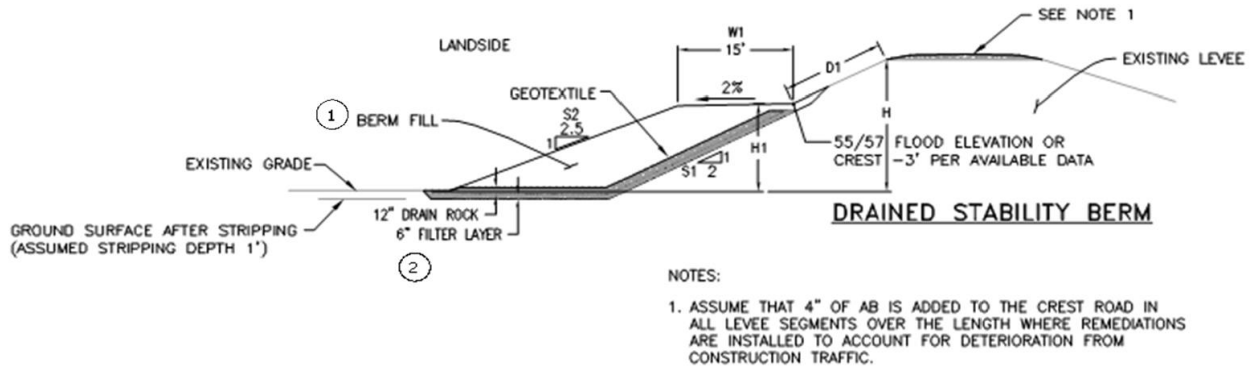


Figure 5. Typical Drained Stability Berm (adapted from URS, 2014b)

6.4.3 Combined Drained Stability and Seepage Berm

Combined drained stability and seepage berms can be used to remediate underseepage, through seepage, and landside levee embankment slope instability. The berm includes a drainage layer on the foundation and levee landside slope that is comprised of drain rock over a sand filter layer placed on the foundation. A geotextile fabric separates the drain rock from the overlying berm fill. Berms are constructed by stripping approximately 1 foot of soil from the existing ground surface, placing geotextile filter material, placing drain material, and then placing a protected layer of embankment soil. The berm fill should be more pervious than the existing levee and shallow foundation layer. A typical combined drained stability and seepage berm is shown as Figure 6. For the purposes of assessing project feasibility, assume that combined drained stability and seepage berms extend a minimum of 40 feet (2 times the levee height) beyond the ends of the levee segment needing improvement. The extended improvement area is intended to address end-around effects. The drained seepage berm will discharge captured water at the berm toe and grading to provide positive drainage away from the levee will be required.

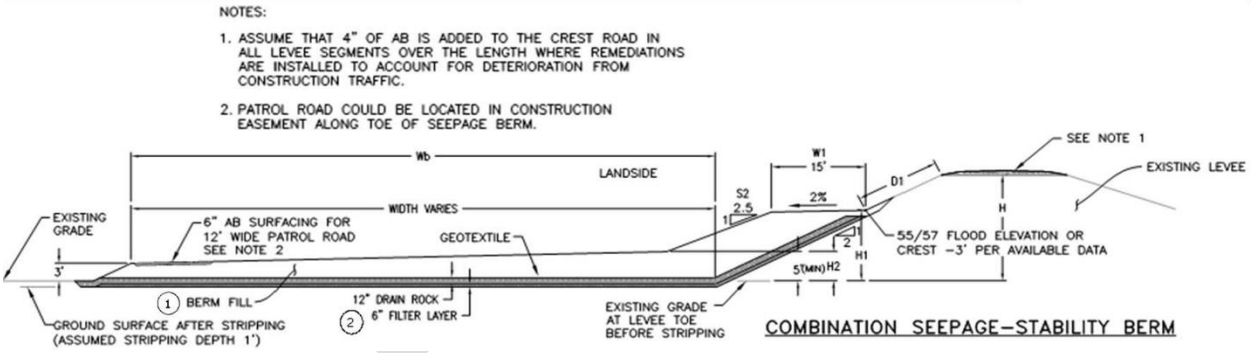


Figure 6. Typical Combined Drained Stability and Seepage Berm (adapted from URS, 2014b)

6.4.4 Erosion Remediation – Rock Slope Revetment

Rock slope revetment can be used to remediate erosion and generally consists of 6 inches of sand bedding overlain by 2 feet of rip-rap. Earthwork should be performed before placing sand bedding to backfill eroded areas and reshape the surface. Rock slope revetment generally extends from the waterside toe to the design WSE.

6.5 Alternative Remediations

Table 4 shows the components of each of the retained alternatives. Several of the levee reaches are common among multiple alternatives. Each levee reach includes up to two possible remediation alternatives that were identify in the geotechnical evaluation (Appendix C). In general, Remediation Alternative 1 should be considered as the preferred alternative. Remediation Alternative 2 may be considered if land acquisition, stakeholder interests, environmental or cultural resource conflicts, cost, or other pertinent limitations apply. Table 4 also includes other alternative components such as the flood gates or ring levee, which would be considered new construction.

Table 4. Alternative Remediations

Alternative	Reach	Segment	Remediation Alternative 1	Remediation Alternative 2
4,5,9	A	244	Drained Stability Berm	-
4,5,9	B	244	Drained Stability Berm	-
4,5,9,11	C	118/303	Cutoff Wall – Levee Degrade ≈ 6 Feet Cutoff Depth Below Degraded Levee ≥ 40 Feet	Combined Drained Stability and Seepage Berm – Width ≥ 75 Feet Thickness at Levee Toe ≥ 5 Feet Thickness at Berm Toe ≥ 3 Feet
4,11	D	118	Cutoff Wall – Levee Degrade ≈ 6 Feet Cutoff Depth Below Degraded Levee ≥ 16 Feet	Drained Stability Berm
4,11	E	118	Cutoff Wall – Levee Degrade ≈ 6 Feet Cutoff Depth Below Degraded Levee ≥ 70 Feet	Combined Drained Stability and Seepage Berm – Width ≥ 82 Feet Thickness at Levee Toe ≥ 6 Feet Thickness at Berm Toe ≥ 3 Feet
4,11	F	118	Cutoff Wall – Levee Degrade ≈ 6 Feet Cutoff Depth Below Degraded Levee ≥ 16 Feet	Drained Stability Berm
4,11	G	118	Cutoff Wall – Levee Degrade ≈ 7 Feet Cutoff Depth Below Degraded Levee ≥ 36 Feet	Combined Drained Stability and Seepage Berm – Width ≥ 90 Feet Thickness at Levee Toe ≥ 6.5 Feet Thickness at Berm Toe ≥ 3 Feet
4,11	H	132/113	Combined Drained Stability and Seepage Berm – Width ≥ 81 Feet Thickness at Levee Toe ≥ 6 Feet Thickness at Berm Toe ≥ 3 Feet	N/A
5	Floodgates		New Construction	

Alternative	Reach	Segment	Remediation Alternative 1	Remediation Alternative 2
11	Ring Levee		New Construction	

6.6 Alternative Costs

The feasibility level costs calculated for the alternatives were developed using the Parametric Cost Estimate Template (PCET). The PCET is a program driven Microsoft Excel spreadsheet developed by URS in 2008 for DWR's Urban Levees Evaluation Program that can estimate costs for 20 alternative remediations for seepage, six remediations for stability, and six remediations for erosion. The PCET also includes percentage allowances for indirect cost items, such as engineering and design, construction management, site restoration, environmental mitigation, temporary and permanent real estate acquisitions, owner legal costs, escalation, and contingency.

Cost estimates for both remediation alternatives for each levee reach were developed using the PCET. Detailed PCET inputs and outputs are presented in the Appendix E – Cost Estimate. The PCET outputs a per-linear foot construction and owner's costs based on the various inputs. Because each levee reach had two possible remediations, a maximum and minimum cost estimate has been determined and summarized in Table 5. It should be noted that Alternative 11 included the flood gates on Elk Slough, which are still under development and therefore those costs are not included at this time. As more information is developed and greater detail is presented during design and implementation, a more rigorous cost estimate would need to be developed.

Table 5. Cost Estimate Summaries

Alternative	Min Alternative Cost (2019 $)	Max Alternative Cost (2019 $)
4	$44.2 million	$52.3 million
5	$26.7 million	$28.8 million
9	$8.0 million	$10.4 million
11	> $41.2 million	> $49.2 million

6.7 Environmental Constraints Analysis

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

The analysis of constraints is intended to facilitate the project planning process, assist with the evaluation of various alternatives, define a recommended project, and assess potential permitting and mitigation requirements. Specifically, the environmental constraints analysis identifies potential constraints based on the anticipated presence or absence of environmental resources; describes the consistency and/or compliance of

each alternative with existing policies; and identifies potential environmental mitigation costs for each alternative site. This analysis also provides basic permit information.

The California Environmental Quality Act (CEQA) Guidelines Section 15262 states that a project involving only feasibility or planning studies for possible future actions which an agency, board, or commission has not approved, adopted, or funded does not require the preparation of an Environmental Impact Report or a Negative Declaration. Section 15262 of the CEQA Guidelines does not apply to the adoption of a plan that will have a legally binding effect on later activities. Therefore, no documentation under CEQA has been prepared for the Feasibility Study.

Detailed results are presented in Appendix B

6.8 Financial Feasibility

The financial analysis which helped in the selection of the recommended alternative for Clarksburg is presented in Appendix F through a financial feasibility analysis. The primary approach for analyzing financial feasibility begins with the assumption that the local funding required for a flood-risk reduction project will be raised through a property-based special benefit assessment. The analysis provides a summary of the local funding methods used by agencies in California to fund flood management improvements and services. The analysis describes the general uses of the funding source and the attributes and applicability of the mechanism for flood management. In addition to these sources, many local agencies supplement funding for flood work, specifically through enterprise revenues related to storm water management and general fund revenues. For purposes of this study it was assumed a land-based assessment was the most appropriate approach to generate local matching funds.

The next assumption is that the local beneficiaries would be solely responsible for long term on-going operations and maintenance (O&M) of any improvements. This would mean that any local annual revenues generated would first pay for the on-going O&M of the project, and any remaining annual revenue could then be dedicated toward the local share of the capital cost either on a pay-go basis or to service debt.

The detailed analysis, presented in Appendix F, determined the capability of the Clarksburg community to fund annual operations and maintenance and cost share in the implementation of the recommended alternative.

6.9 Final Screening

The following sections present the final screen to recommend an alternative. The final screening was informed by hydraulic analysis, geotechnical evaluation, cost estimates, environmental constraints, stakeholder input, and ability to pay analysis.

6.9.1 Alternative 4 – Remediation of Known Deficiencies on Levees on Elk Slough and Sacramento River Adjacent to Clarksburg and North to the West Sacramento Cross Levee

This alternative would target remediations required on the levees which, if breached, would flood the entire basin and produce the deepest flooding. Alternative 4 is shown on

Figure 7. This alternative would provide benefit to more than just the town and therefore helps sustain agriculture and the local economy.

Also, this alternative had the most support the stakeholders and thus is recommended for implementation.

6.9.2 Alternative 5 – Ring Levee

This alternative was introduced by DWR in the 2012 CVFPP as an 8 foot tall ring levee. For this study, the hydraulic modeling showed that the maximum water surface elevation at the location of the proposed ring levee was approximately 10 feet. Adding 3 feet of freeboard, would require a minimum 13 foot ring levee. Alternative 5 is shown on Figure 8. Through the various engagement efforts, stakeholders made it clear that they would not accept a ring levee as the recommended alternative. Concerns about the ring levee included:

- Only one third of the Clarksburg Area population would receive benefit from the ring levee,
- The ability of those benefitting from the ring levee to fund the construction and subsequent operations and maintenance.

This alternative would not meet the study's other objectives as it would do nothing for agricultural sustainability or other multi-benefits.

This alternative was not recommended for future evaluation or implementation.

6.9.3 Alternative 9 – Remediation of Known Deficiencies of Levees Adjacent to Clarksburg

This alternative would focus remediations of knows deficiencies of existing levees around the town of Clarksburg only. For this reason, this alternative should be considered as the bare minimum to reduce life loss and property damage in the town, which is the most densely populated portion of the Clarksburg Area. The remediation required would include a mix of cutoff walls and seepage berms. Alternative 9 is shown on Figure 9. However, this alternative does not meet the study's objectives in that it only provides flood risk reduction at the town and does little for potential levee breaches in other parts of the basin. This alternative also does little for agricultural sustainability and other multi-benefits.

This alternative was not recommended for future evaluation or implementation.

6.9.4 Alternative 11 – Remediation of Known Deficiencies on Levees on Elk Slough and Sacramento River Adjacent to Clarksburg and North to the West Sacramento Cross Levee with Gates on Elk Slough

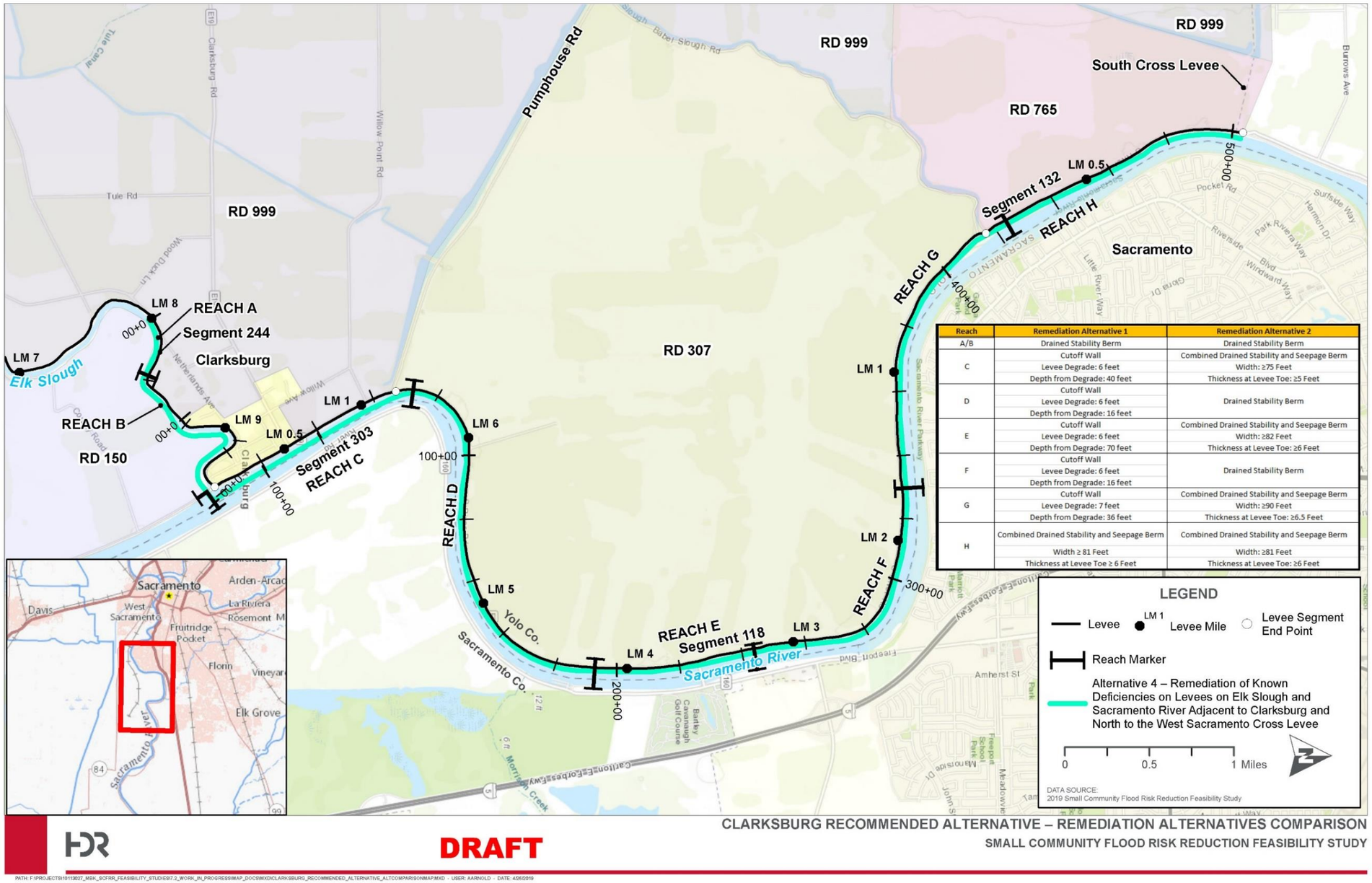
This alternative would have similar benefits to Alternative 4, plus additional benefits gained from the flood gates installed at the upstream and downstream ends of Elk Slough. The flood gates are currently being evaluated as part another feasibility study, the Elk Slough Flood Control and Habitat Improvement Project, as described in Section

1.4. The Elk Slough Study has complementary objectives to this study, therefore, if the floodgates were to be deemed feasible, they could be incorporated into a future solution for the Clarksburg Area. Alternative 11 is shown on Figure 10.

This alternative was not recommended for future evaluation until the Elk Slough Study has been completed.

6.10 Recommended Alternative

Alternative 4 is the recommended alternative for this study. The alignment of the levees and their associated remediations are shown in Figure 7.



Reach	Remediation Alternative 1	Remediation Alternative 2
A/B	Drained Stability Berm	Drained Stability Berm
C	Cutoff Wall Levee Degrade: 6 feet Depth from Degrade: 40 feet	Combined Drained Stability and Seepage Berm Width: ≥75 Feet Thickness at Levee Toe: ≥5 Feet
D	Cutoff Wall Levee Degrade: 6 feet Depth from Degrade: 16 feet	Drained Stability Berm
E	Cutoff Wall Levee Degrade: 6 feet Depth from Degrade: 70 feet	Combined Drained Stability and Seepage Berm Width: ≥82 Feet Thickness at Levee Toe: ≥6 Feet
F	Cutoff Wall Levee Degrade: 6 feet Depth from Degrade: 16 feet	Drained Stability Berm
G	Cutoff Wall Levee Degrade: 7 feet Depth from Degrade: 36 feet	Combined Drained Stability and Seepage Berm Width: ≥90 Feet Thickness at Levee Toe: ≥6.5 Feet
H	Combined Drained Stability and Seepage Berm Width ≥ 81 Feet Thickness at Levee Toe ≥ 6 Feet	Combined Drained Stability and Seepage Berm Width: ≥81 Feet Thickness at Levee Toe: ≥6 Feet

Figure 7. Map of Alternative 4 (Recommended Alternative)

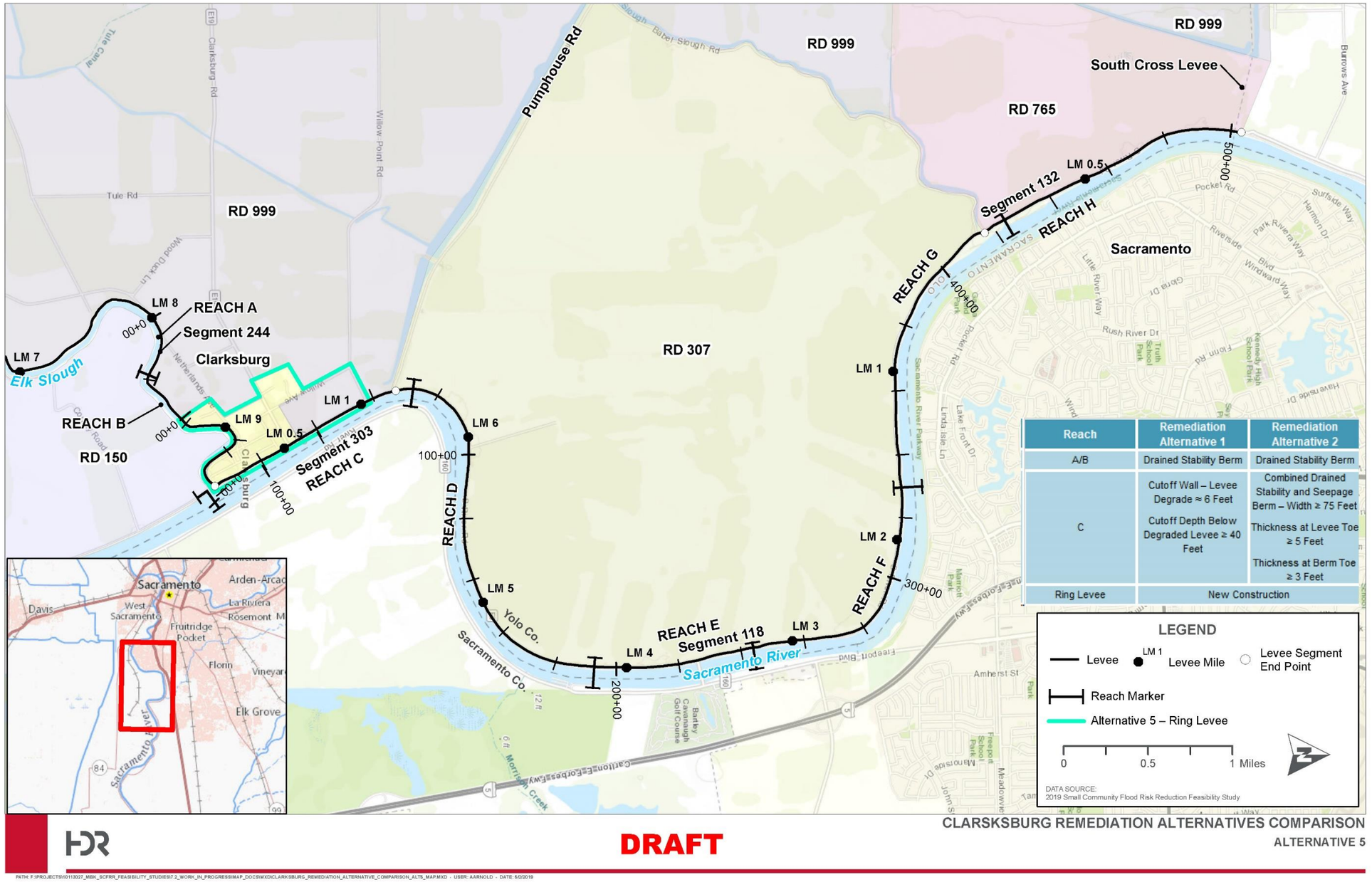


Figure 8. Map of Alternative 5

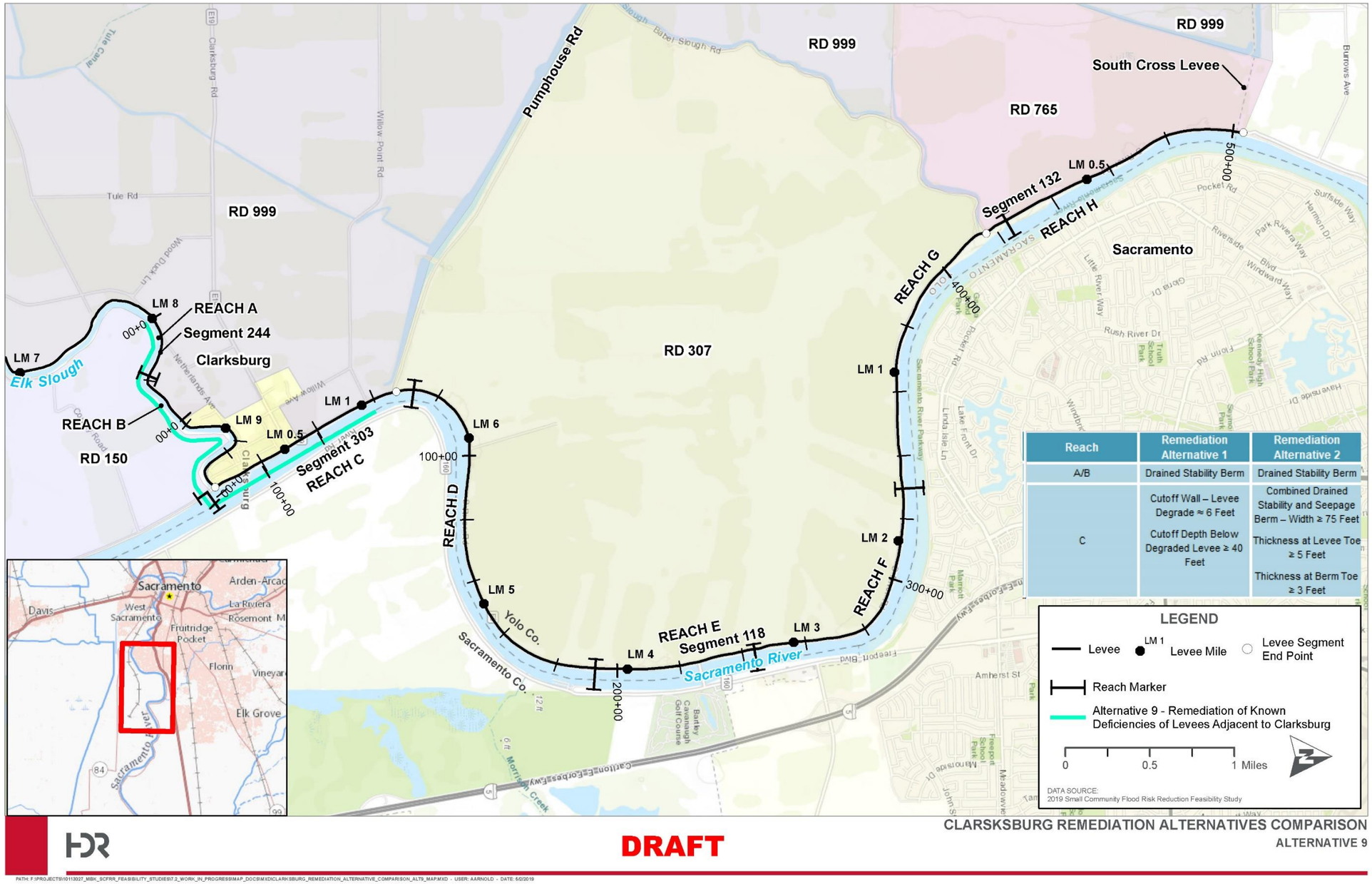
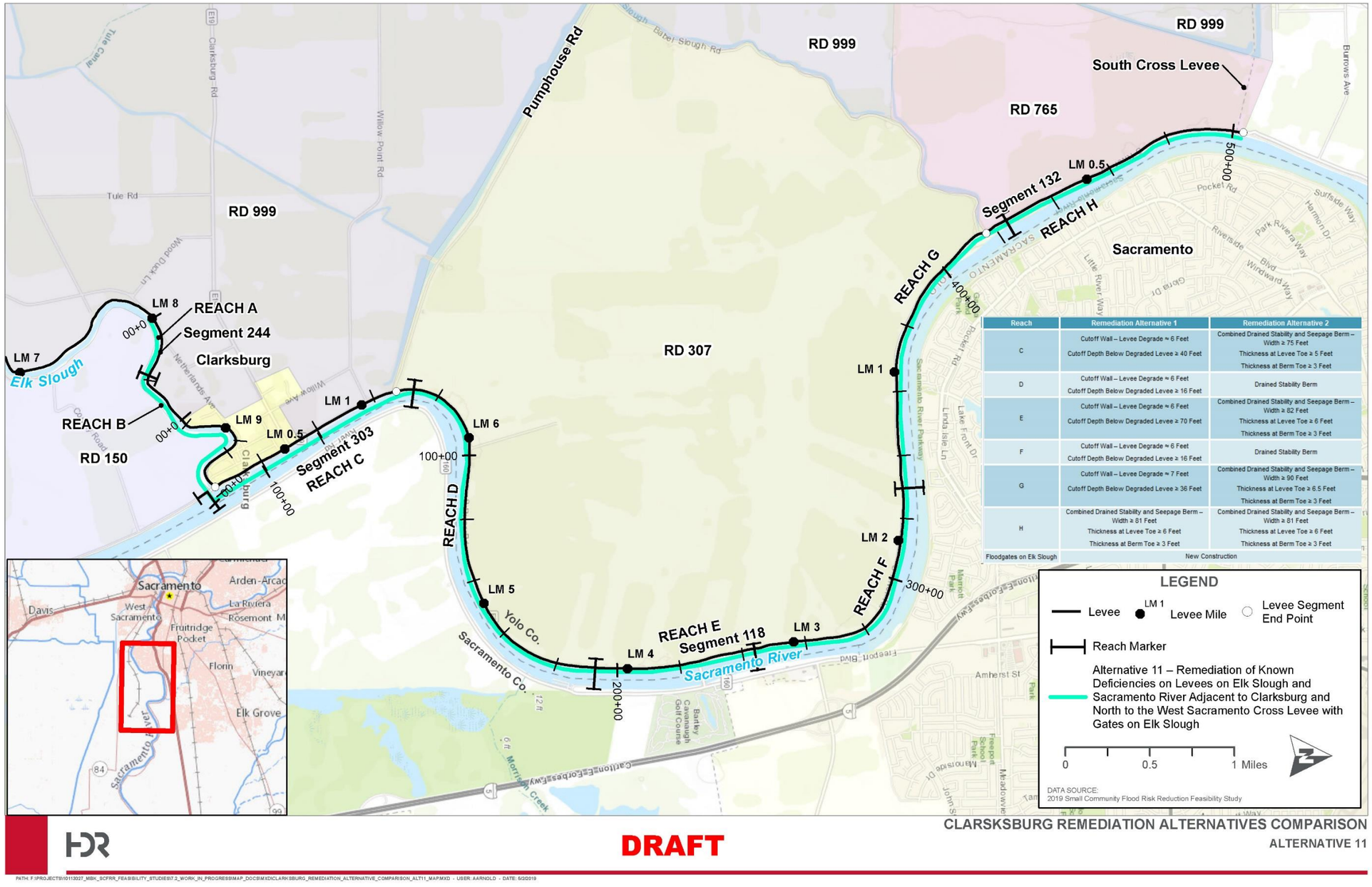


Figure 9. Map of Alternative 9



Reach	Remediation Alternative 1	Remediation Alternative 2
C	Cutoff Wall – Levee Degrade ≈ 6 Feet Cutoff Depth Below Degraded Levee ≥ 40 Feet	Combined Drained Stability and Seepage Berm – Width ≥ 75 Feet Thickness at Levee Toe ≥ 5 Feet Thickness at Berm Toe ≥ 3 Feet
D	Cutoff Wall – Levee Degrade ≈ 6 Feet Cutoff Depth Below Degraded Levee ≥ 16 Feet	Drained Stability Berm
E	Cutoff Wall – Levee Degrade ≈ 6 Feet Cutoff Depth Below Degraded Levee ≥ 70 Feet	Combined Drained Stability and Seepage Berm – Width ≥ 82 Feet Thickness at Levee Toe ≥ 6 Feet Thickness at Berm Toe ≥ 3 Feet
F	Cutoff Wall – Levee Degrade ≈ 6 Feet Cutoff Depth Below Degraded Levee ≥ 16 Feet	Drained Stability Berm
G	Cutoff Wall – Levee Degrade ≈ 7 Feet Cutoff Depth Below Degraded Levee ≥ 36 Feet	Combined Drained Stability and Seepage Berm – Width ≥ 90 Feet Thickness at Levee Toe ≥ 6.5 Feet Thickness at Berm Toe ≥ 3 Feet
H	Combined Drained Stability and Seepage Berm – Width ≥ 81 Feet Thickness at Levee Toe ≥ 6 Feet Thickness at Berm Toe ≥ 3 Feet	Combined Drained Stability and Seepage Berm – Width ≥ 81 Feet Thickness at Levee Toe ≥ 6 Feet Thickness at Berm Toe ≥ 3 Feet
Floodgates on Elk Slough	New Construction	

CLARSKSBURG REMEDIATION ALTERNATIVES COMPARISON
ALTERNATIVE 11

DRAFT

PATH: F:\PROJECTS\61013027_MBK_SCFRR_FEASIBILITY_STUDIES\7.2_WORK_IN_PROGRESS\MAP_DOCS\MXD\CLARKSBURG_REMEDIATION_ALTERNATIVE_COMPARISON_ALT11_MAP.MXD - USER: AARNOLD - DATE: 5/2/2019

Figure 10. Map of Alternative 11

7 Recommendation and Implementation

This section summarizes the considerations of the recommended alternative and the next steps needed for implementation.

7.1 Additional Design Analyses

The following sections present additional design analysis that would be required to support implementation of the recommended alternative.

7.1.1 Hydraulics

The hydrologic and hydraulic analyses performed at the feasibility level of levee design have some limitations. The level of detail and geometric accuracy, for instance, is limited by uncertainty in the ultimate configuration of the levee alignment and levee prism. Therefore, hydrologic and hydraulic analyses and levee design should be part of an iterative process, by which the level of detail in each of them is increased with each iteration; so as the recommended alternative progresses into the design stage, the level of detail in the hydrologic and hydraulic analyses should be adapted to properly represent the final levee design.

It is recommended that the hydrologic model be reviewed and adapted, if necessary, to faithfully represent the final hydrologic configuration of the drainage basins, as they are impacted by the final levee alignment. The hydraulic model, likewise, should be refined to include a precise representation of the levee alignment, roughness, and prism where it encroaches into the path of the flow.

7.1.2 Geotechnical

This document describes the feasibility level geotechnical assessment of the Clarksburg study area levees. We recommend the following items be included in the design level scope:

- Supplemental explorations through the levee crown
  - In the Sacramento River west levee
  - In the Elk Slough west levee
  - Supplemental explorations as necessary based on the selected remediation alternative(s) to reduce the flood risk for the Community of Clarksburg.
- Steady-State Seepage and Stability Analysis
  - Sacramento River west levee Reach F
  - Elk Slough west levee
  - Supplemental analyses as necessary based on the selected remediation alternative(s) to reduce the flood risk for the Community of Clarksburg.

- Performed detailed design analyses in accordance with regulatory and industry standards for the selected remediation alternatives.
- Update seismic hazard assessment and evaluate liquefaction potential or additional cross sections.
- Evaluate three-dimensional effects with respect to seepage and slope stability at confluence of Sacramento River and Elk Slough.
- Coordination with Elk Slough Gate project which proposes to design and install flood gates on Elk Slough, at the upstream end at the confluence with the Sacramento River and the downstream end at the confluence with Sutter Slough
- Identification and evaluation of the penetrations and encroachments (majority pipelines) through the Sacramento River and Elk Slough west levees. Each penetration must be evaluated by a qualified engineer and brought into compliance with Title 23 regulations.
- Update erosion site locations and conditions for all levees to be improved as part of the RDs Five-Year Plans and SWIF.
- Further investigate potential borrow areas for material compliance as embankment fill for berm construction.

7.1.3 Environmental Documentation and Permitting

California Environmental Quality Act (CEQA)

Based on the results of the Environmental Constraints Analysis (Appendix B), it is likely that the recommended alternative, Alternative 4, would result in an impact on the environment and therefore, CEQA documentation would be required. CEQA requires that all state and local government agencies consider the environmental consequences of projects they propose to carry out, or over which they have discretionary authority, before implementing or approving those projects. As specified in Section 15367 of the State CEQA Guidelines, the public agency that has the principal responsibility for carrying out or approving a project, as defined above and as described in more detail below, is the lead agency for purposes of CEQA. As specified in Section 15064(a) of the state CEQA Guidelines, if there is substantial evidence (such as the results of an Initial Study (IS)) that a project, either individually or cumulatively, could have a significant effect on the environment that cannot effectively be mitigated to a less-than-significant level, the lead agency must prepare an Environmental Impact Report (EIR). The lead agency may prepare a Mitigated Negative Declaration (MND), if in the course of the IS analysis, the agency finds that the project would have no significant environmental impacts or could have a significant impact on the environment but that implementing specific mitigation measures would reduce any such impacts to a less-than-significant level (state CEQA Guidelines, Section 15064[f]). The level of CEQA documentation that would be required for the proposed project would be determined during the permitting process.

National Environmental Policy Act (NEPA)

Based on the results of the Environmental Constraints Analysis (Appendix B), it is likely that the project would require compliance with federal regulations, such as the Clean

Water Act, Section 404; National Historic Preservation Act, Section 106; and Endangered Species Act (ESA), Section 7. Because these federal permits and consultations would likely be required, compliance with the National Environmental Policy Act (NEPA) could be triggered. In addition, all of the Yolo Levee System levees are part of the SPFC and thus are identified as state/federal facilities; therefore, any modifications to the levees could also trigger the need for NEPA compliance, as well as a Rivers and Harbors Act, Section 408 permit. The level of NEPA documentation that would be required for the proposed project would be determined during the permitting process.

Permits and Approvals

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

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

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

7.2 Conceptual Finance Plan

Following the selection of a recommended alternative, a compilation of potential funding sources and a conceptual financial plan and funding strategy for implementation was developed in the financial analysis. The funding sources memorandum in Appendix F, identifies an extensive list of potential non-local (Federal and State) funding sources for recommended alternative.

The final memorandum in Appendix F provides a conceptual financial plan and funding strategy for implementation of the recommended alternative. The conceptual finance plan applies information from the Financial Feasibility and Funding Sources memos with funding information provided by the local agencies to identify potential local and non-

local matching funds to implement the recommended alternative. Based on cost estimates described in Section 6.6, a funding "sources and uses" table was prepared to determine funding capabilities for flood risk reduction features.

7.3 Other considerations

Other considerations should be considered with the implementation of the recommended alternative. They are described in the following sections.

7.3.1 Penetrations and Encroachments

From the stakeholder engagement efforts, it is understood that there are also several undocumented or unpermitted penetrations in the levees surrounding the Clarksburg Area. The Area RDs will be working to address these penetrations as part of the SWIF. However, often times it is cost prohibitive to identify or permit the required repairs of each of these penetrations. Therefore, as part of the recommended alternative, the County also recommends the State develop a mechanism to allow for a programmatic permit to address the penetrations in the Clarksburg Area. This programmatic approach would be more efficient and effective in addressing these levee vulnerabilities and also encourage participation from private landowners.

7.3.2 Drainage System Improvements

There are also some drainage issues facing Clarksburg that should be studied further as part of a multi-benefit solution for Clarksburg. The town of Clarksburg has an old concrete pipe system that was used for drainage and water delivery connected to two irrigation/drainage pumps. One of the pumps is on Elk Slough near the high school, the other is near the Sugar Mill on the Sacramento River. These facilities have known leaks and degradation. It is suspected that there are leaks within the pipe system itself as indicated by the amount of water that flows out of the storm grates during rain events. Due to the proximity to the Sacramento River, which has high water levels for most of the year, the town has a shallow groundwater table, as many residents have sump pumps in their basements to pump out water during the wet season which could be exacerbated by this drainage issue. Given this system is no longer reliable for drainage and will need to be removed, properly abandoned, or repaired avoid potential localized flooding.

Normally, Reclamation District 999's drainage system can handle this additional drainage water as long as the ditches are kept free of vegetation. However, during the high water event in 2017, the District lost power to their drainage pumps for an extended period of time and was unable to drain this excess water. This could result in minor flooding within the town of Clarksburg. Furthermore, the entire town is on septic systems which could cause concern for water quality.

7.3.3 Non Structural Measures

Non-Structural measures, which could be implemented in addition to the recommended alternative are discussed in Section 8 and Appendix G.

7.3.4 Multi-Benefit Concepts

Multi-Benefit concepts, which could be implemented in addition to the recommended alternative are discussed in Section 9 and Appendix H.

8 Non-Structural Measures

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

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

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

The results of the non-structural measures evaluation are summarized in this section. A more detailed overview of the non-structural measures evaluation is presented in Appendix G.

8.1 Flood Emergency Evacuation Plan

The Emergency Evacuation Plan is detailed in each district's respective Emergency Operations Plans and Flood Contingency Maps. The town of Clarksburg has its own evacuation map and plan for the primary population concentrations of Clarksburg. These documents include public safety evacuation plans, responsible agencies, and special levee breach procedures.

If the recommended procedures for flood fighting along Pumphouse Road and Babel Slough Road are added to the Emergency Flood Fight Plan, evacuation routes on Pumphouse Road and Babel Slough Road should not be used in coordination with any updated emergency flood fight plans.

8.2 Flood Evacuation Warning System

The Flood Emergency Evacuation Warning System is detailed in each district's respective Emergency Operations Plans and Flood Contingency Maps. These documents include Special Considerations, Communications Plans, Response Activation Triggers, Levee Patrol Plans, and Emergency Broadcasts to the public.

An amendment to Senate Bill No. 821 section 8593.4, which recently passed on September 2018, gives counties authority to implement reverse 911 for cell phones. This gives counties the contact information of resident accountholders for the sole purpose of enrolling residents in a county-operated public emergency warning system. This recent amendment to Senate Bill No. 821 will need to be incorporated into the Flood Emergency Evacuation Warning System procedures.

8.3 Emergency Flood Fight Plan

The Emergency Flood Fight Plan is detailed in each district's respective Emergency Operations Plans and Flood Contingency Maps. These documents include tactical plans, dewatering plans, special considerations, flood contingency options, and tactical facility locations.

The hydraulic analysis performed for this feasibility study indicated flood fighting alone could provide a benefit if a breach were to occur along RD 307. It is recommended that procedures for flood fighting along Pumphouse Road and Babel Slough Road be added to the Emergency Flood Fight Plan. Flood Fighting on Pumphouse Road and Babel Slough Road could potentially benefit the primary population concentrations of Clarksburg.

In the breach scenarios along RD 307, water overtops Babel Slough Road and flows south towards RD 999. The crown elevation along Pumphouse road and Babel Slough Road would have to be at least 29.2 feet (NAVD 88) to contain flood volumes in the RD 307 basin, 2.6 feet higher than the max WSE in RD 307. If flood fighting is occurring on Pumphouse Road and Babel Slough Road, this effort should be coordinated with evacuation plans. Additionally, these roads should not be used as supply staging areas.

The option of emergency floodproofing was evaluated as part of this feasibility study. Structures were assumed to be candidates for emergency floodproofing if they were in flood depths of 2 feet or less. Using results of the hydraulic analysis a GIS analysis was performed to assess structures that are potential candidates for floodproofing. Up to 52 residential structures within the town of Clarksburg may meet the criteria for emergency dry floodproofing. This evaluation assumes: a 100-year flood event, the proposed Miner Slough relief cut in RD 999, and enough time to implement dry floodproofing. It is recommended that this solution be considered and included in future emergency flood fight plans.

8.4 Levee Relief Cuts

KSN prepared preliminary engineering designs for potential relief cuts along Miner Slough for Reclamation District (RD) 999 (Netherlands) and along Elk Slough for RD 150 (Merritt Island). Both feasibility studies were based on a 100-year flood event. KSN concluded that both relief cuts are feasible given the elevation of the floodwaters within the districts are higher than the WSE of Miner Slough or Elk Slough.

Additional hydraulic analysis was performed as part of this feasibility study to analyze potential flood risk reduction of the proposed relief cuts. Hypothetical levee breaches along the Sacramento River were modeled in HEC-RAS as part of the hydraulic analysis.

Subsequently, simulations were performed that also included relief cuts in the locations proposed by KSN.

The hydraulic analysis indicated that if a levee breach were to occur along the Sacramento River in the north end of the Clarksburg basin (e.g. along RD 307 or even near Clarksburg proper), there would be sufficient time to prepare and perform a levee relief cut near the south end of the basin along Miner Slough. The maximum flood stage reduction from a Miner Slough relief cut in RD 999 would be about 2 feet to 3 feet. However, for this to be possible, stages in Miner Slough would have to be in the range of 15 ft (NAVD 88) or lower. A relief cut in RD 999 may be a feasible flood risk reduction strategy given the appropriate conditions.

The analysis also found that an Elk Slough relief cut is not a feasible flood contingency option because the time it takes for the floodwaters from a breach to fill RD 150 and reach a level that equalizes with the receiving water is less than the time it takes to construct the relief cut.

Additional detail on the hydraulic analysis is presented in Appendix D – Hydraulics.

8.5 Voluntary Structure Elevation & Floodproofing

The 2012 CVFPP, 2017 CVFPP, and RFMP assert DWR's interest in elevation and floodproofing of structures in small communities. A GIS analysis was performed to assess structures that are potential candidates for floodproofing by comparing the 2012 CVFPP structure inventory data points to a composite of maximum WSEs from the hydraulic analysis. The GIS analysis concluded that a relief cut in RD 150 would only provide minimal reduction in flood stage and the flood basin would be filled before the relief cut could be completed. Due to this only maximum flood depths in RD 999 were analyzed.

Without the relief cut in RD 999, only 10 structures in the town of Clarksburg and 1 structure in RD 999 experience less than three feet of flooding. With the relief cut, up to 97 structures in the town of Clarksburg and up to 2 structures in RD 999 experience less than three feet of flooding. Residential structures with flooding of less than three feet could undergo dry floodproofing and structures with more than three feet of flooding would require structure elevation.

Concerns were raised by local stakeholders that structure elevations and floodproofing may divert funds from needed levee improvements. If this is a concern, structure elevations may still be accomplished by interested residents. A secondary benefit of this option is that this may allow the interested residents to remodel their homes while elevating the structure. The County could assist residents in acquiring all the proper building permits to elevate their homes and obtain the flood risk reduction benefit.

8.6 Changes to National Flood Insurance Program

Changes to the NFIP have been proposed by previous studies. Based on the 2012 Central Valley Flood Protection Plan (CVFPP), 2017 CVFPP, and the Regional Flood Management Plan (RFMP); some proposed changes to the NFIP include:

1. Revising FEMA Operating Guidance 12-13[1] to designate areas behind a certified levee reach as Zone X (Shaded) instead of Zone D, and
2. Setting insurance rates for structures protected by non-accredited levees according to the level of risk through recognizing a certain level of protection from the existing levee system that is below the 100-year flood elevation,

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

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

FEMA recently made changes to the NFIP that apply to new businesses and renewals, effective April 1, 2019. These changes include premium increases, changes to primary residence determination, introduction of a Severe Repetitive Loss (SRL) Premium, and clear communication of these changes to policy holders.

Currently, DWR has not developed a program for funding any changes to the NFIP. One of the greatest challenges with changing the NFIP is funding. Without sufficient funding it is highly unlikely that changes to the NFIP are a feasible non-structural alternative for Clarksburg at this time.

8.7 Agricultural Conservation Easement

The 2012 CVFPP and 2017 CVFPP both assert DWR's interest in acquiring agricultural conservation easements. However, DWR has not yet developed a program for acquiring agricultural easements and funding has not been acquired. If DWR acquires funding and develops a program, the community of Clarksburg should carefully evaluate the pros and cons of the program as it would apply in the Clarksburg area.

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

[1] These changes were proposed by the Agricultural Floodplain Ordinance Task Force (AFOTF, 2016)

9 Multi-benefit Concepts

Yolo County also investigated multi-benefit opportunities within and surrounding the community of Clarksburg that could be integrated into the recommended alternative. The opportunities investigated included a specific restoration opportunity and potential recreational enhancements. Greater details are presented in Appendix H. The multi-benefit opportunities are presented solely for planning purposes. Their inclusion herein does not commit Yolo County to any specific future actions and has no legally binding effect. Therefore, these multi-benefit opportunities are statutorily exempt from CEQA, per State CEQA Guidelines Section 15262, and they are not subject to environmental review at this time.

9.1 Elk Slough Habitat Restoration Concept

The approach used to identify potential habitat restoration opportunities for this Study focused on identifying improvements that could be directly integrated with flood improvements, consistent with the direction provided in the 2017 Update to the CVFPP. Therefore, a potential habitat restoration concept on Elk Slough is presented. The Study team used aerial maps, high-resolution topography, and local knowledge related to land-use, infrastructure, target species, and habitats to identify a significant habitat enhancement opportunity that could be directly integrated with flood improvements. This habitat restoration opportunity is described in further detail below. Target species associated with this opportunity include, but are not limited to, fish species (e.g., Chinook salmon, green sturgeon), avian species (e.g., Swainson's Hawk, Tri-colored Blackbird, Western Yellow-billed Cuckoo, least Bell's vireo), and reptiles (e.g., giant garter snake).

The proposed Elk Slough concept includes installing operable gates at the upstream and downstream ends of Elk Slough and improving the existing levees along the slough to improve flood protection for the Clarksburg Area. At the slough's upstream end, the existing Sacramento River culvert connection would be replaced with an operable gate and a new road crossing for South River Road. At the downstream end, an operable gate would be installed just upstream of the confluence with Sutter Slough. These two gates would remain open during most of the year to provide fish passage but would close during high water events. The closure of these gates would provide protection from the high flows in the Sacramento River entering into the slough from both its upstream and downstream ends. As a result, the stage or level of water within the slough during these high flow events would be reduced, which would reduce the pressure on the existing levees.

Levee improvements would be necessary with installation of the two gates due to the increased levee scour that would occur with the introduction of increased flows from the Sacramento River. Improvements to the reclamation districts' drainage systems would also be necessary to ensure discharge of drainage water into the slough during periods when the gates are closed does not increase flood stage above current conditions.

The reconnection of the upstream end of Elk Slough to the Sacramento River would provide an additional migration route for anadromous fish (including federally and state-listed Chinook salmon, steelhead, and green sturgeon) as well as additional rearing and

foraging habitat for these species during their upstream and downstream migrations through the Delta.

9.2 Recreational Concepts

The approach used to identify potential recreation opportunities for this report focused on regional improvements identified by local agencies and improvements recommended by local stakeholders.

9.2.1 Clarksburg Branch Line Trail Extension Concept

The Clarksburg Branch Line Trail in West Sacramento runs between Jefferson Boulevard at Locks Drive/South River Road and Gregory Avenue where South River Road loops around and returns. The northern 1.5 mile segment of this popular walking and biking trail between Muscovy Road and South River Road is paved while the less used southern segment, extending an additional 1.7 miles south, has a surface of crushed rock.

The Clarksburg Branch Line Trail Extension Concept includes developing the southern segment of the existing right-of-way located south of Gregory Avenue, initially as an unpaved walking trail and eventually as a paved walking and biking trail. The right-of-way extends south from the City to Pumphouse Road, at which point the Class I bike trail would connect to a new Class II bike path on Pumphouse Road that would extend southeast to South River Road and then south to the community of Clarksburg. The trail extension would also be designed to function as an emergency vehicle access route and emergency evacuation route during periods, if South River Road is closed. To discourage walkers and cyclist from accessing adjacent farm fields, post and cable fencing could be installed along both sides of the trail.

9.2.2 Improved Elk Slough Recreational Boating Access Concept

The dense riparian vegetation along Elk Slough provides a unique recreational experience for boaters in the Delta, who can access the slough from its southern connection to Sutter Slough. By providing a narrow, shaded corridor of overhanging vegetation, the slough provides an opportunity for boaters to escape the more highly used and high-speed boating environments along the Sacramento River and other major tributaries in the Delta. However, the dense riparian cover also contributes to boating hazards. When large trees fall into the slough, they provide improved habitat for aquatic species, particularly along the slough's banks. When this large woody material extends into the center of the slough, it can be a hazard for navigation.

The Improved Elk Slough Recreational Boating Access Concept includes implementing a regular maintenance program that would include removing large woody material from the center of the slough to reduce recreational boating hazards. The large woody material removed from the center of the channel would be secured to the slough bank to improve habitat conditions.

10 References

Agricultural Floodplain Ordinance Task Force. 2016. *Recommended Administrative Refinements of the National Flood Insurance Program to Sustain Agriculture as a Wise Use of the Floodplain in the Leveed Special Flood Hazard Areas*. December 28, 2016.

DWR (Department of Water Resources). 2018. *2018 Inspection and Local Maintaining Agency Report of the Central Valley State-Federal Flood Protection System.*

DWR (Department of Water Resources). 2017. *2017 Inspection and Local Maintaining Agency Report of the Central Valley State-Federal Flood Protection System*.

DWR (Department of Water Resources). 2017. *Central Valley Flood Protection Plan*.

DWR (Department of Water Resources). 2012. *2012 Central Valley Flood Protection Plan*. June 2012.

DWR (Department of Water Resources). 2012. *Central Valley Flood Protection Plan*.

FEMA. 2018. *April 1, 2019, and January 1, 2020, Program Changes.* October 1, 2018.

KSN (Kjeldsen Sinnock Neudeck). 2016-1. *Reclamation District 999 – Netherlands Relief Cut Feasibility Study and Preliminary Engineering Designs* November 21, 2016.

KSN (Kjeldsen Sinnock Neudeck). 2016-2*. Miner Slough Relief Cut Preliminary Engineering Design (P.E.D.).* November 2016.

KSN (Kjeldsen Sinnock Neudeck). 2017-1. *Reclamation District 150 – Merritt Island Relief Cut Feasibility Study and Preliminary Engineering Designs, Kjeldsen Sinnock Neudeck.* November 6, 2017.

KSN (Kjeldsen Sinnock Neudeck). 2017-2. *RD 150 – Elk Slough Relief Cut Flood Contingency Schematics.* November 2017.

MBK (MBK Engineers). 2018. *SCFRR Hydraulic Analysis for the Community of Clarksburg Technical Memorandum.* December 2018.

UC Davis Library. 2017. *50 Features of Special Collections: Holland Land Company Records*, published February 9, 2017. Accessed August 9, 2018. https://www.library.ucdavis.edu/news/50-features-special-collections-holland-land-company-records/

URS. 2011. "*Geotechnical Assessment Report, North NULE Project Study Area, Volume 1 of 6*," April 2011.

URS. 2014. *Geotechnical Overview Report, Volume 1, Existing Conditions, Clarksburg Study Area, Levee Segments 118, 132, 142, 244, and 303.* February 2014.

Yolo County. 2017. *Reclamation District 999 – Netherlands Emergency Operations Plan.* Prepared by Kjeldsen Sinnock Neudeck. June 19, 2017.

Yolo County. 2017. *Reclamation District 765 – Glide District Emergency Operations Plan.* Prepared by Kjeldsen Sinnock Neudeck. June 20, 2017.

Yolo County. 2017. *Reclamation District 307 – Lisbon Tract Emergency Operations Plan.* Prepared by Kjeldsen Sinnock Neudeck. June 20, 2017.

Yolo County. 2017. *Reclamation District 150 – Merritt Island Emergency Operations Plan.* Prepared by Kjeldsen Sinnock Neudeck. October 11, 2017.

Yolo Local Agency Formation Commission. 2016. *Municipal Services Review and Sphere of Influence Study for 15 Fire Protection Districts*. June 2016.

Yolo County Planning, Public Works and Environmental Services Department. 2015. *2015 Clarksburg Area Community Plan*, *Yolo County*. September 2015.

----. Emergency Operations Plans.

----. 2017. Sacramento River Basin Integrated HEC-RAS 1D-2D System Model Documentation. June 2017. Prepared for California Department of Water Resources, ch2m.

----. 2014. *Lower Sacramento River/Delta North Regional Flood Management Plan*. July 2014.

Appendix A. Summary of Stakeholder Meetings

Appendix B. Environmental Constraints Analysis

Appendix C. Geotechnical Evaluation

Appendix D. Hydraulic Analysis

Appendix E. Cost Estimate

Appendix F. Financial Analysis

Appendix G. Non-Structural Measures

Appendix H. Multi-Benefit Options