Knights Landing Small Community Flood Risk Reduction Feasibility Study

Multi-Benefit Opportunities Technical Memorandum

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1 INTRODUCTION

1.1 OVERVIEW

This Technical Memorandum has been prepared to identify multi-benefit opportunities within the Knights Landing region that can be integrated into identified flood improvement alternatives to enhance the function of the region's flood system, consistent with the objectives of the Central Valley Flood Protection Plan 2017 Update (CVFPP). The CVFPP strongly supports and encourages the planning and implementation of projects that provide multiple benefits, including increasing flood system resilience by protecting and restoring important ecosystems, and improving water supply, water quality, recreation and public education related to integrated water management. According to the CVFPP, a multi-benefit approach more efficiently and effectively leverages flood infrastructure to achieve a broader array of public benefits and may potentially increase access to more funding sources (CVFPB, pg. 3-47).

The preparation of the CVFPP included the development of a Conservation Strategy that identified non-regulatory measurable objectives and long-term approaches for improving riverine and floodplain ecosystems. These improvements were proposed to be implemented through multi-benefit projects that include ecosystem restoration or enhancements. The Conservation Strategy provides guidance for developing and measuring the performance of ecosystem conservation and restoration actions based upon four key goals:

- Improve dynamic hydrologic and geomorphic processes;
- Increase and improve riverine and floodplain habitats;
- Contribute to the recovery of native species; and
- Reduce stressors.

The Technical Memorandum explores a range of opportunities that could achieve the CVFPP objectives for multi-benefit projects, consistent with the Conservation Strategy, including specifically integrating ecosystem restoration with flood risk management. This includes identifying and evaluating potential habitat restoration concepts, recreational enhancement opportunities, and water supply improvement opportunities that could be integrated into the flood risk reduction alternatives evaluated in the Knights Landing Small Community Flood Risk Reduction Feasibility Study (Feasibility Study).

This Technical Memorandum is divided into five chapters: Chapter 1 includes this introduction, Chapter 2 provides a description of the preliminary habitat restoration opportunities and the screening process used to select specific restoration concepts for further evaluation; Chapter 3 describes in greater detail the highest potential habitat restoration concepts; Chapter 4 identifies potential recreational opportunities, recreation recommendations and water supply improvement opportunities; and Chapter 5 includes references used in the preparation of this report.

1.2 CALIFORNIA ENVIRONMENTAL QUALITY ACT COMPLIANCE

The multi-benefit concepts/opportunities identified in this report have been developed to a conceptual level and they do not meet the definition of a "project" as defined by the California Environmental Quality Act (CEQA) (California Public Resources Code [PRC], Division 13, Section 21000 et seq.). The State CEQA Guidelines define a project as the whole of an action, which has a potential for resulting in either the direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment (California Code of Regulations [CCR], Chapter 14, Section 15378). State CEQA Guidelines Section 15262 further 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 required the preparation of an Environmental Impact Report or a Negative Declaration. Section 15262 does not apply to the adoption of a plan that will have a legally binding effect on later activities.

The multi-benefit concepts/opportunities represented in this report are presented solely for planning purposes. Their inclusion herein does not commit the County to any specific future actions and has no legally binding effect. Therefore, these multi-benefit concepts/opportunities are statutorily exempt from CEQA, per State CEQA Guidelines Section 15262, and they are not subject to environmental review at this time.

2 PRELIMINARY HABITAT RESTORATION CONCEPTS

2.1 METHODOLOGY

The approach used to identify potential habitat restoration concepts for this report initially focused on what could possibly be implemented without regard for existing land use or infrastructure constraints. As an example, the geographic scope was not limited to the Knights Landing basin in recognition of the high value habitats that are located directly outside of the basin such as along the Sacramento River. This approach allowed the project team to initially identify opportunities with high restoration potential. Using this approach, the project team identified ten preliminary habitat restoration concepts through the use of aerial maps, high-resolution topography, and local knowledge related to land-use, infrastructure, target species, and habitats. Target species included, but were not limited to, salmonids (Chinook salmon and steelhead), numerous avian species (Swainson's Hawk, Tri-colored Blackbird, Western Yellow-billed Cuckoo, etc.), and reptiles (e.g. giant garter snake).

Following the identification of the preliminary restoration concepts, the project team qualitatively evaluated each one based on a number of factors that are identified in Table 1. These factors included their ability to provide ecological uplift, whether they include or support recreational activities, their cost to construct and operate, the estimated permitting complexity, their effects on agricultural sustainability, the overall feasibility of implementing the improvements, and their contribution to reducing flood risks. This evaluation process was used to screen out those concepts that were likely to be less feasible to implement. Following this screening process, the remaining concepts were evaluated in greater detail. This more detailed evaluation is described in Chapter 3.

2.2 DESCRIPTIONS OF PRELIMINARY RESTORATION CONCEPTS

The following are the descriptions of the ten preliminary habitat restoration concepts identified during the initial development process (Figure 1).

2.2.1 SUTTER BYPASS TRIANGLE PROPERTY ENHANCEMENT CONCEPT

The Sutter Bypass triangle property is located at the southeastern tip of the Sutter Bypass directly adjacent to and southeast of the Sutter Bypass west levee and directly northwest of the western edge of the Fremont Weir. Located north of the Sacramento River in Sutter County, this property is regularly inundated during large storm events. However, more frequent inundation would result in more consistent activation of the floodplain habitat, which benefits listed fish species. The identified enhancement includes increasing the topographic variability of the property and improving the hydrologic connection to the Sacramento River to improve connectivity to the existing low-lying areas (channel along backside and low area in southern half of the property). No modifications to existing levees are proposed in association with this concept. However, because it is located in the Sutter Bypass, any modifications would likely require a Rivers and Harbors Act Section 408 permit.

2.2.2 GRAYS BEND CHANNEL CONNECTION CONCEPT

The Grays Bend area includes the oxbow that is located directly south of the Sacramento River and directly southwest of the Fremont Weir at the confluence of the Sacramento River, Yolo Bypass, and Sutter Bypass. Although this oxbow site is located within the Knights Landing basin, it is within the boundaries of Sutter County due to the historical alignment of the Sacramento River following the oxbow alignment. The county lines were

originally established along the centerline of the Sacramento River, which has since shifted north. This concept proposes to modify the existing gate that currently connects the Sacramento River to the Grays Bend oxbow channel to allow for fish access to this backwater off-channel habitat (and provide volitional ingress/egress). The east end of this channel at the Yolo Bypass levee would remain unchanged. The specific type of modification would depend on objectives formulated at a later time. Although opening the oxbow channel to the Sacramento River would provide significant salmonid benefits due to the large area of floodplain within the oxbow that would be activated, the opening would also allow high flows in the river to enter the oxbow, which would represent a serious flood risk for the Knights Landing basin due to the poor quality of the levee surrounding the oxbow.

2.2.3 GRAYS BEND RIPARIAN ENHANCEMENT CONCEPT

This concept includes lowering the elevation of the interior perimeter of the Grays Bend oxbow to expand the width of the vegetated riparian area surrounding the oxbow channel. The inside banks of the oxbow channel would be excavated to create a narrow inset floodplain that would be vegetated with native riparian forest species. This concept does not propose any modifications to the existing gate that currently connects the Sacramento River to the oxbow channel. However, this concept could be implemented in conjunction with either the Grays Bend Channel Connection concept or the Grays Bend Levee Setback concept. The excavated soil could be used as a source material for the construction of berms for improvements along the Sacramento River or for the construction of one of the cross levees being contemplated within the Feasibility Study

2.2.4 GRAYS BEND LEVEE SETBACK CONCEPT

This concept includes constructing a new levee around the entire Grays Bend oxbow and opening a direct connection to the Sacramento River to allow the entire oxbow to be inundated by the Sacramento River. The existing berm that surrounds the oxbow would be used as a base upon which the new levee would be constructed. The western channel of the oxbow would be directly connected to the Sacramento River to allow river water to flow directly into the oxbow channel and to inundate the entire oxbow during high river flow events. The new levee would tie into the Sacramento River levee on the west end and the west Yolo Bypass levee on the east end of the oxbow, creating approximately 2.5 miles of new levee. Implementation of this concept would negate the need for the Grays Bend Channel Connection concept above.

This setback could provide some flood protection benefits by reducing the stage of the Sacramento River downstream and would create new activated floodplain habitat. However, this levee setback concept would result in the substantial loss of agricultural lands and would substantially increase the length of levee protecting the Knights Landing basin, which could increase long-term flood risks. This concept would also require the removal of existing riparian habitat located on and adjacent to the existing berm surrounding the oxbow.

2.2.5 HOG FARM LEVEE SETBACK CONCEPT

The Hog Farm site is a triangle property located directly adjacent to and south of the Sacramento River and directly west of the Grays Bend oxbow within the Knights Landing basin. Similar to the Grays Bend Levee Setback concept, this concept contemplates building up the existing berm around the Hog Farm property to provide an approximately 35-acre setback area that would be connected to the Sacramento River. The existing Sacramento River levee would be degraded to allow the setback area to be regularly inundated. Due to its small size, this setback would likely have negligible flood benefits although it would create new activated floodplain

habitat along the river. However, this setback would require the relocation of a residence on this property and would result in the loss of agricultural lands.

2.2.6 SACRAMENTO RIVER LEFT BANK LEVEE SETBACK CONCEPTS

Two levee setback options were evaluated on the left back (i.e., east side) of the Sacramento River within the Horseshoe Lake area of Sutter County. Both of these levees setbacks would include extending a levee northwest from the Sutter Bypass west levee to the Sacramento River east levee to form setback areas that would parallel Griffith Road, which runs on top of the Sacramento River east levee. The smaller setback area would include a new levee that would be setback between 500 and 1,200 feet from the existing Sacramento River east levee to create a total setback area of approximately 115 acres. This setback area would not include the three residences located on Griffith Road directly adjacent to the Sacramento River's east levee. The larger setback area would include a new levee that would be setback between 3,300 and 4,300 feet from the Sacramento River east levee to create a total setback area of approximately 500 acres. This larger setback area would include the three residences located on Griffith Road as well as Horseshoe Lake. This concept would include degrading portions of the Sacramento River east levee to allow the setback areas for either alignment to be inundated. These setbacks could provide flood protection benefits by reducing the stage of the Sacramento River downstream of the setbacks and would create new activated floodplain habitat. However, both of these levee setback concepts would result in the substantial loss of agricultural lands and for the larger setback option, would require the relocation of three residences.

2.2.7 SACRAMENTO RIVER RIGHT BANK LEVEE SETBACK CONCEPTS

Similar to the left bank Sacramento River levee setbacks described above, two levee setback options were also evaluated on the right bank (i.e., west side) of the Sacramento River. These setbacks are both located within Yolo County just north of the narrowest point in the Knights Landing basin between the Knights Landing Ridge Cut and the Sacramento River. Both of these setback levee alignments are located within the bend in the Sacramento River located directly south of Mary Lake and the wide area within the Sacramento River identified as Portuguese Bend. The smaller setback area would include a new levee that would be setback approximately 500 feet at its widest from the existing Sacramento River west levee to create a total setback area of approximately 45 acres. The levee would extend north from the Sacramento River west levee for approximately 2,600 feet along the existing alignment of Road 116B until it reaches a sharp left turn in the road. At this point the levee would no longer follow the County Road 116B alignment but would instead continue north for approximately 3,100 feet until it again ties into the Sacramento River west levee. This smaller setback area would not include the residence located on County Road 116B at the sharp turn but would include a residence located further north and directly adjacent to the Sacramento River west levee.

The larger setback area would include a new levee that would be setback approximately 1,050 feet at its widest from the existing Sacramento River west levee to create a total setback area of approximately 95 acres. Unlike the smaller setback levee, the larger setback levee would not follow the County Road 116B alignment along its 2,500-foot southern segment. This segment would be west of the County Road 116B alignment. However, once County Road 116B diverts to the west, the 2,700-foot northern alignment of this setback levee would align with County Road 116B. This larger setback area would include the residence located at the sharp bend in County Road 116B and the residence located directly adjacent to the Sacramento River west levee.

This concept would include degrading portions of the Sacramento River west levee to allow the setback areas for either alignment to be inundated. These setbacks could provide some flood protection benefits by reducing the stage of the Sacramento River downstream of the setbacks and would create new activated floodplain habitat. However, both of these levee setback concepts would result in the substantial loss of agricultural lands and would require the relocation of residences. Habitat restoration components could be integrated into the levee improvements needed at Mid-Valley Sites 9 and 10, which are located at the northern end of these setback areas.

2.2.8 PORTUGUESE BEND ENHANCEMENT CONCEPT

The Portuguese Bend area is located southeast of the Knights Landing community within a wide area of the Sacramento River. This area is located entirely within the existing levees of the Sacramento River and includes lands on both the west side and east side of the river. The lands on the west side of the river are in Yolo County and the lands on the east side are in Sutter County. Crescent-shaped Mary Lake is located in the center of the area east of the river. This concept includes improving the connectivity of the lands within this area to the Sacramento River to create more frequently activated floodplain habitat. This would be accomplished by strategically excavating specific areas to increase the topographic and hydrologic diversity including specifically improving the connectivity to Mary Lake and other low-lying areas. This concept also includes restoring riparian habitat on both sides of the river in targeted areas. No modifications to existing levees are proposed in association with this concept, although habitat restoration components could be integrated into the levee improvements needed at Mid-Valley Sites 9 and 10, which are located at the southern end of this area. Also, excavation activities could provide a material source for berm or cross levee construction.

2.2.9 KNIGHTS LANDING RIDGE CUT ENHANCEMENT CONCEPT

The Knights Landing Ridge Cut (KLRC) is located along the southern boundary of the Knights Landing basin and transports agricultural drainage water from the Colusa Basin Drain into the Yolo Bypass. This concept includes excavating the mid-channel island within the KLRC to increase the channels capacity, to reduce cross channel erosion, and to provide a material source to construct berms or a cross levee. Some of the excavated material would also be used to reinforce both of the KLRC levee toes and to provide a base for planting riparian vegetation, which would aid in stabilizing the levees and reducing their exposure to erosion.

2.2.10 NEW CROSS LEVEE ADJACENT BORROW SITE ENHANCEMENT CONCEPT

This concept assumes that if the Alternative 1 cross levee is constructed within the Knights Landing basin, the borrow material necessary to construct the new levee would be excavated from the lands directly adjacent to the levee and a riparian woodland corridor consisting of approximately 40 acres would be established adjacent to the cross levee. The riparian woodland corridor would connect the riparian corridor along the KLRC with the riparian corridor along the Sacramento River. The length of this new corridor would be approximately 5,200 feet and would be approximately 325 feet wide (i.e., the width necessary to provide for the minimum habitat width recommended for the endangered Western Yellow-billed Cuckoo). This concept would involve lowering the woodland corridor footprint by 1 to 3 feet to provide a borrow source for levee construction (estimated to provide 63,000 to 190,000 cubic yards). It would also serve as a wind and agricultural buffer between the Knights Landing community and the adjacent farm fields at certain times of the year. The woodland corridor could mitigate for any habitat/vegetation loss due to levee repair actions associated with the selected alternative in the Feasibility Study.

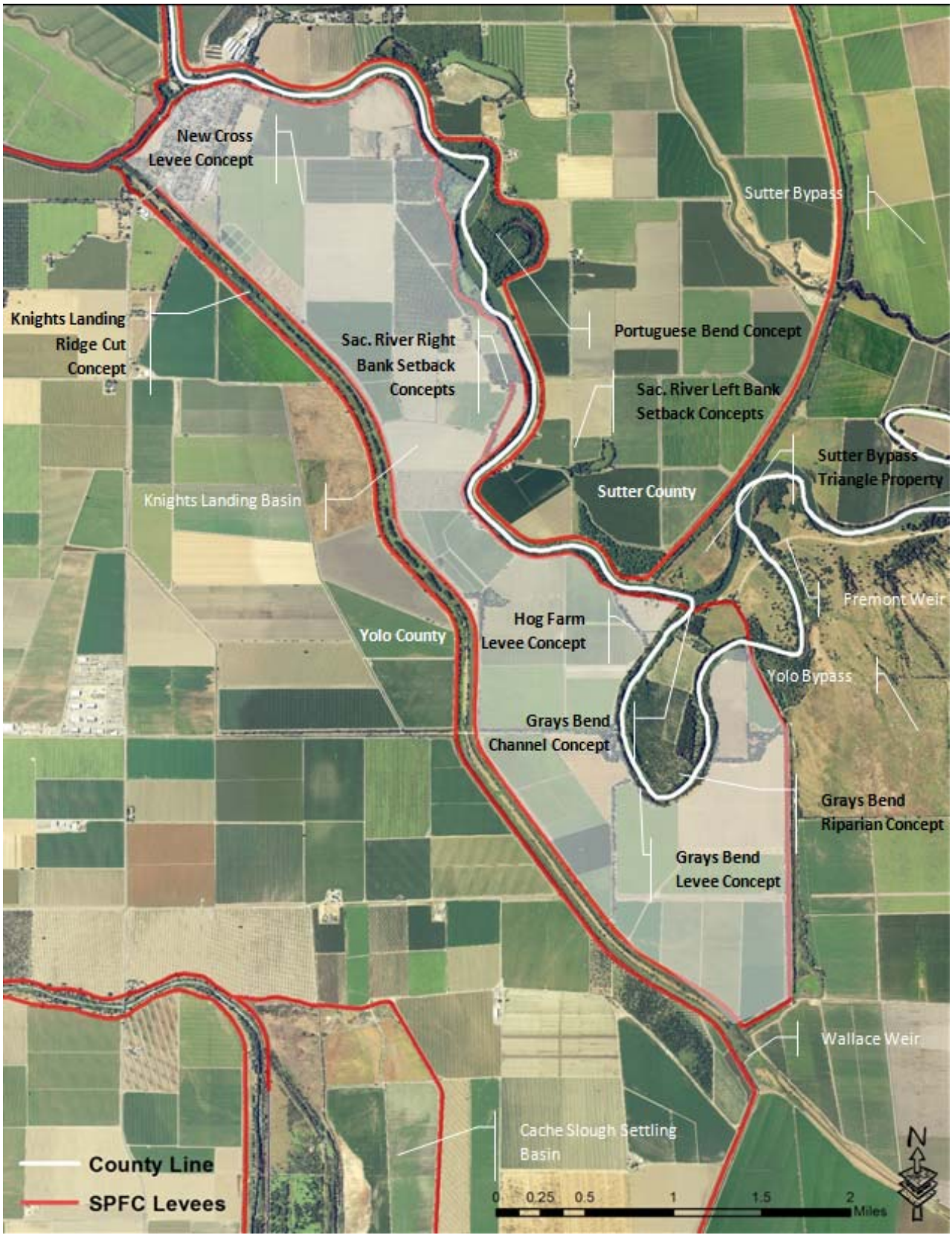

Figure 1. Map of preliminary restoration concepts. State Plan of Flood Control (SPFC) levees are shown in red

2.3 SCREENING OF PRELIMINARY HABITAT RESTORATION CONCEPTS

Table 1 provides a summary of categories used to qualitatively compare and screen preliminary habitat restoration concepts. Categories were scored Low, Moderate, or High representing potential or relative values associated with each category. The goal was to identify realistic and feasible restoration concepts that would merit more detailed review due to their potential ability to be planned and implemented in the near future in connection with the flood improvement alternatives identified in the Feasibility Study.

Using this screening process, the preliminary habitat restoration concepts were narrowed to those that would have at least a moderate feasibility of implementation. Five of the ten concepts met this criterion. Of these five concepts, the Yolo Bypass Triangle Property Enhancement Concept (Concept 1) was eliminated from more detailed review due to its low flood risk reduction benefit and its high permitting effort due to its location in the Sutter Bypass. The Cross Levee Riparian Corridor Concept (Concept 10) was also eliminated from more detailed review due to potential concerns regarding its local acceptability. The three remaining concepts included the Grays Bend Riparian Enhancement Concept (Concept 3), the Portuguese Bend Enhancement Concept (Concept 8), and the Knights Landing Ridge Cut Enhancement Concept (Concept 9). These concepts were identified as having the highest potential to be implementable in connection with the flood improvement alternatives identified in the Feasibility Study. Therefore, a more detailed evaluation of these three concepts was conducted and is presented in Chapter 3.

Although a more detailed review of the other seven concepts was not included in this report, the analysis of these concepts was done at a relatively high planning level and should be considered preliminary. The analysis is not intended to preclude these concepts from being evaluated in greater detail in future planning studies or from ultimately being considered for implementation.

Project Concept	Ecological Uplift	Recreation	Cost	Permitting Effort	Agricultural Sustainability	Overall Feasibility	Flood Risk Benefit
1. Yolo Bypass Triangle Property Enhancement	Mod	Low	Low	High	NA	Mod	Low
2. Grays Bend Channel Connection	Mod	Low	High	High	Low	Low	Low
3. Grays Bend Riparian Enhancement	High	Low	Mod	Mod	Low	Mod	Mod
4. Grays Bend Levee Setback	High	Low	High	High	Low	Low	Mod
5. Hog Farm Levee Setback	High	Low	High	High	Low	Low	Low
6. Sacramento River Left Bank Levee Setbacks	High	Mod	High	High	Low	Low	Mod
7. Sacramento River Right Bank Levee Setbacks	High	Mod	High	High	Low	Low	Mod
8. Portuguese Bend Enhancement	Mod	Low	Mod	Mod	NA	Mod	Low
9. Knights Landing Ridge Cut Enhancement	Mod	Mod	Mod	Mod	NA	Mod	Mod
10. Cross Levee Riparian Corridor	Mod	Mod	Mod	Mod	Low	Mod	Mod

LEGEND	LOW	MODERATE	HIGH

Table 1. Screening Criteria and Qualitative Concept Rankings

Notes:
Ecological Uplift: Estimated potential ecological uplift relative to other projects (assumed equal value between target species
Recreation: Potential recreational opportunities associated with concepts
Cost: Preliminary estimate of concept cost relative to other projects
Permitting Effort: Estimated permitting effort relative to other projects
Agricultural Sustainability: Compatibility with continued agricultural production
Overall Feasibility: Relative ability to implement based on a variety of criteria including costs, permitability, level of physical restoration actions necessary, ability to control the land, connection to flood improvements, local acceptability, and compatibility with agricultural lands.
Flood Risk Benefit: Estimated flood risk reduction benefits relative to other projects

3 HIGHEST POTENTIAL HABITAT RESTORATION CONCEPTS

Following the screening process, the three remaining concepts identified with the highest potential to be implementable in connection with the Feasibility Study's flood improvements are described in detail below.

3.1 GRAYS BEND RIPARIAN ENHANCEMENT CONCEPT

CONCEPT BACKGROUND

The Grays Bend project area sits at the confluence of the Sacramento River, Yolo Bypass, and Sutter Bypass, and encompasses an entire oxbow feature, which was historically the alignment of the mainstem of the Sacramento River (Figure 2). The oxbow channel forms the county line between Yolo and Sutter counties with the oxbow area located within Sutter County. The property is privately owned and direct landowner engagement would need to be initiated if this concept is considered for integration with any of the flood improvement alternatives evaluated in the Feasibility Study.

The majority of the project area is actively farmed. Based on interpretation of historical imagery in Google Earth, land use patterns have changed little over the past 25 years within the oxbow (Figure 3). A narrow riparian fringe forest located along both banks of the oxbow channel and a 13-acre forested patch located along the eastern portion of the oxbow were also evident in 1993.

The entire oxbow feature is located within the Knights Landing basin and is protected by State Plan of Flood Control (SPFC) levees. A manual slide gate located at the connection between the Sacramento River and the western end of the oxbow channel provides river water to the oxbow channel. No hydraulic connection is present at the eastern end of the oxbow channel where it meets the western Yolo Bypass levee.

The project area's existing topography, based on 2008 LiDAR data from the California Department of Water Resources (DWR), is represented in Figure 4. A typical cross section of the oxbow channel is shown in Figure 5. The interior bank of the oxbow channel is approximately 10 feet higher than the water surface elevation (WSE) of the channel (based on the WSE on the date of the LiDAR flight – March 25, 2008) and approximately 15 feet lower than the berm crown on the opposite (exterior) bank. This berm runs along the entire oxbow bend parallel to the exterior bank of the oxbow channel. County Road 16 is located on top of this berm.

RESTORATION CONCEPT

The objective of this concept is to improve the quality and quantity of shaded riverine aquatic (SRA) habitat along the interior bank of the oxbow channel by widening both the area of inundated riparian habitat and expanding the width of the riparian fringe forest. At the conceptual design level, this would be accomplished by creating a narrow inset floodplain bench and laying back the banks, as well as widening the riparian corridor through active planting with native riparian species (Figure 6 and 7).

The width of the proposed riparian enhancements is estimated to be approximately 100 feet from the existing left edge of bank (except for one wider area adjacent to the existing forested patch in order to connect with this area), and the enhancement footprint (white shaded area in Figure 6) encompasses approximately 35 acres. The target species for this enhancement concept are birds dependent on healthy riparian habitat including Western Yellow-

billed Cuckoo, least Bell's vireo, and tricolored black bird, as well as other native species such as western pond turtle. If designed with appropriate basking areas and upland hibernacula, the concept could also support giant garter snake. The length of riparian enhancements would be refined based on a more detailed evaluation and landowner interest.

The excavated soil could be used as a source material for the construction of berms for improvements along the Sacramento River or for the construction of one of the cross levees being contemplated within the Knights Landing basin, although the haul distances would need to be considered in determining whether this concept is implementable. Also, the habitat creation would potentially offset any riparian habitat impacts that may occur due to levee repairs along the Sacramento River.

The cost to implement this restoration concept is roughly estimated to be $4.9 million. This cost estimate was prepared purely for comparative purposes and should not be relied upon for funding decisions without further refinement of the permitting requirements and the concept details.

Figure 2. Grays Bend Riparian Enhancement Concept project area

Figure 3. Historical aerial imagery (Google Earth) of the project area over the last 25 years (June 1993 and February 2018)

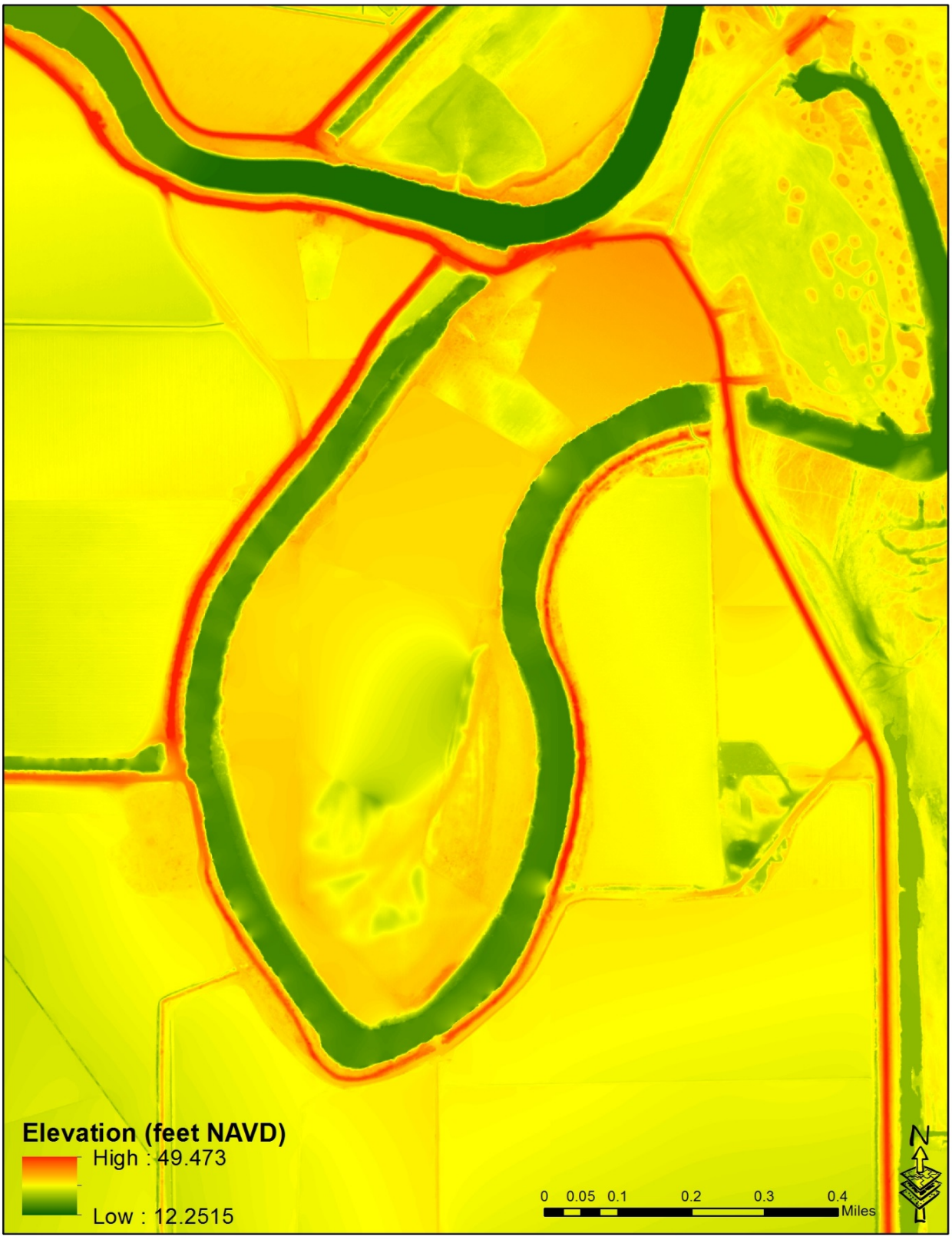

Figure 4. Detailed topography of the project area based on 2008 LiDAR data from the California Department of Water Resources (DWR)

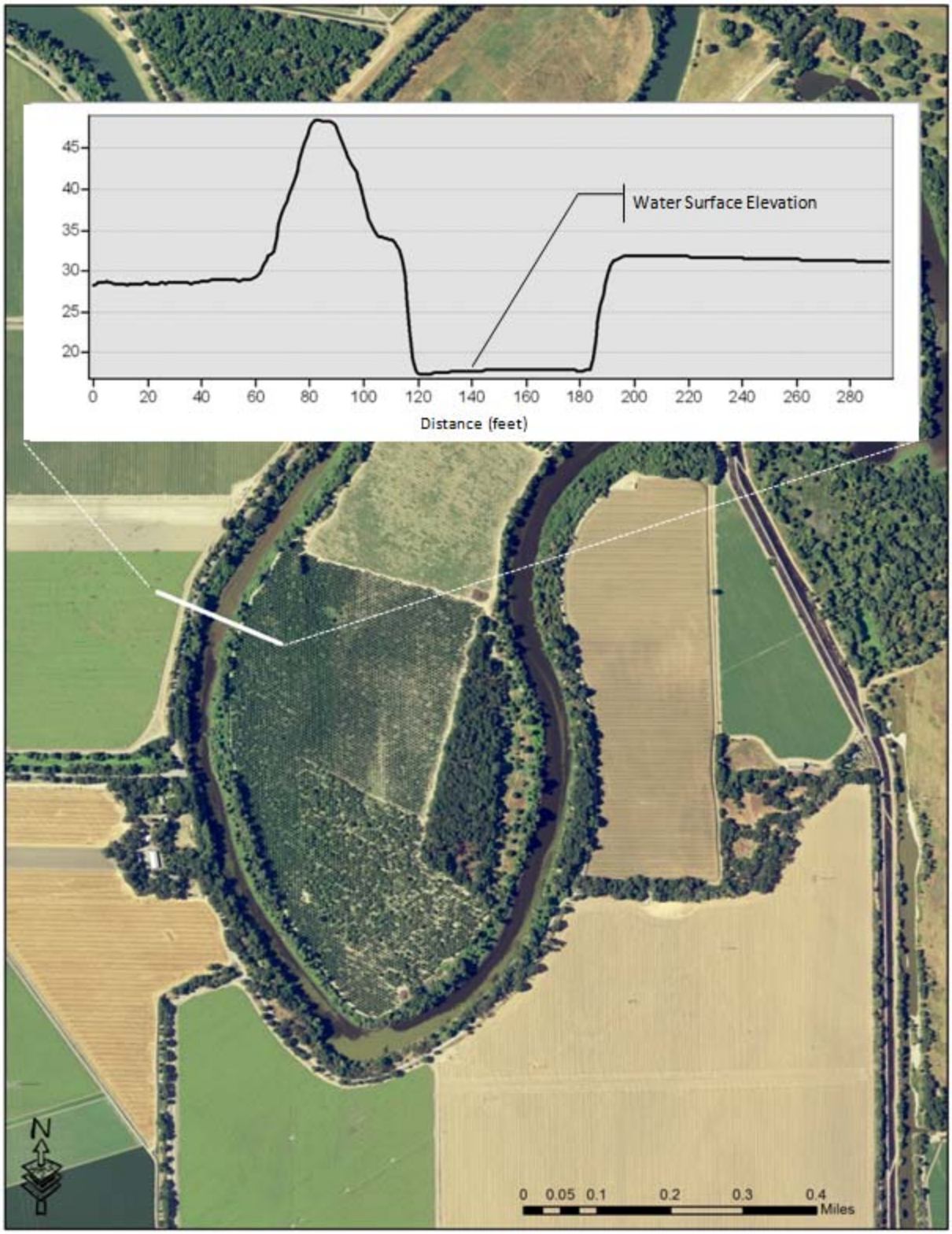

Figure 5. Typical cross section across oxbow channel based on DWR LiDAR data (Note that what appears to be the channel bottom is the water surface elevation on the LiDAR flight date)

Figure 6. Grays Bend Riparian Enhancement Concept footprint

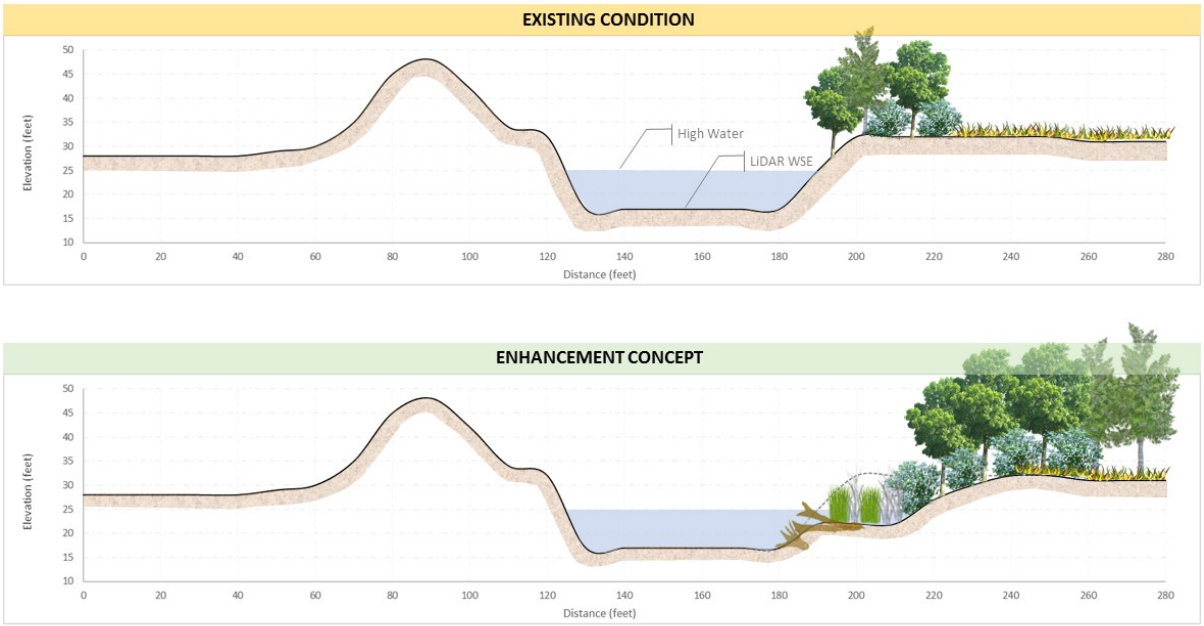

Figure 7. Conceptual design drawing of Grays Bend Riparian Enhancements

3.2 PORTUGUESE BEND ENHANCEMENT CONCEPT

CONCEPT BACKGROUND

The Portuguese Bend area is located southeast of the Knights Landing community within a wide area of the Sacramento River (Figure 8). The area includes Mary Lake, which is an oxbow feature that is intermittently inundated by high flows within the Sacramento River. This area is located entirely within the floodplain between the existing levees of the Sacramento River and includes lands on both the west side and east side of the river. The lands on the west side of the river are in Yolo County and the lands on the east side are in Sutter County. The property is privately owned.

The project area is not currently farmed. However, historical imagery in Google Earth indicates that in the early 1990s, some active agricultural production occurred along the east bank areas (Figure 9). Since 1993, a relatively dense canopy of riparian vegetation has grown over much of the area.

Based on DWR Floodplain Inundation Potential (FIP) mapping, conducted during the development of the CVFPP Conservation Strategy, the site is largely mapped as 2-year floodplain (i.e., 50% chance peak flow), with small pockets of frequently activated floodplain (FAF). FAF is defined as inundation of a floodplain area 1 foot or more above the water surface of a 67% chance spring flow that is sustained for at least 7 days and occurs in 2 out of 3 years (Figure 10).

RESTORATION CONCEPT

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

Areas of excavation to improve floodplain connectivity were identified based on an analysis of the FIP maps (Figure 10) and LiDAR topography (Figure 11). Low-lying areas that were targeted for improved connectivity (i.e., more frequent connectivity to the river) can be seen as darker greens in Figure 11 (i.e., off-channel areas of darker green). These areas also generally correspond to the blue Frequently Activated Floodplain (FAF) areas identified in the FIP map (Figure 10). Most of these low-lying areas have higher ground surrounding them that block water during lower to intermediate flows. Targeted excavation would connect these low-lying areas to the river so that they inundate earlier and more frequently, and so that fish do not become stranded when the river level drops. Restoration would consist of targeted excavation in five areas comprising approximately 25 acres. Riparian restoration would occur in two areas comprising approximately 28 acres. Figures 12 and 13 identify the restoration concept on different base layers.

The entire project area is also mapped as having “good” to “excellent” deep percolation (a proxy for groundwater recharge potential based on the soils’ saturated hydraulic conductivity properties) based on the UC Davis Soil Agricultural Groundwater Banking Index (SAGBI) tool (Figure 14). Therefore, increasing the area of inundation through targeted excavation would enhance the ability of this area to contribute to localized groundwater recharge.

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

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

Figure 8. Portuguese Bend Concept project area

Figure 9. Comparison of changes in site conditions over the last 25 years at Portuguese Bend (June 1993 and February 2018) – Note changes in vegetation cover and composition in east bank areas (Google Earth imagery).

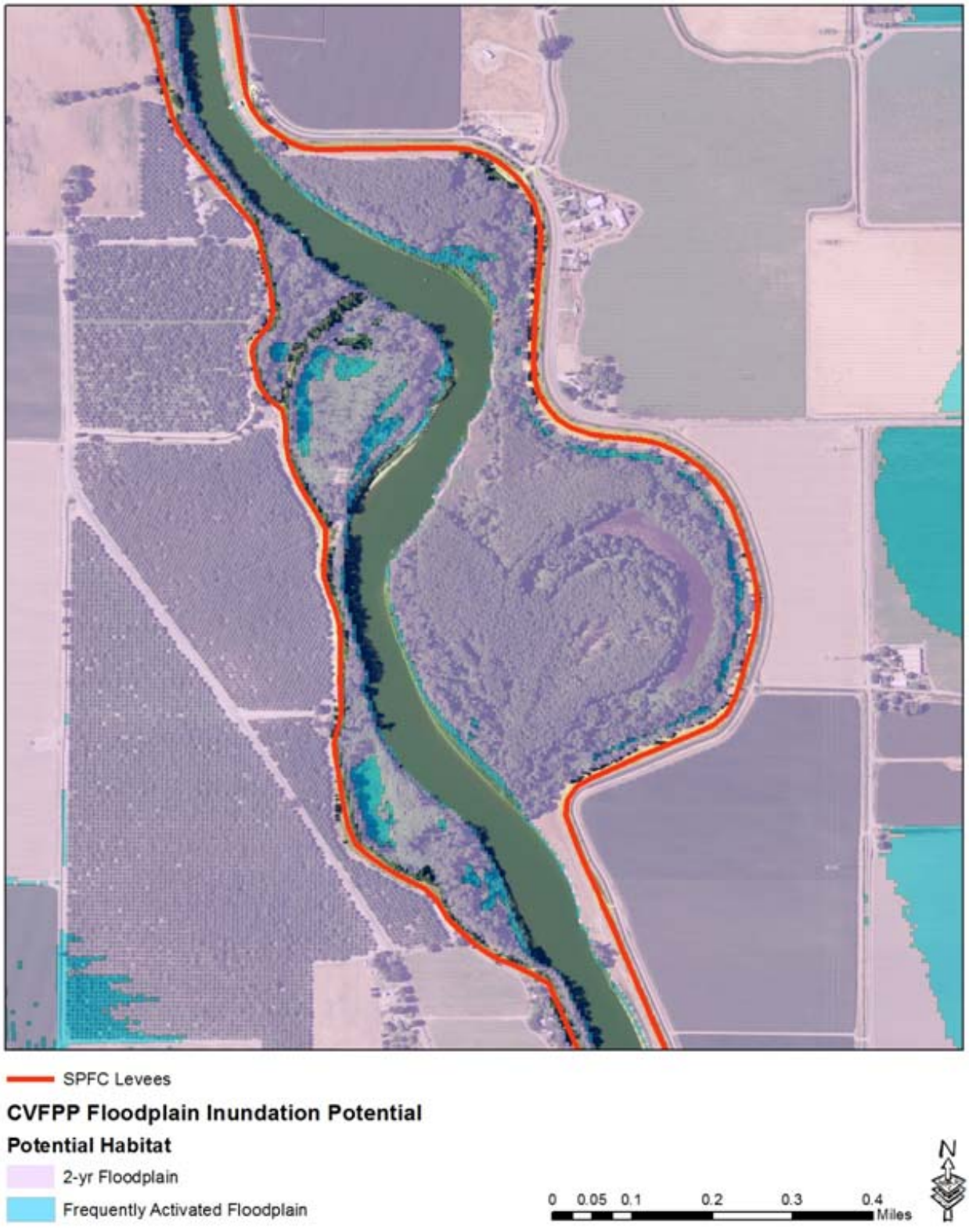

Figure 10. Floodplain Inundation Potential for the project area

Figure 11. Map of project area topography based on 2008 LiDAR

Figure 12. Recommended excavation and riparian restoration areas (with aerial base layer).

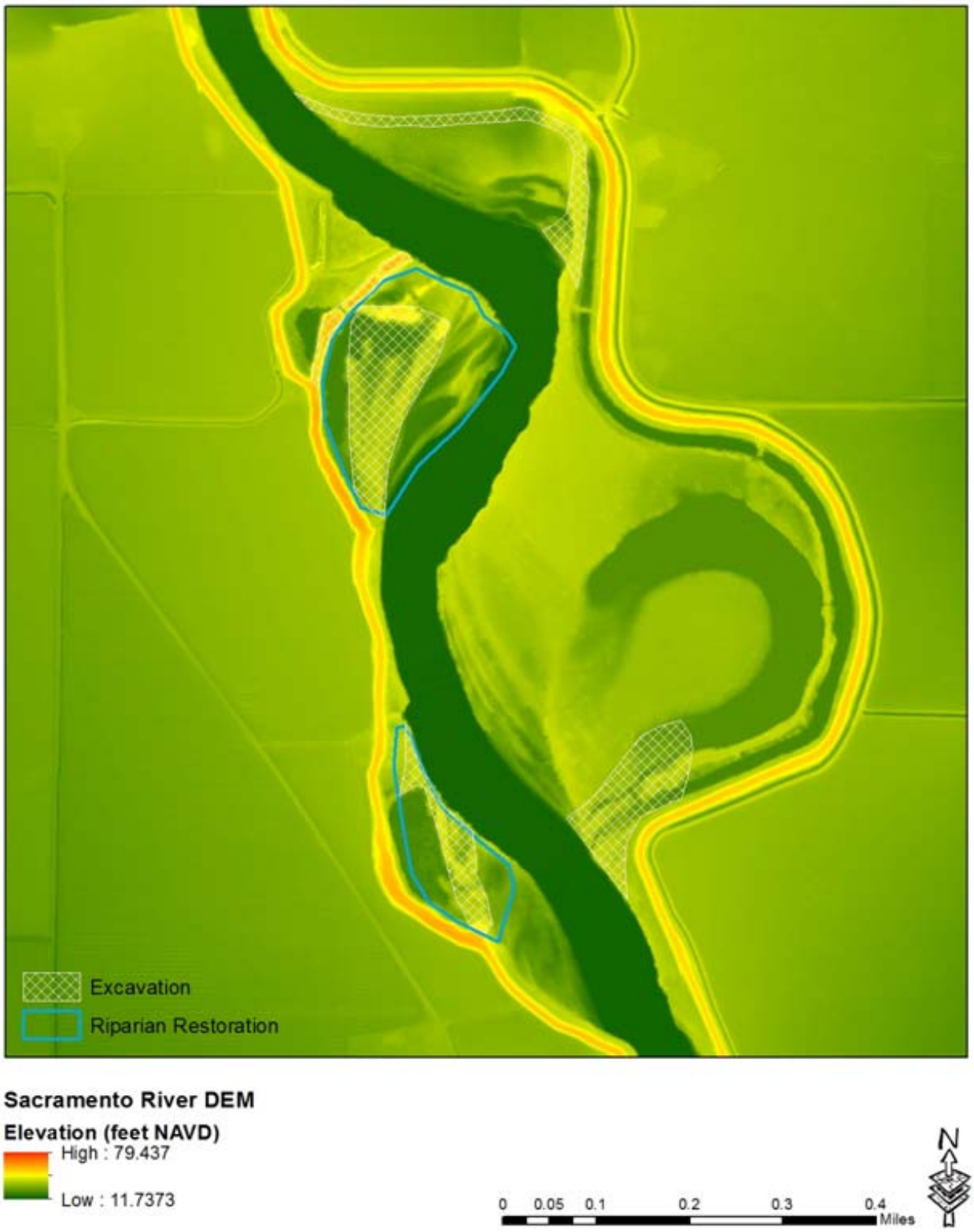

Figure 13. Recommended excavation and riparian restoration areas (with LiDAR base layer)

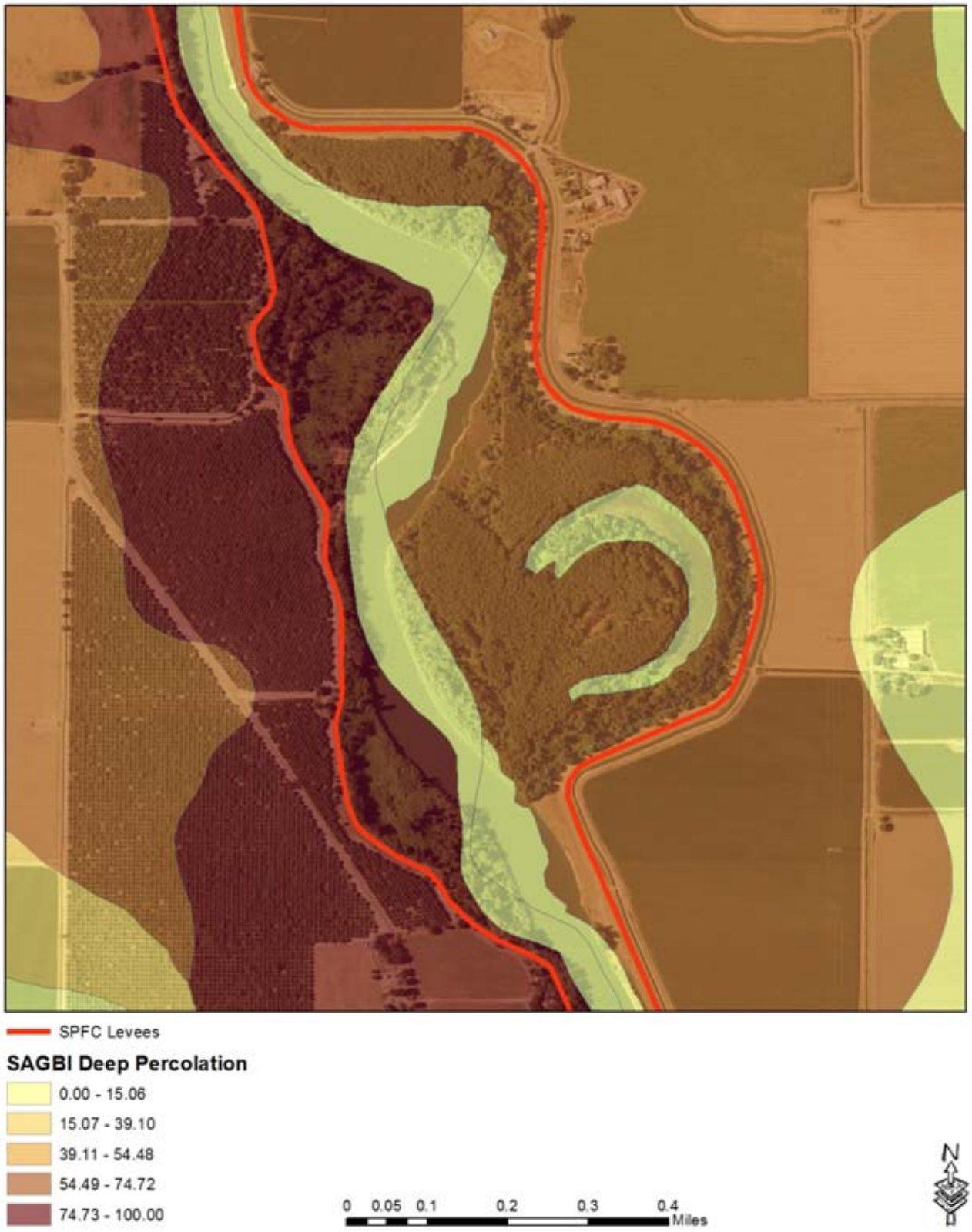

Figure 14. Map of deep percolation areas based on UC Davis' Soil Agricultural Groundwater Banking Index (SAGBI)

3.3 KNIGHTS LANDING RIDGE CUT ENHANCEMENT CONCEPT

CONCEPT BACKGROUND

The KLRC was constructed in 1930 by the US Army Corps of Engineers (USACE) and the State of California to transport agricultural drainage water from the Colusa Basin Drain into the Yolo Bypass. Maintained by the Knights Landing Ridge Drainage District, the KLRC extends approximately 6 miles southeast from its confluence with the Colusa Basin Drain near the western edge of the unincorporated community of Knights Landing to the recently reconstructed Wallace Weir. The levees on both sides of the KLRC provide flood protection for the community of Knights Landing and for the surrounding agricultural lands to the northeast and southwest.

The KLRC was designed to convey 20,000 cubic feet per second (cfs) during large discharge events. When the Sacramento River is low (e.g., during the August to September drain period associated with rice production), water from the Colusa Drain discharges into the Sacramento River through the Knights Landing Outfall Gates (KLOG). When the Sacramento River exceeds 25 feet in elevation (USACE datum) (e.g., in the winter and spring months), KLOG is closed and all flows from the Colusa Drain are conveyed through the KLRC into the Yolo Bypass.

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

In addition, the island has eroded in some areas resulting in the formation of narrow cross channels that divert flows directly toward the levees, resulting in scouring of the levee toe in some areas. Over time, this scouring could degrade the levee integrity. However, these cross channels also provide the ability for flows to move from one channel to the other, which facilitates water movement through the KLRC. The continued ability to move water efficiently through the KLRC is important to both upstream and downstream water users and dischargers.

RESTORATION CONCEPT

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

The concept includes several assumptions, the primary of which is that the material excavated out of the KLRC would be suitable for berm or cross levee construction. Additional analysis will be necessary to verify this assumption. Also, for initial rough-calculation purposes, the mid-channel island was assumed to consist of two typical configurations – a Narrow Island and a Wide Island. In general, the Narrow Island is more densely vegetated and has more mature cover while the Wide Island is sparsely vegetated due to regular maintenance/mowing. The Narrow Island configuration was assumed to extend from Knights Landing southeast for 2.3 miles and the Wide Island was assumed to continue to Wallace Weir (Figure 15). Figures 16 and 17 show the Narrow and Wide Island sections separately with typical cross sections and LiDAR images using field surveys conducted by MBK Engineers on May 7, 2010. The island is assumed to be excavated along its entire length down to its lowest point and a two-step bank is assumed to be constructed on each side of the channel using available cut material. Using simplified geometry to estimate the cross sectional cut/fill areas for ease of calculation, the total estimated remaining volume of material available for construction of berms or a cross levee would be approximately 1,680,000 cubic yards (Figures 18 and 19).

The riparian enhancement along the levee toes is proposed to be implemented in a two-step design that is based on the existing hydrology (Figure 20), which showed stage variation of only approximately 4 feet for the period of available data (December 2017 – December 2018). The elevations of the two steps were chosen based on this hydrology (roughly 22.5 feet and 20 feet) – the lower elevation step would be inundated year round and the higher step would be an intermittently inundated feature, with vegetation planting palettes chosen to match the hydrology and target wildlife species (Figure 21). An additional design consideration includes the placement of woody material from trees removed from the excavated island along the restored levee banks to provide cover and habitat complexity.

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

Figure 15. Knights Landing Ridge Cut mid-channel island assumptions

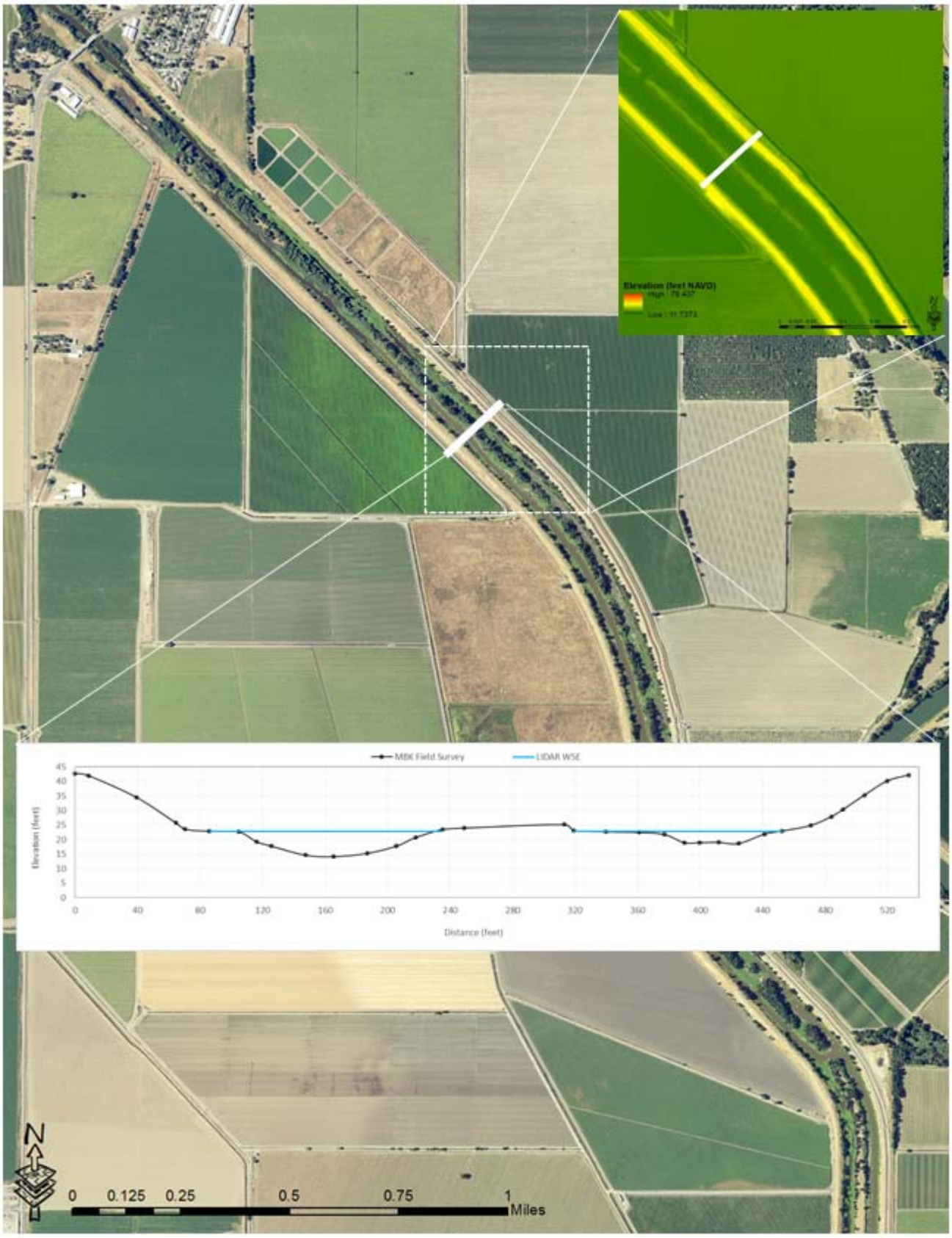

Figure 16. Narrow Island reach with representative field survey cross section and LiDAR image

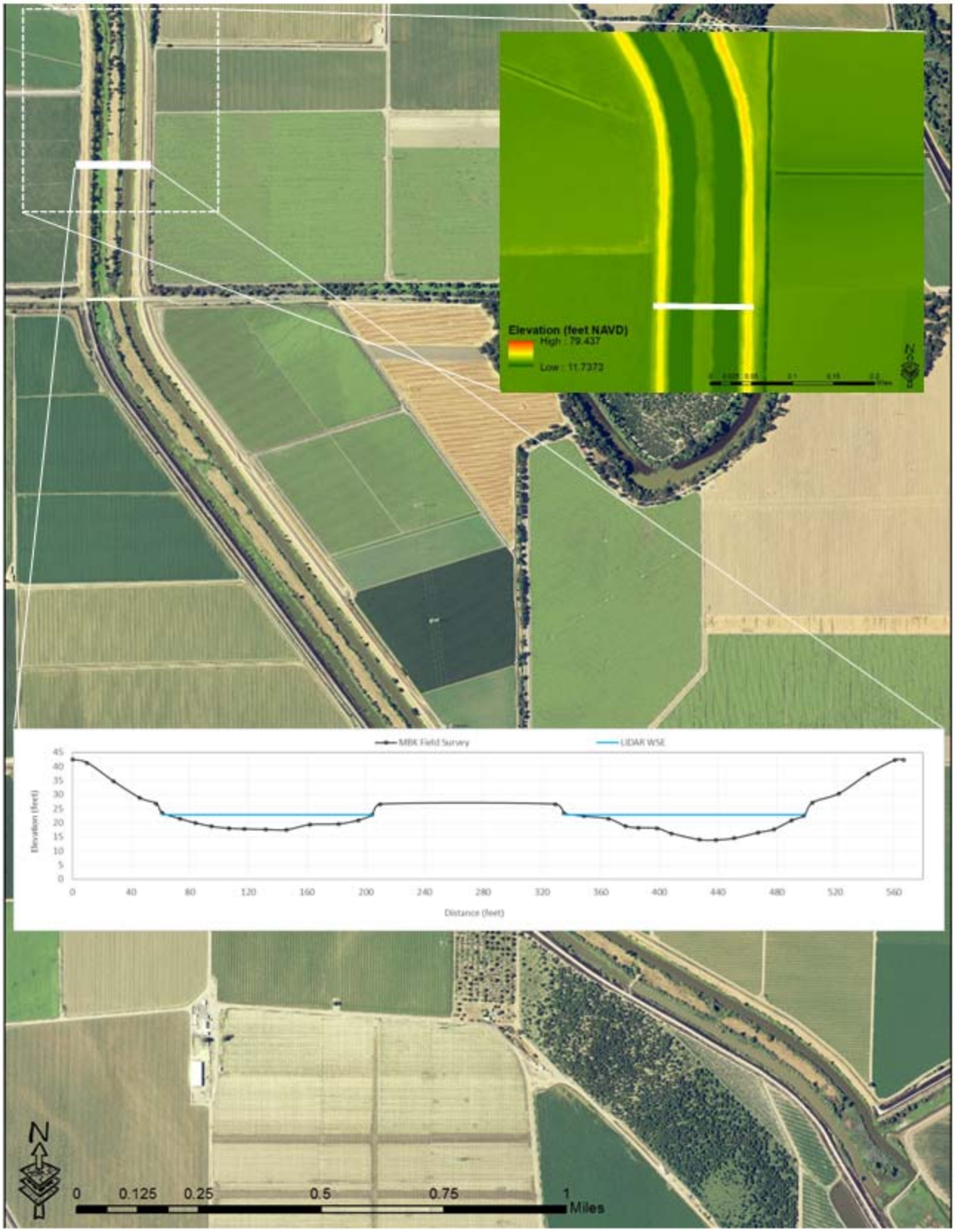

Figure 17. Wide Island reach with representative field survey cross section and LiDAR image

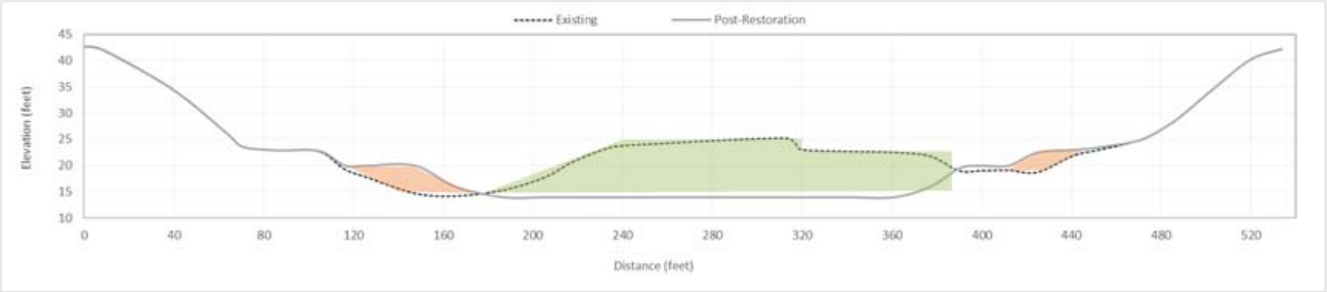

Figure 18. Narrow Island Type - Existing and post-restoration topography with cut (green) and fill (orange) areas identified

Notes: Cross Sectional Areas: Cut = 1,680 ft^2, Fill = 230 ft^2, Available for Berm or Cross Levees = 1,450 ft^2
Volumes: Cut = 1,680 ft^2 x 12,144 ft = 20,401,920 ft^3 = **755,627 cy**, Fill = 230 ft^2 x 12,144 ft = 2,793,120 ft^3 = **103,449 cy,** Available for Berm or Cross Levees = **652,178 cy**

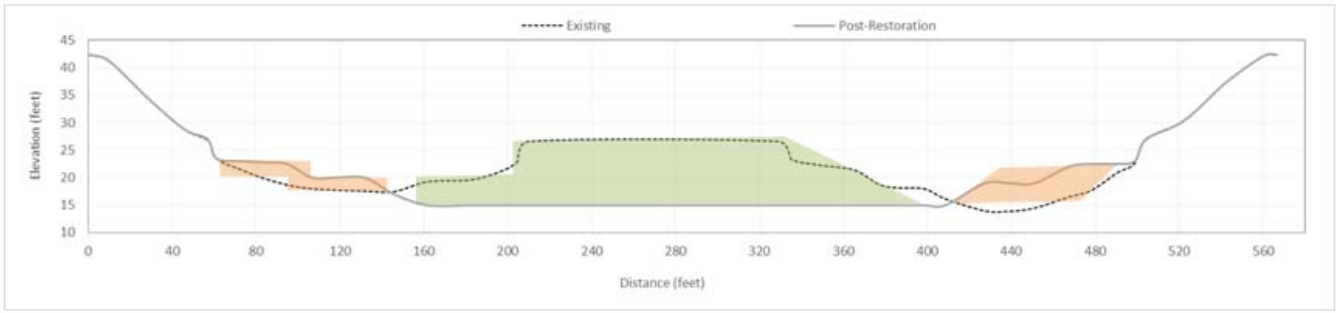

Figure 19. Wide Island Type - Existing and post-restoration topography with cut (green) and fill (orange) areas identified

Notes: Cross Sectional Areas: Cut = 2,110 ft^2, Fill = 690 ft^2, Available for Berm or Cross Levees = 1,420 ft^2
Volumes: Cut = 2,110 ft^2 x 19,536 ft = 41,220,960 ft^3 = **1,526,702 cy**, Fill = 690 ft^2 x 19,536 ft = 13,479,840 ft^3 = **499,253 cy**, Available for Berm or Cross Levees = **1,027,449 cy**

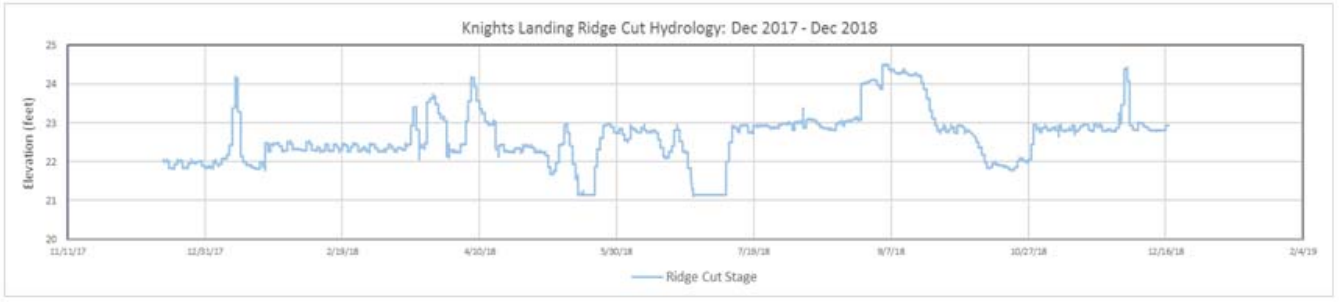

Figure 20. Knights Landing Ridge Cut 15-minute water stage (DWR station: Ridge Cut Slough at Knights Landing)

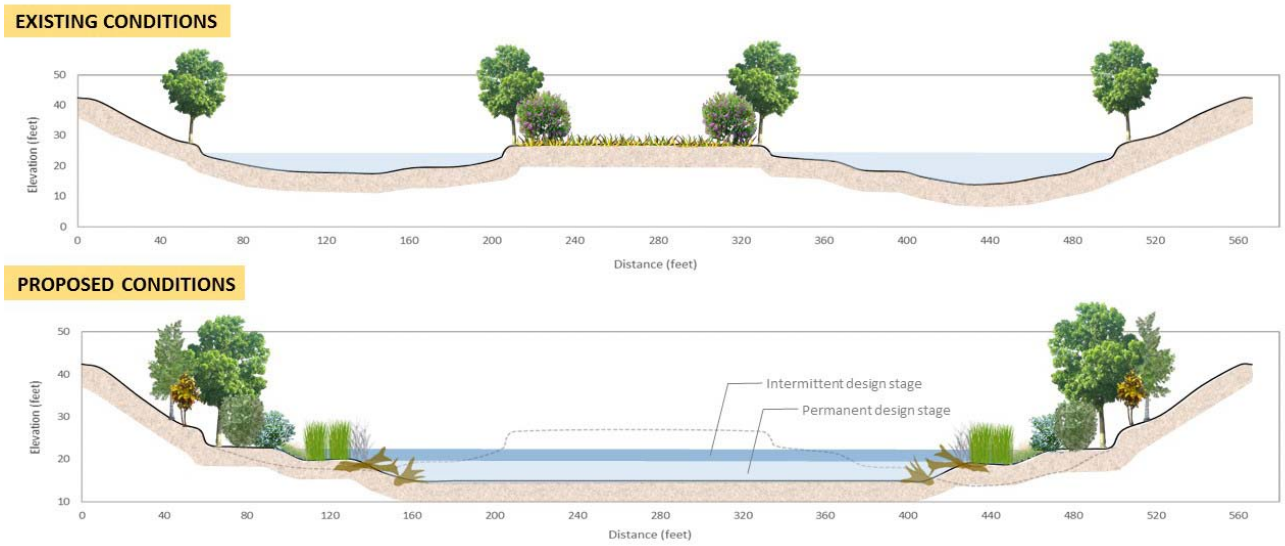

Figure 21. Existing and proposed conditions for conceptual KLRC riparian enhancements

4 RECREATION AND WATER SUPPLY OPPORTUNITIES

In 2016, Yolo County used funds from a Community Development Block Grant to prepare the Knights Landing Revitalization Study (Revitalization Study). Completed in September 2016, the Revitalization Study identified twelve recommendations to improve the economic potential of the Knights Landing community. Of these twelve recommendations, three focused on recreational enhancements within the community including establishing a new public park on a portion of the Sci-Tech Academy Charter School site, establishing a promenade overlook on the Sacramento River, and improving the Knights Landing boat launch area. The Revitalization Study also separately identified recreational opportunities along the levee that extends along the northwestern edge of the community adjacent to the Colusa Basin Drain and parallel to Reed Street. In addition, as part of the Feasibility Study effort, additional recreational opportunities were explored that could be integrated with the proposed flood improvement alternatives. The following describes the recreational opportunities identified in the Revitalization Study and an additional recreational opportunity identified during the preparation of this Technical Memorandum. The recreational discussion is followed by a description of water supply improvement opportunities in Knights Landing.

4.1 NEW PUBLIC PARK AT SCI-TECH ACEDEMY CHARTER SCHOOL

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

4.2 SACRAMENTO RIVER PROMENADE

The Revitalization Study identified the development of a promenade along the Sacramento River between State Route 113 and Railroad Street. This promenade would include a trail along the existing levee alignment that would include sitting areas, picnic tables and overlook plazas. The intent of this promenade would be to attract local residents and visitors who want to enjoy river views, walk along the river or have a picnic (Wahlstrom & Associates 2016). The trail could connect to the Colusa Basin Drain east levee trail improvements described below to form a continuous path along the northern and western portions of the community.

This area includes privately-owned commercial parcels that appear to have frontage running along the top of the levee. The area is locate d on a high bank so direct river access is not realistic, which is why a promenade approach was identified in the Revitalization Study. The Study determined that the creation of a new promenade could be accomplished by developing Front Street as a pedestrian-oriented roadway with pathways down the levee to the river bank. This site is readily accessible from the multi-family development and eastern neighborhoods of Knights Landing. Therefore, it offers an opportunity to connect the community to the river. A similar promenade was developed by the City of Oroville at the top of the levee above their town along the Feather River, identified as Century Plaza (Wahlstrom & Associates 2016).

4.3 KNIGHTS LANDING BOAT LAUNCH IMPROVEMENTS

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

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

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

4.4 COLUSA BASIN DRAIN LEVEE RECREATIONAL IMPROVEMENTS

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

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

4.5 NEW CROSS LEVEE LOOP TRAIL

Although the existing levees on the perimeter of the Knights Landing community are currently used by residents as walking trails, the typical use represents an out and back activity along the same route. However, if a cross levee is constructed directly east of the community, the new levee could provide a loop trail that would allow residents to walk or run complete around the community. If the cross levee in closest proximity to the community is constructed (Alternative 1), the distance of the round-trip loop would vary between 2.5 and 3 miles, depending

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

Also, if riparian vegetation is planted within a potential borrow area adjacent to a new cross levee alignment (Alternative 1), as described in the ecosystem opportunities discussion earlier in this report (Restoration Concept 10), the cross levee trail could incorporate walking paths within the riparian corridor. Providing a walking path through an adjacent riparian corridor would provide recreationalist with an alternative walking environment that may be more enjoyable due to greater wildlife diversity and would likely be more useable during the hot summer months once the vegetation matures.

4.6 WIDENED RECREATIONAL PARKING ON SACRAMENTO RIVER

Recreationalists currently access the Sacramento River, primarily for fishing purposes, from County Road 116B near Wild Irishman Bend (Figure 22). Vehicles park along the roadway on top of the levee in this area although sufficient space is not currently available to safely accommodate parking. Vehicles parking in this area can cause safety hazards for vehicles traveling on this roadway and pedestrians accessing the river. These parked vehicles can also slow or completely block emergency responders. The expansion of County Road 116B in this area sufficient to safely accommodate vehicle parking would eliminate this roadway hazard and would provide an improved recreational amenity for the community. The length of the road widening necessary to accommodate the current and estimated parking demand would need to be determined prior to initiating the improvements.

4.7 RECREATIONAL OPPORTUNITIES RECOMMENDATIONS

In preparing this report, the project team concluded that because the recreational opportunities were more limited than the habitat restoration opportunities, the use of a screening process to narrow the number of opportunities was not necessary. Instead, the following recommendations were developed based on a review of the recreational opportunities identified above. The recommended recreational opportunities are identified in Figure 22.

- **New Public Park at Sci-Tech School** - The development of a new public park at the Sci-Tech Academy Charter School would provide a beneficial recreational amenity for the community but it is not directly connected to any of the flood improvement alternatives evaluated in the Feasibility Study. Therefore, it is not recommended for implementation as part of this flood planning effort.

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

- **Knights Landing Boat Launch Improvements** - The Boat Launch improvements are anticipate to be constructed in the summer of 2019. Therefore, no action is necessary as part of the Feasibility Study to further implement the Boat Launch project. Although the creation of a natural park south of the Boat Launch and the installation of a pedestrian bridge across the Colusa Basin Drain would provide beneficial recreational amenities for the community, they are not directly connected to any of the flood improvement alternatives evaluated in the Feasibility Study. Therefore, they are not recommended for implementation as part of this flood planning effort.

- **Colusa Basin Drain Levee Recreational Improvements** - The development of the recreational improvements along the Colusa Basin Drain east levee would represent a substantial recreational amenity for the community that would be directly connected to alternatives evaluated in the Feasibility Study. Therefore, the integration of these improvements should be considered in any levee improvement planning and/or design along the Colusa Basin Drain from Reed Street to State Route 113.

- **New Cross Levee Loop Trail** - The development of the recreational improvements along a new cross levee would represent a substantial recreational amenity for the community that would be directly connected to alternatives evaluated in the Feasibility Study. Therefore, the integration of these improvements should be considered in any cross levee improvement planning and/or design.

- **Widened Recreational Parking on Sacramento River** - The expansion of County Road 116B adjacent to the Sacramento River near Wild Irishman Bend (Figure 22) to accommodate parking for people accessing the river, particularly for fishing, would eliminate an existing safety hazard caused by road blockages and would accommodate an existing recreational use. This road expansion would be directly related to levee improvements along the Sacramento River that are included in the alternatives evaluated in the Feasibility Study. Therefore, the integration of these improvements should be considered in any levee improvement planning and/or design along the Sacramento River near Wild Irishman Bend.

4.8 WATER SUPPLY IMPROVEMENT OPPORTUNITIES

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

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

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

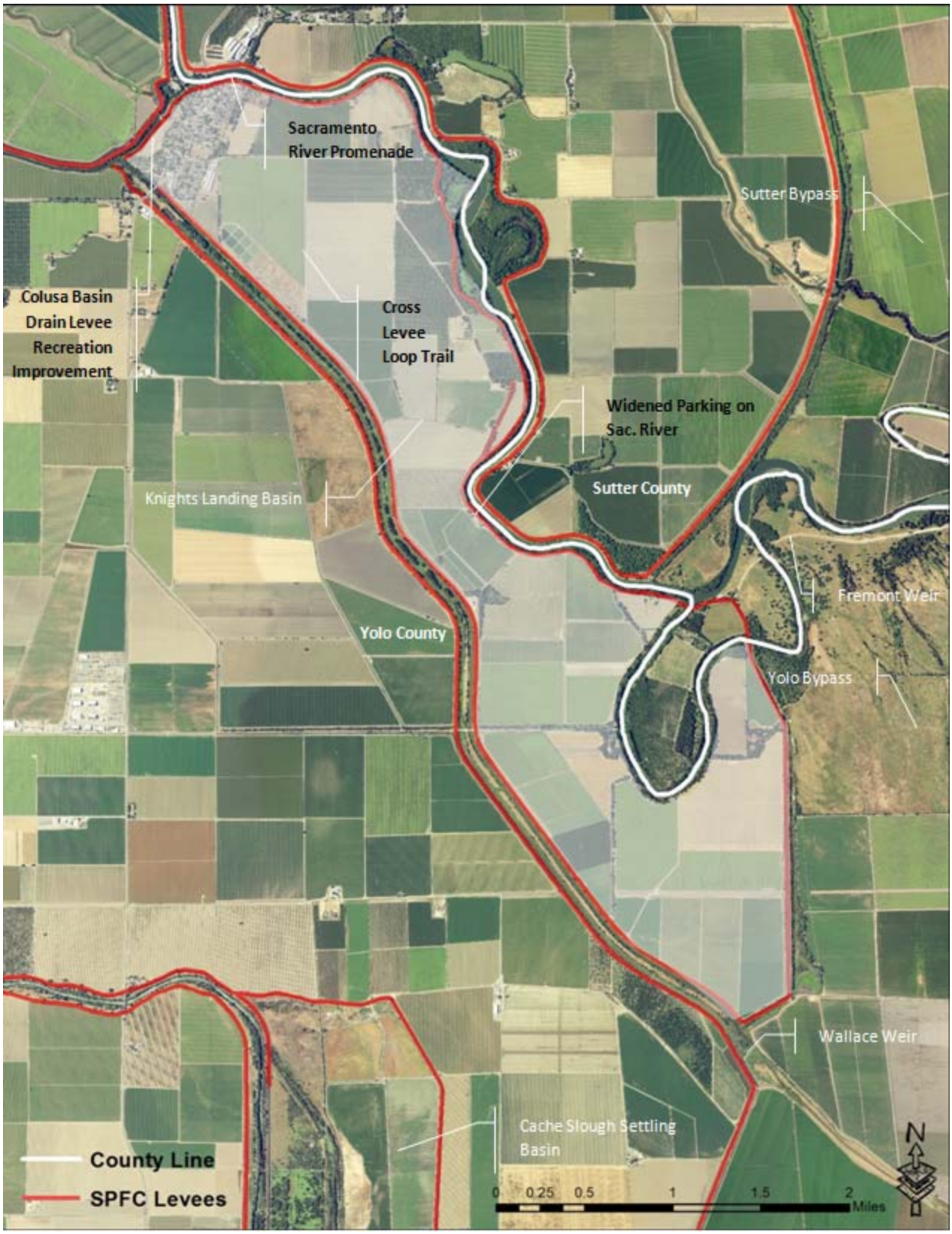

Figure 22. Map of preliminary recreational opportunities. State Plan of Flood Control levees are shown in red

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