Appendix O – Baseline Study Deliverable for Flood Conveyance Optimization, Environmental Science Associates, June 2019.

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BASELINE STUDY DELIVERABLE FOR FLOOD CONVEYANCE OPTIMIZATION

LOOKOUT SLOUGH TIDAL HABITAT RESTORATION AND FLOOD IMPROVEMENT PROJECT

Prepared for:

Reclamation District 2098
7178 Yolano Rd.
Dixon, CA 95620

On behalf of:

Ecosystem Investment Partners
5550 Newbury St.
Baltimore, MD 21209

Contact: David Urban
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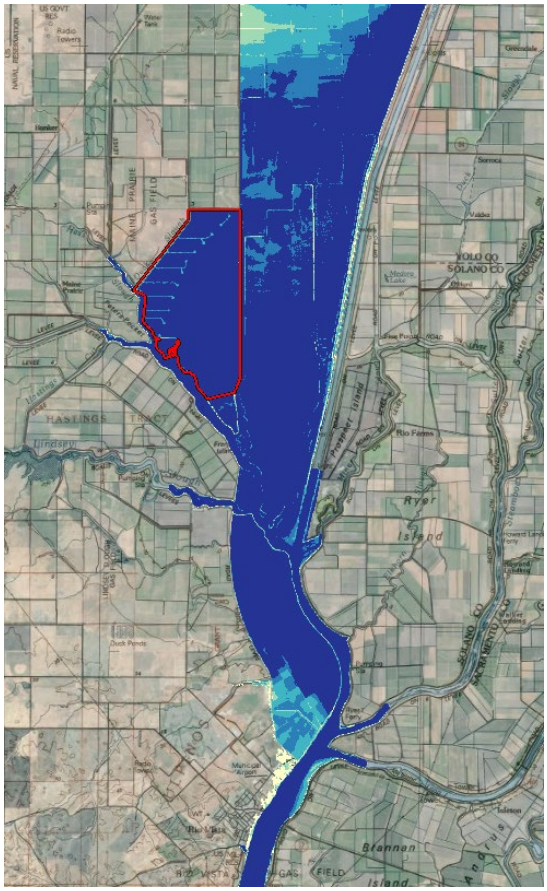
Contact: John Pritchard

Date: June 2019



Ecosystem Investment Partners

ESA

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BASELINE STUDY DELIVERABLE FOR FLOOD CONVEYANCE OPTIMIZATION

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June 2019

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LOOKOUT SLOUGH TIDAL HABITAT RESTORATION AND FLOOD IMPROVEMENT PROJECT

Baseline Study Deliverable for Flood Conveyance Optimization

Executive Summary

The Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (Project), if approved, will create approximately 3,000 acres of natural freshwater tidal marsh in the Cache Slough Complex in the northern Sacramento-San Joaquin Delta (**Figure ES-1**) and increase the regional flood conveyance capacity of the Yolo Bypass. The Project is being funded by the California Department of Water Resources (DWR) to meet multiple objectives:

- To meet goals outlined in the State of California's Bay Delta Conservation Plan (BDCP) as well as the U.S. Fish and Wildlife Service's (FWS) Biological Opinion (BiOp) issued as part of the Long-Term Operational Criteria and Plan (OCAP) for coordination of the Central Valley Project and State Water Project. The Project is within the priority habitat restoration areas delineated in the 2008 FWS BiOp Delta Smelt Crediting Decision Model, and will create creditable acres for Delta Smelt that will satisfy DWR's obligations under the Delta Smelt BiOp and salmonids under the Salmonid BiOp.

- To meet regional flood protection objectives to increase the conveyance capacity of the Yolo Bypass in a manner that is consistent with the 2017 DWR Sacramento Basin-Wide Feasibility Study (BWFS). By setting back the existing State-Federal levee along the west side of the Yolo Bypass, the Project will provide flood control storage and reduce upstream flood stages in the Yolo Bypass.

This report documents the methods, data, and assumptions used to achieve the following objectives:

- Selection of a preferred alternative design concept that maximizes flood benefits in the Yolo Bypass while meeting habitat enhancement objectives, and which has negligible effects on the overall hydraulic performance of the system.

- Determine the design water surface elevation for levee improvements associated with the Project. Either the 100-year design water surface or the 1957 authorized design profile will be used as the basis of design, whichever is greater.

- Demonstrate that the proposed design concept achieves equal or superior hydraulic performance as the preferred Yolo Bypass improvement concept (Yolo Bypass Option 3)

described in the Central Valley Flood Protection Plan Basin-wide Feasibility Study – Sacramento River (DWR, 2016).

This report describes the evaluation of an array of hydraulic design conceptual plans to formulate and select a preferred concept design plan for altering the existing levee system along the west side of the Yolo Bypass and east sides of Cache Slough and Hass Slough. The analysis establishes that the 1957 authorized design water surface profile shall be used as the basis for design for the Project's setback levee. The design top of levee shall include six feet of freeboard, plus one additional foot of freeboard for climate resiliency. Finally, analysis of the Future Cumulative Condition indicates that the Project will achieve superior hydraulic performance relative to the preferred concept plan (Yolo Bypass Option 3) identified in the BWFS.

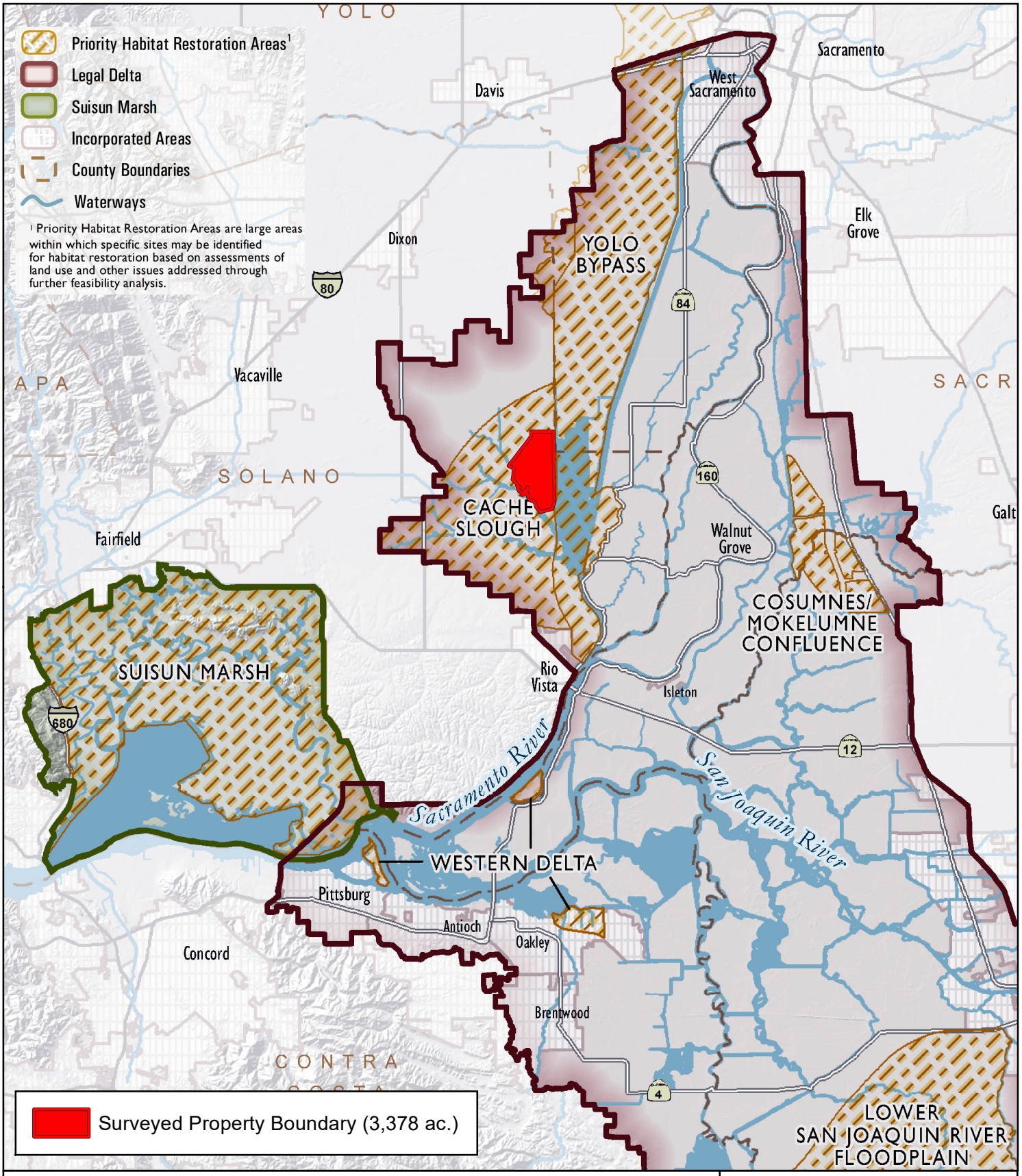

Figure ES-1
Location Map

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 3 6 12
Miles

Ecosystem Investment Partners

Prepared by: ESA

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
Delta Stewardship Council, 2013

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LOOKOUT SLOUGH TIDAL HABITAT RESTORATION AND FLOOD IMPROVEMENT PROJECT

Baseline Study Deliverable for Flood Conveyance Optimization

Introduction

The Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (Project) is comprised of two contracts: 1) The Lookout Slough Tidal Restoration Project and 2) The Lookout Slough Levee Setback Project. The goal of the combined Project is to create approximately 3,000 acres of natural freshwater tidal marsh in the Cache Slough Complex in the northern Sacramento-San Joaquin Delta (**Figure 1**) and increase the regional flood conveyance capacity of the Yolo Bypass. The Project is being funded by the California Department of Water Resources (DWR) to meet multiple objectives:

- To meet goals outlined in the State of California's Bay Delta Conservation Plan (BDCP) as well as the U.S. Fish and Wildlife Service's (FWS) Biological Opinion (BiOp) issued as part of the Long-Term Operational Criteria and Plan (OCAP) for coordination of the Central Valley Project and State Water Project. The Project is within the priority habitat restoration areas delineated in the 2008 FWS BiOp Delta Smelt Crediting Decision Model, and will create creditable acres for Delta Smelt that will satisfy DWR's obligations under the Delta Smelt BiOp and salmonids under the Salmonid BiOp.

- To meet regional flood management objectives to increase the conveyance capacity of the Yolo Bypass in a manner that is consistent with the 2017 DWR Sacramento Basin-Wide Feasibility Study (BWFS). By setting back the existing State-Federal levee along the west side of the Yolo Bypass, the Project will provide flood storage and reduce upstream flood stages in the Yolo Bypass.

For the DWR contracted EIP III Credit Co., LLC (EIP) to develop and, if approved, implement the Project as a multi-benefit project targeting both habitat restoration and flood risk reduction. Environmental Science Associates (ESA) is a subconsultant to EIP responsible for hydraulic analyses on the Project. This report documents the methods, data, and assumptions used to achieve the following objectives:

- Selection of a preferred design concept to partially degrade the existing west levee of the Yolo Bypass at Shag Slough that maximizes flood benefits in the Yolo Bypass while meeting habitat enhancement objectives, and which has negligible adverse effects on the overall hydraulic performance of the system.

- Determination of the design water surface elevation for levee improvements associated with the Project. The 100-year design water surface or the 1957 authorized design profile will be used as the basis of design, whichever is higher.

- Demonstrate that the proposed design concept achieves equal or superior hydraulic performance as the preferred Yolo Bypass improvement concept (Yolo Bypass Option 3) described in the BWFS (DWR, 2016).

Documentation of the hydrologic and hydraulic model development for the respective flood and ecosystem restoration objectives used as to support this analysis have been prepared separately as part of the Project's overall Basis of Design Report documentation (ESA, 2019a and 2019b).

Background

The Project is located within the Cache Slough Complex, in the northwest corner of the Sacramento-San Joaquin Delta in Solano and Yolo Counties. The Cache Slough Complex is considered ideal for tidal restoration by federal and state wildlife agencies as a result of its "connectivity to the Yolo Bypass floodplain, suitable elevations, high turbidity, high primary and secondary productivity, and use by Delta smelt, Chinook salmon, and other native fishes" (CDFW, 2017a).

The Project is bounded to the north by Liberty Island Road, to the east by the Yolo Bypass, to the south by Cache Slough, and to the west by Duck Slough. With the exception of the levee system, land on the Project site ranges between El. -2.0 feet (NAVD 88) and El. 9.0 feet (NAVD 88), and generally slopes from west to east. Precipitation at the site is derived from frontal storms originating from the Pacific Ocean during the primary wet season between the months of October and May. The site receives a mean annual rainfall of approximately 17 inches (Solano County, 1999) and is characterized by poorly drained clay soils, with high runoff potential (USDA, 2018).

Historic Landscape

Up to the early 20th century, the majority of the site was part of the historic tidal tule marsh complex (**Figure 2**) that formed the low-lying southern portion of the Yolo Basin. The upper portions of the Yolo Basin were formed by Holocene basin deposits laid down by the Sacramento River and the two major west side tributaries, Cache Creek and Putah Creek (**Figure 3**). These deposits grade basin-ward into the plains of the north Delta, which is characterized by peat-rich muds (Helley and Harwood, 1983). Flood-basin deposits in this region are typically firm to stiff silty clay, clayey silt, and silt (Atwater, 1982).

The Yolo Basin was largely cutoff from the Sacramento River, except in times when the natural levees along the banks of the river overtopped, similar to flows cresting Fremont Weir today (Opperman et al., 2017). The Yolo Basin received seasonal runoff from the west side tributaries, including Cache Creek and Putah Creek, as well as groundwater seepage from the Sacramento River. These sources, combined with freshwater tidal inundation, fed the historic freshwater tidal marsh and channels where the Project is located (PWA, 2008).

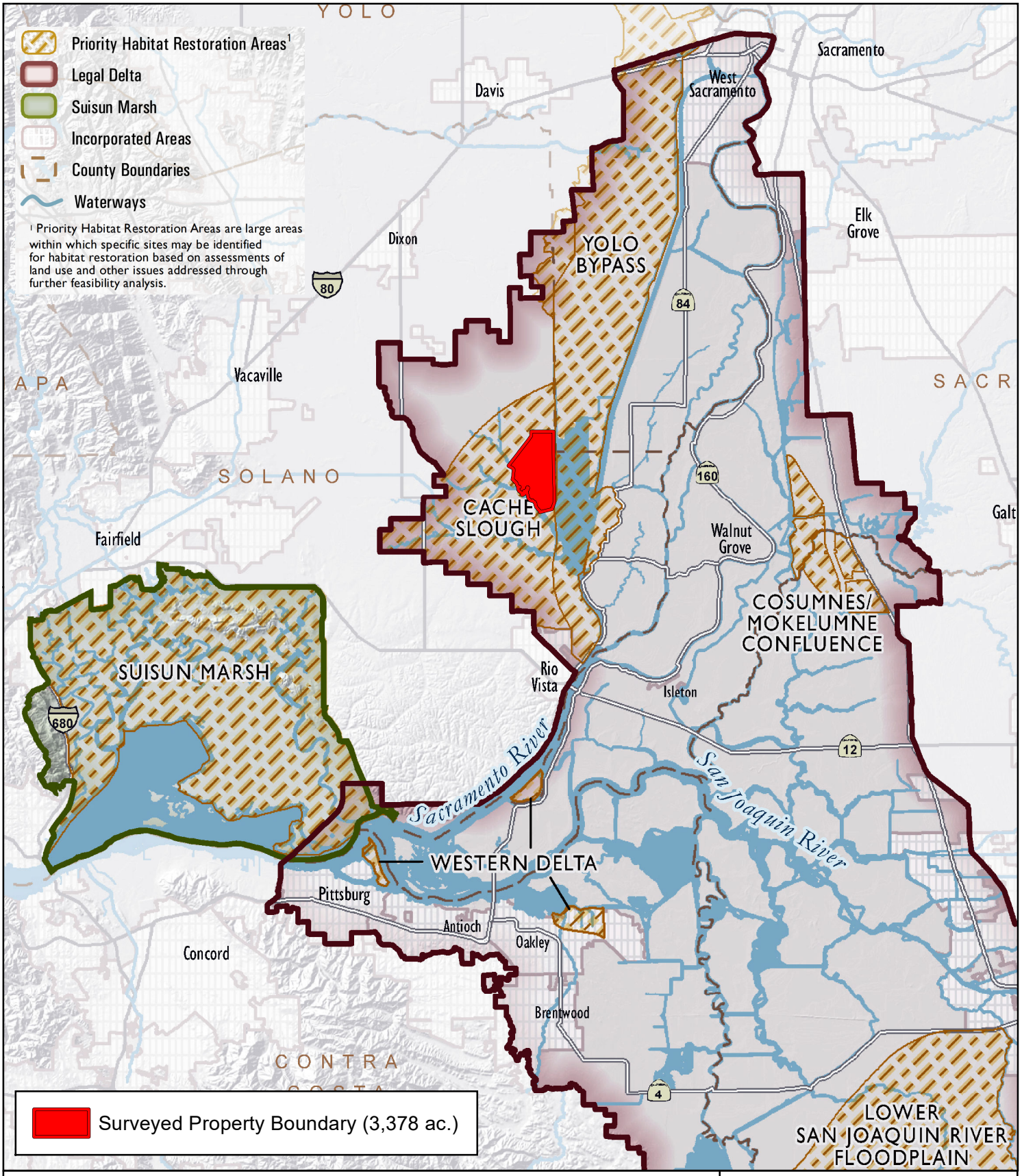

Figure 1
Location Map

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 3 6 12
Miles

Ecosystem Investment Partners

Prepared by: ESA

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
Delta Stewardship Council, 2013

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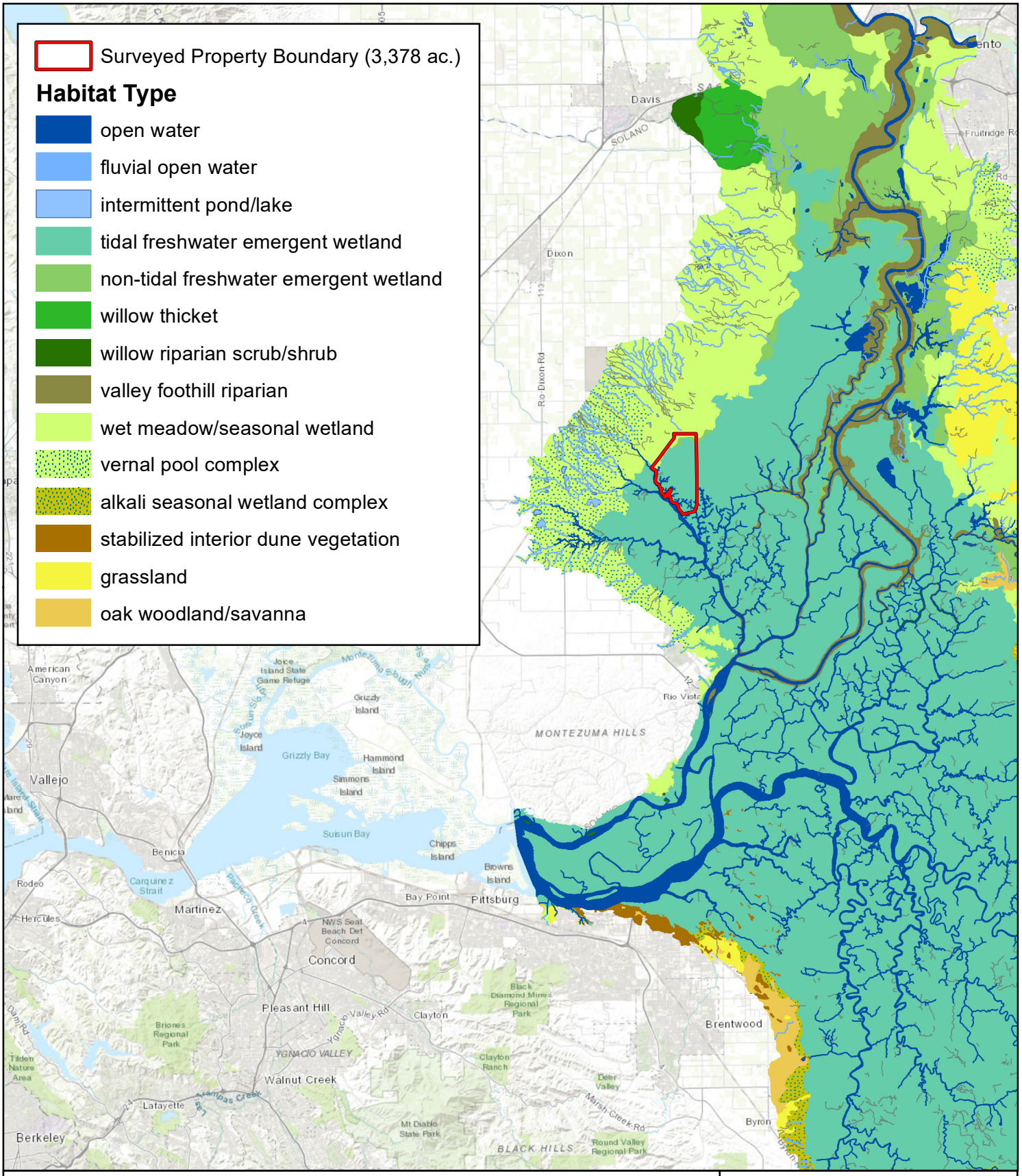

Figure 2
Historical Ecology

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

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S

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Miles

Ecosystem Investment Partners

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
SFEI, 2012

Prepared by: ESA

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Figure 3
Geologic Map of Sacramento-San Joaquin Delta, California

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

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Miles

Ecosystem Investment Partners

Prepared by: ESA

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
Atwater, 1982

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The Project is located in what is understood to have been part of the historic tidally-inundated marsh above Cache Slough. Vegetation on the majority of the Project site was tules (*Scirpus acutus,* also known as Hardstem Bulrush), a dense perennial wetland plant species which historically dominated the marshplains of the region. The density of tules and willows in the region are considered to be one of the reasons that these areas were not carefully surveyed prior to reclamation (Atwater, 1982). The site would have been relatively level, gradually draining southward into Cache Slough, with the marshplain edge dictated by elevation of the highest tides (PWA, 2008). As shown on Figure 2, a network of blind tidal channels formed along the banks of Cache Slough.

Existing Conditions

Beginning in the 1930's and continuing through the 1960's, a series of levee improvements were constructed along the east side of Cache Slough and the west side Yolo Bypass as part of the Sacramento River Flood Control Project (SRFCP) to develop and protect approximately 13,000 acres of agricultural land and associated structures and roads (U.S. Army Corps of Engineers [USACE], 1962). Following repairs in 1962, the southern portion of the original levee system experienced significant subsidence, and in 1986 a plan for a cross levee at the southern limit of the project site was finalized and then constructed by the USACE (URS, 2011 and USACE, 1986). The remnant levee system south of the cross levee was subsequently abandoned and breached in May 1992 by the USACE to create the Cache Slough mitigation area south of the Project (Stevens & Rejmankova, 1995). The existing levee system bounding the Project (**Figure 4**) is currently maintained and operated by Reclamation District (RD) No. 2098.

Until recently, the Project site was managed separately by three primary land owners (**Figure 5**):

- The Vogel Island portion of the project was originally purchased for use as a duck club, but in recent years has been primarily been operated as grazing land for sheep. Historically, the island drained by gravity through a gated outfall structure into Cache Slough. During winter flood season the berms forming the perimeter of Vogel Island often overtop, flooding the property. These same berms prevent flood waters from draining once the island is inundated, creating a condition where water and potentially fish are trapped inside a temporary lake.

- The Bowlsbey Ranch property north and west of Lookout Slough has been operated and managed as irrigated pasture for livestock. The land is irrigated using water pumped from Hass Slough and drains generally from west to east through a network of agricultural ditches to a toe drain that runs parallel to western and northern sides of Lookout Slough, which collects in the southeast corner of the site before ultimately being pumped back to Hass Slough.

- The Liberty Farms property was used for agricultural production for many years before being converted to a duck club circa 2005. Although the northern portion of the property continues to be used for agricultural production, the majority of the site is seasonally flooded and drained through a series of artificial channels to manage vegetation on the duck club. The property is seasonally flooded using water sourced from Cache Slough and is drained via pumping to Shag Slough.

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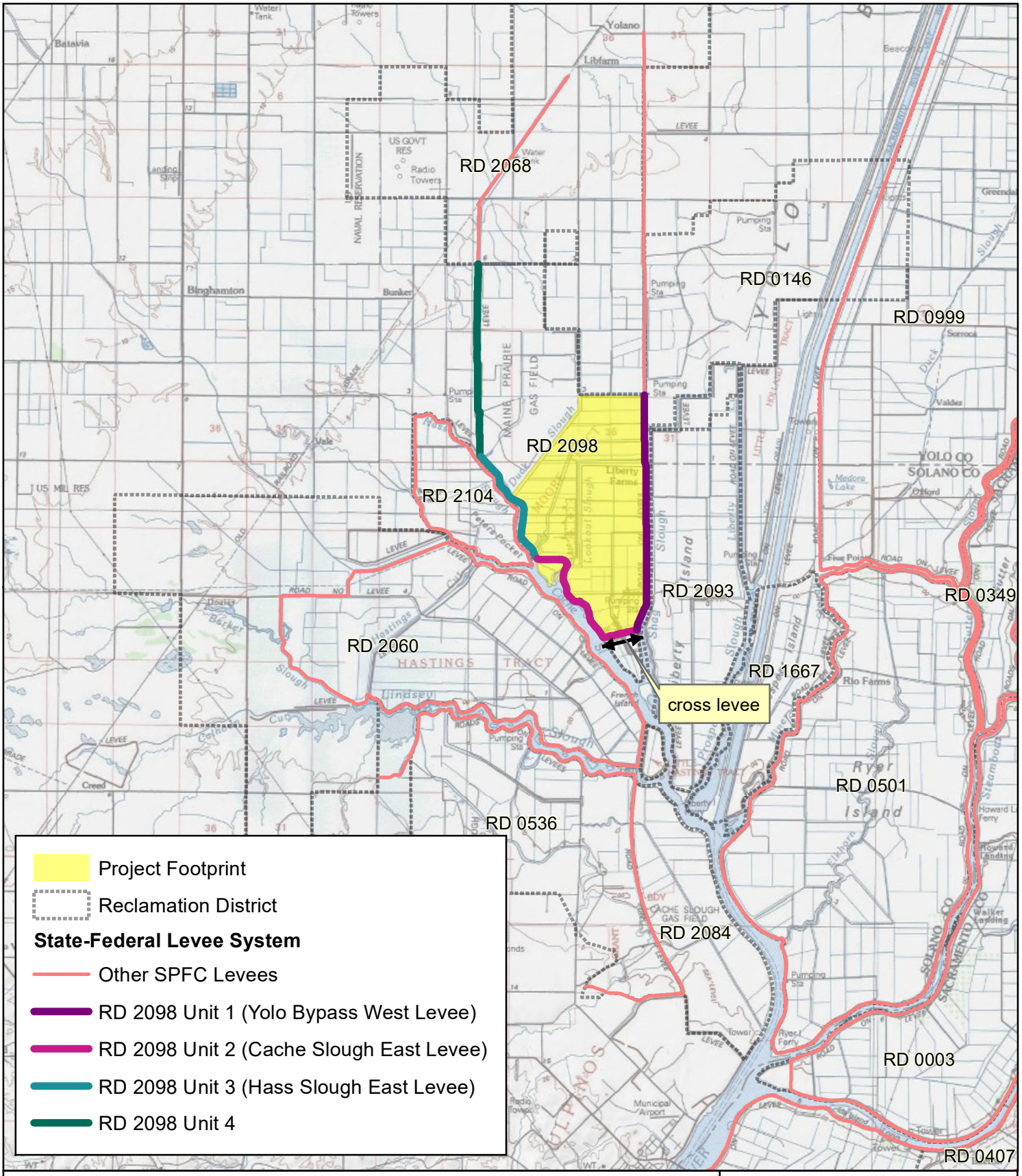

Figure 4
Existing Levee System

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 1 2
Miles

Ecosystem Investment Partners

Map Prepared Date: 4/28/2019
Map Prepared By: Brent Davis
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
CA Levee Database, CBI, DWR
ESRI Surface Layers

Prepared by: ESA

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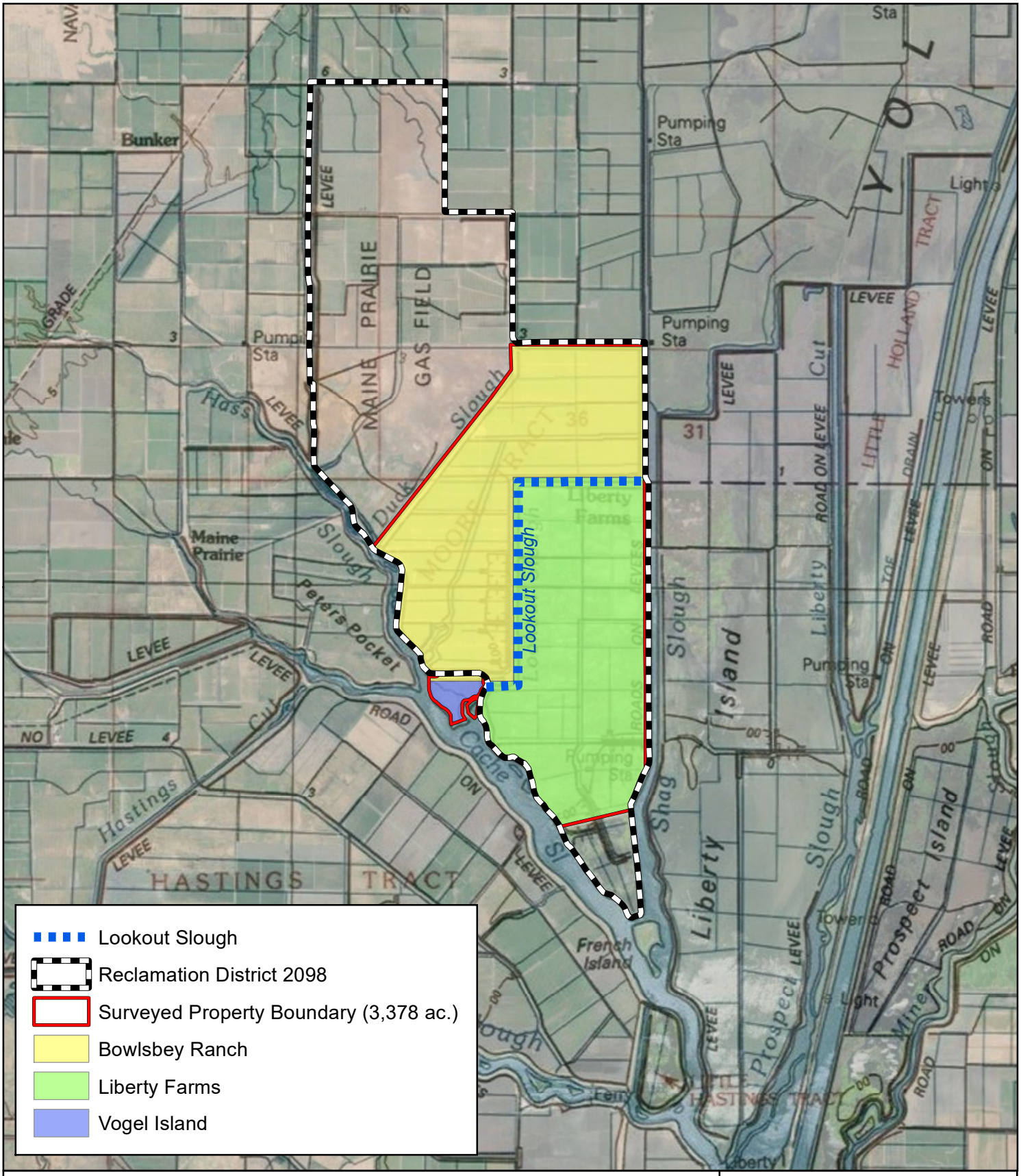

Figure 5
Land Ownership

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Prepared by: ESA

Map Prepared Date: 4/28/2019
Map Prepared By: JPritchard
Base Source: Wood Rogers
Base Date: 10/24/2017
Data Source(s):

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F05_Property_Boundaries.mxd

The State-Federal levee system ensures that the Project land is currently inaccessible to fishes, including Delta smelt, green sturgeon, Central Valley Spring Run Chinook salmon, Sacramento River Winter-run Chinook salmon, Central Valley steelhead, and longfin smelt, except during winter runoff events which periodically flood the Vogel Island tract.

The Project will establish tidal hydraulic connectivity to all three pieces of land by breaching the levees at Cache Slough and at the Yolo Bypass along Shag Slough. The existing pumping and irrigation channel network will be decommissioned and replaced with a network of tidal channels which will allow the site to flood and drain by gravity with the tides. In doing so, the Project will have a continuous supply of fresh water and suspended sediment which will promote establishment of a mosaic of subtidal, intertidal, and uplands habitat types.

Construction of the habitat restoration components of the Project necessitates alteration of the State-Federal levee system. To maintain the existing level of flood protection for lands north of the Project (RD 2068) and lands west of the Project (RD 2098), a new setback levee will be constructed along the northern and western boundaries of the project. The Project will also increase the conveyance capacity in this part of the Yolo Bypass, consistent with DWR's regional planning objectives (DWR, 2016).

Engineering Circular 1165-2-220 (USACE, 2018) states that any project proposing to alter a federal project in any way "*must not be injurious to the public interest or affect the USACE project's ability to meet its authorized purpose*." If that can be shown, then the Project can receive a Section 408 Permit before construction begins.

Two of the alterations to be made as part of the Project classify the Project as falling under jurisdiction of Section 408:

1. Breaching and degrading the existing west (right) levee of the Yolo Bypass between Liberty Island Road and the southern end of Liberty Farms.

2. Breaching of the existing east (left) levee of Cache Slough near the terminus of Lookout Slough, and re-operation of the remnant east (left) Cache Slough and Hass Slough embankments as training levees.

Project Datums

All data for the project is referenced to the North American Datum of 1983 (NAD 83) and the California State Plane II (feet) coordinate system. All vertical elevations described in this report are referenced to the North American Vertical Datum of 1988 (NAVD 88) and are reported in units of feet.

Hydraulic Design Criteria

The project design concept screening criteria was developed iteratively through engagement between EIP's project delivery team, DWR staff, and members of the Lower Sacramento River/Delta North Regional Flood Management Plan Workgroup including the Sacramento Area Flood Control Agency (SAFCA), Solano County, the Solano County Water Agency (SCWA),

RD 2060, RD 2068, and RD 2098. A summary of the criteria used for designing and modifying the Project flood management features follows below.

Existing State-Federal Project Levee System

The existing State-Federal levee system bounding the Project includes the west levee of the Yolo Bypass (RD 2098 Unit 1) bordering Shag Slough, the cross levee and Cache Slough east levee (both of which compose RD 2098 Unit 2), and the Hass Slough east levee (RD 2098 Unit 3). With the exception of the cross levee (USACE, 1986), the existing system was designed and constructed in 1961 by the USACE as part of the Sacramento River Flood Control Project (SRFCP [USACE, 1962]). The west levee of the Yolo Bypass was originally designed and constructed with a crest six feet above the 1957 design water surface profile (1957 Profile), and the levees along Cache Slough and Hass Slough were constructed with a crest at least three feet above the 1957 design water surface profile (USACE, 1962). The 1957 Profile is based on specified design discharges (not tied to a recurrence frequency) and adopted concurrent conditions at confluences of study streams (USACE, 1993). The 1957 Profile reflects revisions made up to and during design of the SRFCP, as agreed upon by the Reclamation Board (now the Central Valley Flood Protection Board), the State of California, and the USACE, as published in "Levee and Channel Profiles, Sacramento River Flood Control Project," dated March 15, 1957. In this portion of the Yolo Bypass, the 1957 profile was based on flow extents and durations from the 1907 and 1909 floods (DWR, 2016, U.S. House, 1917), which established the authorized design flow of 490,000 cfs.

The six-foot freeboard criterion along the west levee of the Yolo Bypass provides a factor of safety for both flood stage and run-up from wind-generated waves in the Yolo Bypass. Historically, wind waves can grow to four feet or more during large storm events due to the combination of long fetch lengths in the Yolo Bypass and strong sustained winds (DWR, 2016).

Levee Design Height

The Project design will conform to the latest Central Valley Flood Protection Board (CVFPB), USACE, and Federal Emergency Management Agency (FEMA) standards, methods, procedures, and policies for levee design including the following:

- *California Code of Regulations, Title 23, § 120 – Levees*
- *USACE Engineering Manual No. 1110-2-1913 – Engineering and Design – Design and Construction of Levees*
- *USACE, Design Guidance for Levee Under-Seepage, ETL 1110-2-569, May 1, 2005*
- *Code of Federal Regulations, Title 44. § 65.10 – Mapping of Areas Protected by Levee Systems*

In 2007, the California Legislature passed several bills adding to and amending State flood management and land use laws. As part of this legislation, cities and counties within the Sacramento-San Joaquin Valley are required to make a Finding related either to an urban level of flood protection (defined as a 1-in-200 chance event) or to the FEMA standard of flood protection before: 1) entering into a development agreement within a flood hazard zone; 2) approving a

discretionary permit or entitlement of any property development or use that is located in a flood hazard zone; or 3) approving a tentative map/parcel map for a subdivision that is located in a flood hazard zone (California Government Code Sections 65865.5, 65962, and 66474.5). These requirements apply to protecting "urban or urbanizing" areas as defined by California Government Code Section 65007 paragraphs (j) and (k). "Urban" and "urbanizing" areas are defined as those areas with a population greater than 10,000, or that will have a population greater than 10,000 within 10 years, respectively (DWR, 2012). Since the alterations proposed by the Project will not affect any urban or urbanizing areas, this criterion does not apply. Outside of urban or urbanizing areas within the Central Valley, the 1% ACE (100-year) water surface elevation is generally used as the basis for design. The Project will use the 1% ACE (100-year) water surface elevation or the authorized 1957 design profile, whichever is higher.

When establishing the design elevation of the levee crown, factors of safety are added to the design water surface elevation to account for uncertainty, climate change and sea-level rise, as well as to provide system resiliency.

Design Water Surface Profile

Wood Rodgers, Inc. (Wood Rodgers) is preparing the civil design of the Project and has reviewed criteria being used by DWR for the design of the Lower Elkhorn Basin Levee Setback (LEBLS) Project, a similar non-urban setback levee proposed along the east levee of the Yolo Bypass north of the confluence with the Sacramento Bypass. The design water surface used in the LEBLS project is based on a 100-year design water surface computed using Central Valley Hydrology Study (CVHS) hydrology (1997 storm pattern with 95% scaling) developed during the Basin-Wide Feasibility Study (BWFS) for the Sacramento River Basin recently prepared by DWR as part of the 2017 Central Valley Flood Protection Plan (CVFPP). For the LEBLS Project, DWR has also provided six feet of freeboard, consistent with the levee design in the Sutter and Yolo Bypasses. As part of the LEBLS design, DWR added an additional one foot of freeboard for resiliency to address future effects of climate change, for a total of seven feet of freeboard above the design water surface elevation. For purposes of the current Project, the 1957 authorized design or the 1% ACE (100-year) water surface will be used as the basis for design, whichever is higher. In addition to the minimum required six feet of freeboard, an additional 1 foot of freeboard will be included for climate resiliency. Although this is a more conservative approach than required by the CVFPB and the USACE, it is consistent with DWR flood planning objectives for the region.

10% ACE (10-year) Design Water Surface Elevation

Once approved and constructed, the project would restore full tidal range to as much of the site as possible. This would be accomplished by breaching the existing levee system to establish connectivity to the diurnal tidal signal. It is anticipated that this connection between waterways and the adjacent floodplain would result in some attenuation during higher frequency storm events. To further improve floodplain connectivity during larger events (equal or greater than 10% ACE, or 10-year flows) and further increase capacity in the Yolo Bypass, portions or all of the west (right) bank levee of the Yolo Bypass along Shag Slough could be degraded to the elevation of the 10% ACE (10-year) design event.

Authorized Design Flow (1957 Profile)

The 1957 authorized design capacity of this portion of the Yolo Bypass is 490,000 cfs (USACE, 1957). The resultant design water surface profile establishes the minimum design height of the Project levee system. At the northeastern corner of the Project, the design water surface of the 1957 Profile at the west (right) bank levee of the Yolo Bypass is approximately El. 20.6 feet (NAVD 88) (USACE, 1957 and Atkins, 2013). At the southeastern corner of the project, the design water surface at the west (right) bank of the Yolo Bypass is approximately El. 18.6 feet (USACE, 1957 and Atkins, 2013).

1% ACE (100-year) Design Water Surface Elevation

To establish the design height of the levee, the Project performance for the 1% ACE (100-year) design flow was evaluated. The resultant water surface elevation was compared with the authorized design (1957 Profile), and the higher of the two was used to establish the design height for the Project flood management features. This approach is conservative and ensures consistency with DWR's planning objectives for rural and non-urban areas (DWR, 2017a).

Table 1 summarizes the Project design flows and downstream tailwater assumptions used in the analysis.

TABLE 1
BOUNDARY CONDITION SUMMARY (PEAK FLOW AND STAGE SUMMARY)

Source	HEC-RAS Cross-Section Handoff Designation	1957 Authorized Design Flow and Profile	Baseline Condition		Future Cumulative Condition	
			1997 Pattern 40% Scaling 10% ACE (10-year)	1997 Pattern 95% Scaling 1% ACE (100-year)	1997 Pattern 40% Scaling 10% ACE (10-year)	1997 Pattern 95% Scaling 1% ACE (100-year)
Yolo Bypass	YOL R03 RM 30.494	490,000 cfs	206,944 cfs	489,525 cfs	242,064 cfs	472,014 cfs
Sacramento River Deep Water Ship Channel	SAD R01 RM 20.254	N/A	1,063 cfs	14,984 cfs	1,935 cfs	18,255 cfs
Hass Slough	HAS R01 RM 2.111	N/A	169 cfs	1,965 cfs	177 cfs	2,546 cfs
Cache Slough	CAS R04 RM 25.486	N/A	118 cfs	2,535 cfs	129 cfs	993 cfs
Miner Slough	MIN R01 RM 5.908	10,000 cfs	10,687 cfs	18,125 cfs	10,627 cfs	12,559 cfs
Lindsey Slough	LIN R01 RM 2.354	N/A	541 cfs	2,826 cfs	569 cfs	4,713 cfs
Steamboat Slough	STM R01 RM 1.968	43,500 cfs	25,657 cfs	35,508 cfs	25,801 cfs	30,970 cfs
Sacramento River (Inflow)	SAC R05 RM 16.790	35,900 cfs	40,444 cfs	47,130 cfs	40,596 cfs	41,490 cfs
Sacramento River (Downstream Stage, NAVD 88)	SAC R04 RM 9.742	11.51 feet	9.13 feet	10.11 feet	8.94 feet	10.24 feet

Hydraulic Impact Considerations

If approved, alteration of the State-Federal levee system would change hydrologic and hydraulic conditions in the Yolo Bypass and Cache Slough Complex. Recognizing this, the analysis includes considerations to ensure that any increases to water surface elevation, velocity, wind-wave, or other hydraulic effects are negligible. Areas identified as sensitive to the Project performance during flood conditions are identified below.

Impacts to the Yolo Bypass

The Project seeks to reduce flood stages in the Yolo Bypass by setting back the existing west (right) bank levee of the Yolo Bypass between Liberty Island Road and the southern boundary of the Project, thereby increasing the overall conveyance corridor width and floodplain storage during large flood events. The Project seeks to maximize resultant stage reductions in this part of the Yolo Bypass without adversely impacting other parts of the system.

Impacts to Cache Slough and Hass Slough

The adjacent levee systems along the west banks of Cache Slough and Hass Slough lack freeboard and suffer from deferred maintenance. This makes them particularly vulnerable to increases in water level, erosion, or wind-wave run-up. One important component of the habitat enhancement objectives of the Project includes establishing hydraulic connectivity between the restored marsh habitat and Cache Slough through a breach of the existing Cache Slough levee. The Project design objectives include sizing the opening to avoid raising water levels in Cache Slough and Hass Slough more than 0.01 feet and designing the opening to remain stable over time.

Impacts to Downstream Areas, including Rio Vista

The city of Rio Vista is vulnerable to flooding from the Sacramento River and the Yolo Bypass. The city receives modest flood protection from an existing floodwall that extends from the dock at the end of Montezuma Street to just north of Main Street. This floodwall was overtopped in 1986 and was subsequently raised. Since the raising, the floodwall has not been overtopped by a flood event. However, downtown Rio Vista regularly experiences flooding from minor storm events and high tides (Flood Protect, 2014).

Elevated water stages resulting from a 10-year flood event in the Sacramento River also overtop the west bank of the Sacramento River upstream of State Highway 12 and flow through the highway underpass, thereby effectively flanking the existing floodwall and flooding downtown Rio Vista. During these high water events, businesses upstream of State Highway 12 are forced to close until floodwaters recede, since flooding along State Highway 84 makes the businesses inaccessible.

The project will alter the hydraulics of the Cache Slough Complex during a large flood. Although these changes are assumed to be beneficial due to attenuation of the flood wave in the overbank areas of the Project site, care must be taken to keep water levels from increasing in the vicinity of Rio Vista.

System Performance Assumptions

The proposed project alterations are being evaluated relative to the Baseline Condition, as well as the Future Cumulative Condition Baseline scenarios described below. Per USACE EC 1165-2-220, Appendix F, Section F-3.f (USACE, 2018), all project features are assumed to be stable and functional to the top of containment (USACE, 2018) in this analysis. Levees are not assumed to breach or otherwise malfunction in the analysis of pre- and post-project conditions. Levees are allowed to overtop and spill water to storage areas adjacent to levees, without failing. The Project also is assumed to be stabilized to the authorized condition, and based on this assumption, fragility curves are not required.

Levees of the SPFC that do not meet the minimum project standard have been modeled as meeting the minimum authorized height (i.e., the 1957 design profile). Where existing top of levee heights exceed the authorized height, they are modeled as such (DWR, 2017b). These assumptions reflect the ability of upstream projects to engage in maintenance and provide a conservative estimate of flow delivery in the area of interest. This approach is consistent with the assumptions used for LEBLS and similar projects in the region.

Baseline Condition for Design

The Baseline Condition modeling of the 1% ACE (100-year) design flow assumes the following Early Implementation Projects (DWR, 2017b):

- American River Common Features Project WRDA 96/99 sites
- Folsom Dam Joint Federal Project (JFP) – including water control manual updated considering forecast-based operations as of August 19, 2016
- Marysville Ring Levee
- Sutter Basin Project – Feather River West Levee Project
- Three Rivers Levee Improvement Project (TRLIA)
- Natomas Levee Improvement Project (NLIP)
- West Sacramento 2016 sites (Southport Levee Improvement Project)
- Hamilton City – Phase 1
- Star Bend (SBFCA)
- Bear River

Future Cumulative Condition

The Future Cumulative Condition scenario builds upon the assumptions in the Baseline Condition, and reflects full build-out of the elements of the recommended Yolo Bypass expansion option (Yolo Bypass Option 3) described in the BWFS (DWR, 2016) and reproduced on **Figure 6**. This option is being evaluated for purposes of demonstrating that the proposed design

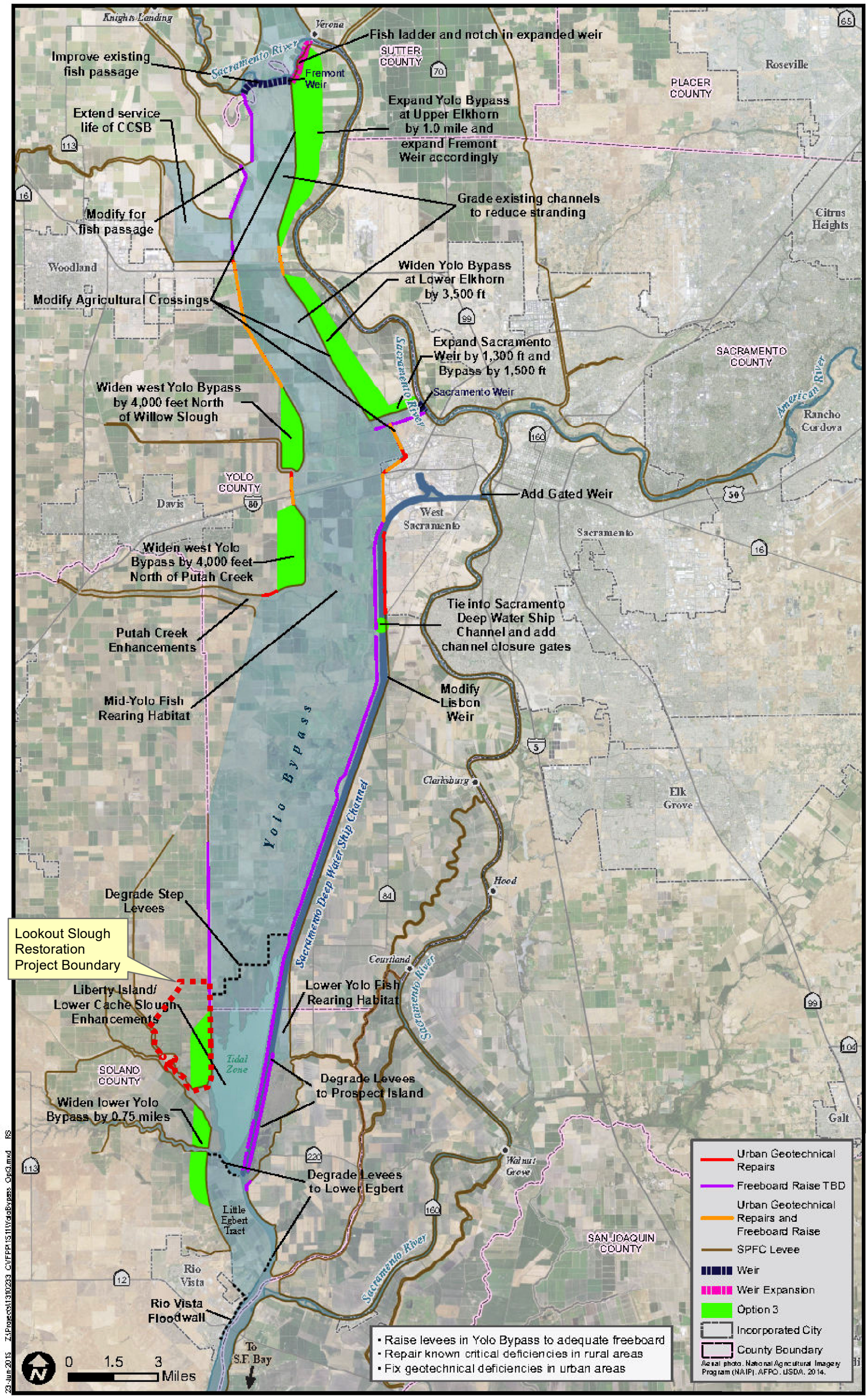

Figure 6
Future Cumulative Condition (BWFS Yolo Bypass Option 3)

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Prepared by:
ESA

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Map Prepared Date: 4/28/2019
Map Prepared By: JPritchard
Base Source: Wood Rogers
Base Date: 10/24/17
Data Source(s): DWR, 2016

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F07_BWFS_YB3.mxd

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concept achieves equal or superior performance relative to the Yolo Bypass improvement concept described in the BWFS. The Future Cumulative Condition includes implementation of the following features:

- **Upper Elkhorn and Fremont Weir Expansion** – a one-mile expansion of the Upper Elkhorn Basin with a corresponding expansion of Fremont Weir
- **Lower Elkhorn Expansion** – a 3,500-feet levee setback along the Lower Elkhorn Basin
- **Sacramento Weir and Bypass Expansion** – a 1,500-feet expansion of the Sacramento Weir and Bypass
- **Cache Creek Settling Basin** – measures to extend useful life of the Cache Creek Settling Basin and address concerns regarding mercury in its sediment
- **Levee Setback Near Willow Slough Bypass** – a 4,000-feet levee setback on the west side of the bypass north of Willow Slough and south of I-80
- **Levee Setback Near Putah Creek** – a 5,000-feet levee setback on the west side of the Yolo Bypass north of Putah Creek
- **Tie-in to Sacramento River Deep Water Ship Channel** – a gated weir to tie into the Sacramento River Deep Water Ship Channel and a closure structure to prevent high stages from reaching West Sacramento
- **Degradation of Step Levees and Lower Egbert Track Levees** – degrading remaining levee segments in the lower Yolo Bypass at the north end of Little Holland Tract and Liberty Island and degrading portions of the Lower Egbert Track (RD 2084) levees.
- **Lower Yolo Bypass Setback** – levee setback south of RD 2068 to Rio Vista, including removal of cross levee at southern boundary of RD 2098)
- **Build Weirs on Prospect Island Levee** – build weirs along portions of the Prospect Island west levee
- **Improved Flood Protection for Rio Vista and Highway 84** – flood protection improvements for the city of Rio Vista to address potential hydraulic impacts of Yolo Bypass capacity improvements
- **Fix-in-place Levee Improvements** – provide six feet of freeboard over the estimated 200-year flood flows (represented by the 110-percent scaling of the 1997 storm pattern)
- **Geotechnical Levee Improvements** – fix any remaining geotechnical inadequacies for urban areas unaddressed in the future baseline condition and fix known critical geotechnical deficiencies for rural and small communities.

Project Hydraulic Optimization

Analysis was performed to evaluate the proposed modifications to the existing levee system to balance maximizing flood risk reduction and habitat benefits while minimizing costs associated with long term operations and maintenance, construction cost, and environmental impacts. In general, flood risk reduction in the Yolo Bypass and habitat uplift on the Project site increases as the west levee of the Yolo Bypass is increasingly degraded. However, construction costs and environmental impacts also increase with levee degradation, but not necessarily at the same rate as the benefits. Depending on how the project is configured, the potential to adversely impact stages in Hass Slough and Cache Slough must also be considered. Additional constraints related to hydraulic performance include ensuring the Project meets or exceeds the performance of the Yolo Bypass Option 3 configuration described in the BWFS.

Optimization Objectives

The optimization analysis was conducted with the following objectives in mind:

1. Determine the configuration of the levee system around the project that would maximize flood benefits

2. Determine if direct hydraulically connectivity between the Project habitat features and Cache Slough is possible, via levee breaching or degradation, while minimizing adverse impacts offsite.

3. Minimize earthwork and offsite impacts

Variables and Constraints

The hydraulic performance of the Project will depend primarily on where and how much the levee degradation and breaching is configured. Parameters determined to be constrained by the optimization process relate to water levels offsite at specific index locations and earthwork volumes. The Project's hydraulic influence on water levels in the system is generally localized, and so attention during the optimization analysis was focused at index point locations near the site including the Yolo Bypass, Cache Slough, and Hass Slough. The water levels at these locations are considered to be the parameters that would be constrained during the optimization process. Concept Plans must perform equal to or better than the Yolo Bypass Option 3 concept in the Yolo Bypass (lowering water levels at the north end of the Project by at least 0.16 feet), without significantly raising water levels in the Cache Slough and Hass Slough (increases limited to 0.04 feet).

Optimization Process

Project optimization was achieved using a phased approach. The first phase consisted of identifying individual components of the existing State-Federal levee system that might be altered to achieve the habitat and flood improvement objectives of the Project. Recognizing that it would be impractical to evaluate all possible combinations of modifications identified in the project component matrix, the second phase involved iterative development of a focused array of

alternatives. The third phase involved analyzing the focused array of alternatives to determine the optimal project based on the constrained variables and evaluating the sensitivity of each variable.

Project Component Matrix

Six modular project components were identified as potential alterations to the State-Federal levee system by EIP's project delivery team and DWR (**Figure 7**):

A. A new setback levee along the west and north sides of the Project area

B. Modification to the west (right bank) levee of the Yolo Bypass between the northern boundary of the Project and the Yolo/Solano County line

C. Modification to the west (right bank) levee of the Yolo Bypass between the Yolo/Solano County line and the southwestern corner of the project (where the west levee of the Yolo Bypass meets the Cross Levee).

D. Breach of the east (left bank) levee of Cache Slough near the southern terminus of Lookout Slough

E. Modification of east (left bank) levee of Cache Slough below Vogel Island

F. Modification of the Cross Levee

The project component matrix was used as a tool to develop conceptual alternatives by alteration of these modular components to various degrees (i.e., partial vs. full levee degrades) and in combination with one another. EIP's project delivery team developed an array of focused alternatives iteratively using engineering judgment and engaging with DWR and members of the Lower Sacramento River/Delta North Regional Flood Management Plan Workgroup including the Sacramento Area Flood Control Agency (SAFCA), Solano County, the Solano County Water Agency (SCWA), RD 2060, RD 2068, and RD 2098. **Table 2** summarizes the array of design concept plans and how each component would be implemented for each of the specific alternatives.

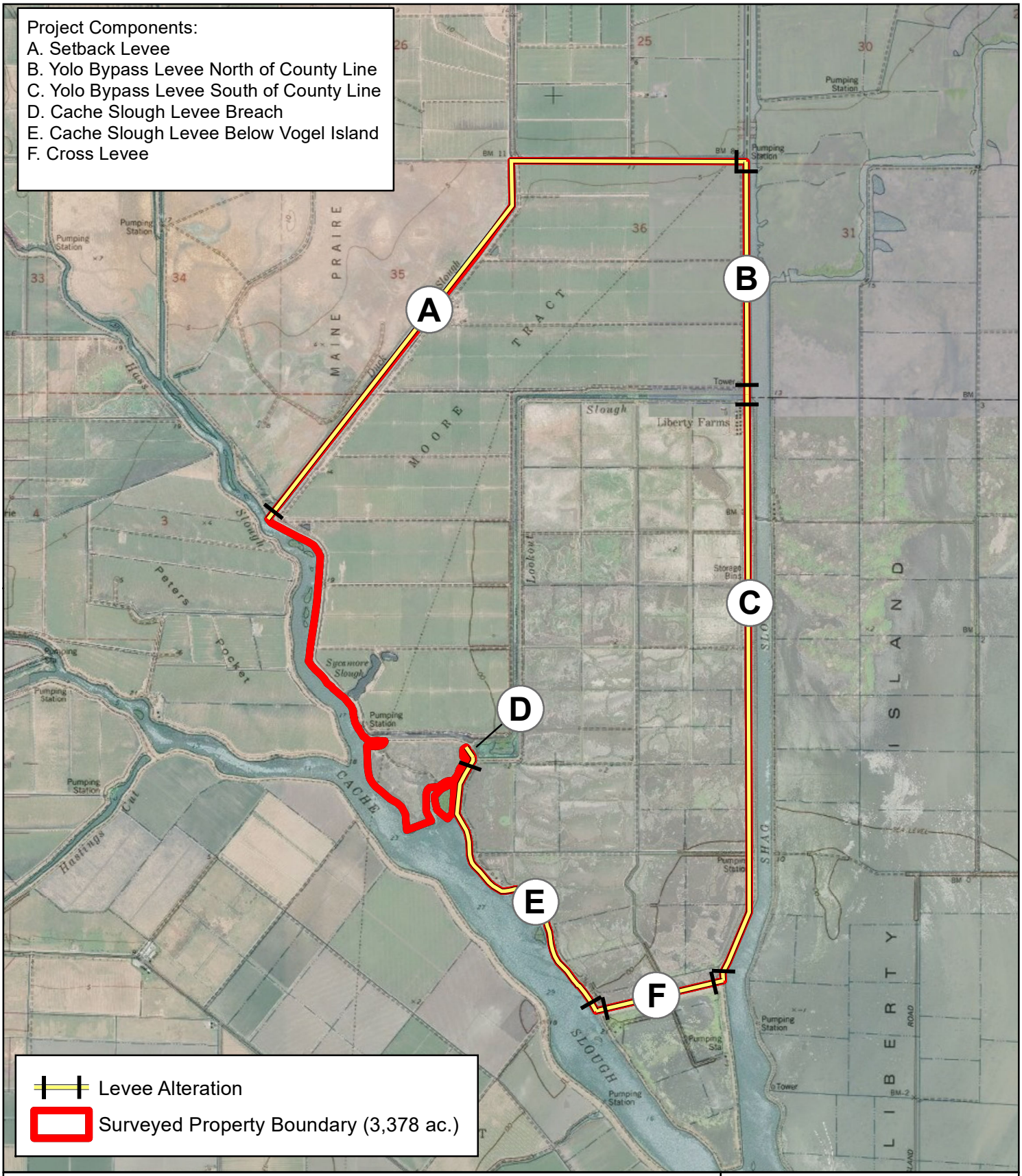

Figure 7
Project Concept Components

N
W E
S

Ecosystem Investment Partners

Prepared by: ESA

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 0.25 0.5 1
Miles

Map Prepared Date: 4/28/2019
Map Prepared By: JPritchard
Base Source: Wood Rogers
Base Date: 10/24/2017
Data Source(s):

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TABLE 2
DESIGN CONCEPT PLAN ARRAY – SUMMARY OF PROJECT COMPONENTS

Concept Plan	Project Component					
	A Setback Levee	B Yolo Bypass Levee North of County Line	C Yolo Bypass Levee South of County Line	D Cache Slough Levee Breach	E Cache Slough Levee Below Vogel Island	F Cross Levee
1	✓		●			●
2	✓		○			○
3	✓		○	✓		○
4	✓		●	✓	●	●
5	✓	●	●			●
6	✓		○	✓		○
7[a]	✓		●			
8[a]	✓		○			
9[a]	✓	○	●			
10[a]	✓		○	✓		
11	✓	○	○	✓		
12[b]	✓	○	○	✓		
13[b]	✓	○	○	✓		
14	✓			✓		
15	✓[c]		●			●

NOTES:
a. Project Concept Plans 7 through 10 were not evaluated separately under the Future Cumulative Condition as their geometry configurations duplicate Project Concept Plans 1, 2, 5, and 6, respectively (due to the degradation of the cross levee in the Future Cumulative Condition Baseline scenario).
b. Project Concept Plans 12 and 13 are similar to Concept Plan 11, but features reduced degrade sections
c. Project Concept Plan 15 reflects the setback Yolo Bypass Option 3 levee alignment shown in the BWFS. Note that this option is not evaluated separately in the Future Cumulative Condition as it is part of the Future Cumulative Condition baseline.

● = fully degrade (vertically) the existing embankment to the landside toe of the existing levee

○ = partially degrade (vertically) the top of the existing embankment to match the 10-year design water surface elevation in the Yolo Bypass

Design Concept Plan Array

Fourteen design concept plans were evaluated, all of which would require construction of a new setback levee on the northwest side of the property, and grading on the interior of the site to create a network of tidal channels and marshplain habitat. Each of the concepts would also require breaching of portions of the west levee of the Yolo Bypass to establish diurnal tidal exchange with the proposed tidal marsh habitat. This section provides a brief description of the unique design features and levee alterations associated with each of the respective concept plans.

Concept Plan 1

Concept Plan 1 proposes to fully degrade the Yolo Bypass west levee south of the Yolo/Solano County line, as well as fully degrade the Cross Levee. This would connect the southern portion of

the site to the Yolo Bypass, and further enhance connectivity to the Yolo Bypass during the winter and spring storm seasons. This concept plan would provide habitat connectivity to Shag Slough on the west side of the Yolo Bypass and the Cache Slough Mitigation area south of the Cross Levee.

Concept Plan 2

Concept Plan 2 proposes to partially degrade the Yolo Bypass west levee south of the Yolo/Solano County line, as well as partially degrade the Cross Levee. The alterations to the existing levees at both locations would consist of degrading the tops of the existing levees to match the 10-year design water surface elevation. During floods in excess of a 10-year design event, these embankments would overtop and function as weirs, providing additional hydraulic connectivity between the Project site and Yolo Bypass during high water events. This concept plan would provide habitat connectivity to Shag Slough on the west side of the Yolo Bypass.

Concept Plan 3

Concept Plan 3 is similar to Concept Plan 2 with respect to modifications of the west levee of the Yolo Bypass and the Cross Levee. Although functionally similar to Concept Plan 2, this concept plan would add a 450-foot wide levee breach at Cache Slough near the southern terminus of Lookout Slough. This concept plan would provide habitat connectivity to Shag Slough on the west side of the Yolo Bypass, as well as to Cache Slough.

Concept Plan 4

Concept Plan 4 proposes to fully degrade the Yolo Bypass west levee south of the Yolo/Solano County line, fully degrade the Cross Levee, as well as fully degrade the east levee of Cache Slough downstream of the southern terminus of Lookout Slough. This would connect the southern portion of the site to the Yolo Bypass and Cache Slough, and further enhance connectivity to the Yolo Bypass and Cache Slough during the winter and spring storm seasons. This concept plan would provide habitat connectivity to Shag Slough on the west side of the Yolo Bypass, the Cache Slough Mitigation area south of the Cross Levee, as well as to Cache Slough itself.

Concept Plan 5

Concept Plan 5 is similar to Concept Plan 1 with respect to modifications of the west levee of the Yolo Bypass and the Cross Levee. Although functionally similar to Concept Plan 1, this concept plan would include fully degrading the west levee of the Yolo Bypass between the Yolo/Solano County line and Liberty Island Road at the tie-in between the proposed setback levee and the west levee of the Yolo Bypass maintained by RD 2068. This concept plan would provide habitat connectivity to Shag Slough on the west side of the Yolo Bypass and the Cache Slough Mitigation area south of the Cross Levee.

Concept Plan 6

Concept Plan 6 is similar to Concept Plan 3 with respect to modifications of the west levee of the Yolo Bypass and the Cross Levee. Although functionally similar to Concept Plan 3, this concept plan would reduce the width of the proposed levee breach at Cache Slough near the southern

terminus of Lookout Slough to 100 feet. This concept plan would provide habitat connectivity to Shag Slough on the west side of the Yolo Bypass, as well as to Cache Slough.

Concept Plan 7

Concept Plan 7 proposes to fully degrade the Yolo Bypass west levee south of the Yolo/Solano County line. This would connect the southern portion of the site to the Yolo Bypass and further enhance connectivity to the Yolo Bypass during the winter and spring storm seasons. This concept plan would provide habitat connectivity to Shag Slough on the west side of the Yolo Bypass.

Concept Plan 8

Concept Plan 8 proposes to partially degrade the Yolo Bypass west levee south of the Yolo/Solano County line. Alteration of the existing levee would consist of degrading the top of the existing levees to match the 10-year design water surface elevation in the Yolo Bypass. During floods in excess of a 10-year design event, the embankment would overtop and function as a weir, providing additional hydraulic connectivity between the Project site and Yolo Bypass during high water events. This concept plan would limit habitat connectivity to Shag Slough on the west side of the Yolo Bypass.

Concept Plan 9

Concept Plan 9 proposes to fully degrade the Yolo Bypass west levee south of Liberty Island Road. This would connect the western portion of the site to the Yolo Bypass and further enhance connectivity to the Yolo Bypass during the winter and spring storm seasons. This concept plan would limit habitat connectivity to Shag Slough on the west side of the Yolo Bypass.

Concept Plan 10

This concept plan is similar to Concept Plan 8 in that it proposes to partially degrade the Yolo Bypass west levee south of the Yolo/Solano County line. Alteration of the existing levee would consist of degrading the top of the existing levees to match the 10-year design water surface elevation in the Yolo Bypass. During floods in excess of a 10-year design event, the embankment would overtop and function as a weir, providing additional hydraulic connectivity between the Project site and Yolo Bypass during high water events. This concept plan would also include a 100-foot wide breach of the Cache Slough levee near the terminus of Lookout Slough. This concept plan would provide habitat connectivity to Shag Slough on the west side of the Yolo Bypass as well as Cache Slough.

Concept Plan 11

This concept plan is similar to Concept Plan 10 in that it proposes to partially degrade the Yolo Bypass west levee, but would also include degrading the levee north of the County line up to Liberty Island Road. Alteration of the existing levee would consist of degrading the top of the existing levees to match the 10-year design water surface elevation in the Yolo Bypass. During floods in excess of a 10-year design event, the embankment would overtop and function as a weir, providing additional hydraulic connectivity between the Project site and Yolo Bypass during high water events. This concept plan would also include a 100-foot wide breach of the Cache Slough

levee near the terminus of Lookout Slough. This concept plan would provide habitat connectivity to Shag Slough on the west side of the Yolo Bypass as well as Cache Slough.

Concept Plan 12

This concept plan is similar to Concept Plan 11 in that it proposes to partially degrade the Yolo Bypass west levee, and would also include degrading the levee north of the County line up to Liberty Island Road. Alteration of the existing levee would consist of degrading the top of the existing levees in two 3,500-foot sections (one at the north end of the project as an inlet weir, and a second to the south to serve as an outlet weir). Each of the degraded sections would be lowered to match the 10-year design water surface elevation in the Yolo Bypass. During floods in excess of a 10-year design event, these portions of the embankment would overtop and function as weirs at the inlet and outlet of the site, providing additional hydraulic connectivity between the Project site and Yolo Bypass during high water events. This concept plan would also include a 100-foot wide breach of the Cache Slough levee near the terminus of Lookout Slough. This concept plan would provide habitat connectivity to Shag Slough on the west side of the Yolo Bypass as well as Cache Slough.

Concept Plan 13

This concept plan is similar to Concept Plan 12, except that alteration of the existing levee would consist of degrading the top of the existing levees in two 1,500-foot sections (one at the north end of the project as an inlet weir, and a second to the south to serve as an outlet weir). Each of the degraded sections would be lowered to match the 10-year design water surface elevation in the Yolo Bypass. During floods in excess of a 10-year design event, these portions of the embankment would overtop and function as weirs at the inlet and outlet of the site, providing additional hydraulic connectivity between the Project site and Yolo Bypass during high water events. This concept plan would also include a 100-foot wide breach of the Cache Slough levee near the terminus of Lookout Slough. This concept plan would provide habitat connectivity to Shag Slough on the west side of the Yolo Bypass as well as Cache Slough.

Concept Plan 14

This concept plan represents a minimal earthwork alternative, whereby alterations to the Yolo Bypass west levee would be limited to breaching only to connect the tidal channel network to Shag Slough. This concept plan would also include a 100-foot wide breach of the Cache Slough levee near the terminus of Lookout Slough. This concept plan would provide habitat connectivity to Shag Slough on the west side of the Yolo Bypass as well as Cache Slough.

Concept Plan 15

This concept plan represents a partial implementation of the Yolo Bypass Option 3 concept, whereby the levee setbacks and degrades depicted the BWFS within the Project footprint would be implemented. This would include fully degrading the west levee of the Yolo Bypass south of the County line, removal of the Cross Levee, and construction of a new setback levee following the alignment shown in the BWFS. This concept plan was evaluated separately against the existing condition Baseline Condition for comparison against the other alternative concept plans.

It is part of the Future Cumulative Condition baseline configuration, and is therefore not broken out separately in the Future Cumulative Condition performance comparisons.

Optimization Analysis of Concept Plan Array

Analysis of the alternatives array was conducted in two parts. The first step involved performing hydraulic analysis to identify whether or not the optimization constraints related to change in water surface were violated. The second step involved summarizing the performance of each alternative relative to the three primary optimization objectives.

Hydraulic Analysis

The design concept plan array was evaluated using the Baseline Condition and Future Cumulative Condition two-dimensional hydraulic models developed to support the Project design (ESA, 2019b). The Baseline Condition generally represents conditions as they are on the ground today, whereas the Future Cumulative Condition represents the implementation of several projects to increase the conveyance capacity of the Yolo Bypass as described in the BWFS (Figure 6).

For purposes of the screening assessment, the 100-year design event was used for comparing hydraulic performance between the alternative concept plans. The design event hydrology was developed using information prepared by DWR for the BWFS (DWR, 2016), which was based on data and tools developed for the Central Valley Hydrology Study (CVHS) completed by the USACE and DWR in 2013. In this part of the system, DWR identified the 1997 historic storm pattern with a scaling factor of 95% as corresponding to a 100-year design storm event.

A total of eleven index points were selected as locations to review the hydraulic impacts of the concept plans relative to both the Baseline and Future Cumulative Conditions scenarios. Shown on **Figure 8**, the following locations were identified during preliminary hydraulic analysis in close coordination with DWR and local interests:

1. West (left) bank of Yolo Bypass at County Road 155
2. Hass Slough at western boundary of RD 2098
3. Cache Slough near Hastings Cut
4. West (left) bank of Yolo Bypass at northern boundary of the Project
5. West (left) bank of Yolo Bypass at Yolo County/Solano County Line
6. Cache Slough at Confluence with Yolo Bypass
7. Lindsey Slough approximately 1 mile upstream of Hastings Island Road Bridge
8. Cache Slough at northern end of Little Egbert Tract
9. Cache Slough at Ryer Island
10. Cache Slough at southern end of Little Egbert Tract
11. Sacramento River at Rio Vista

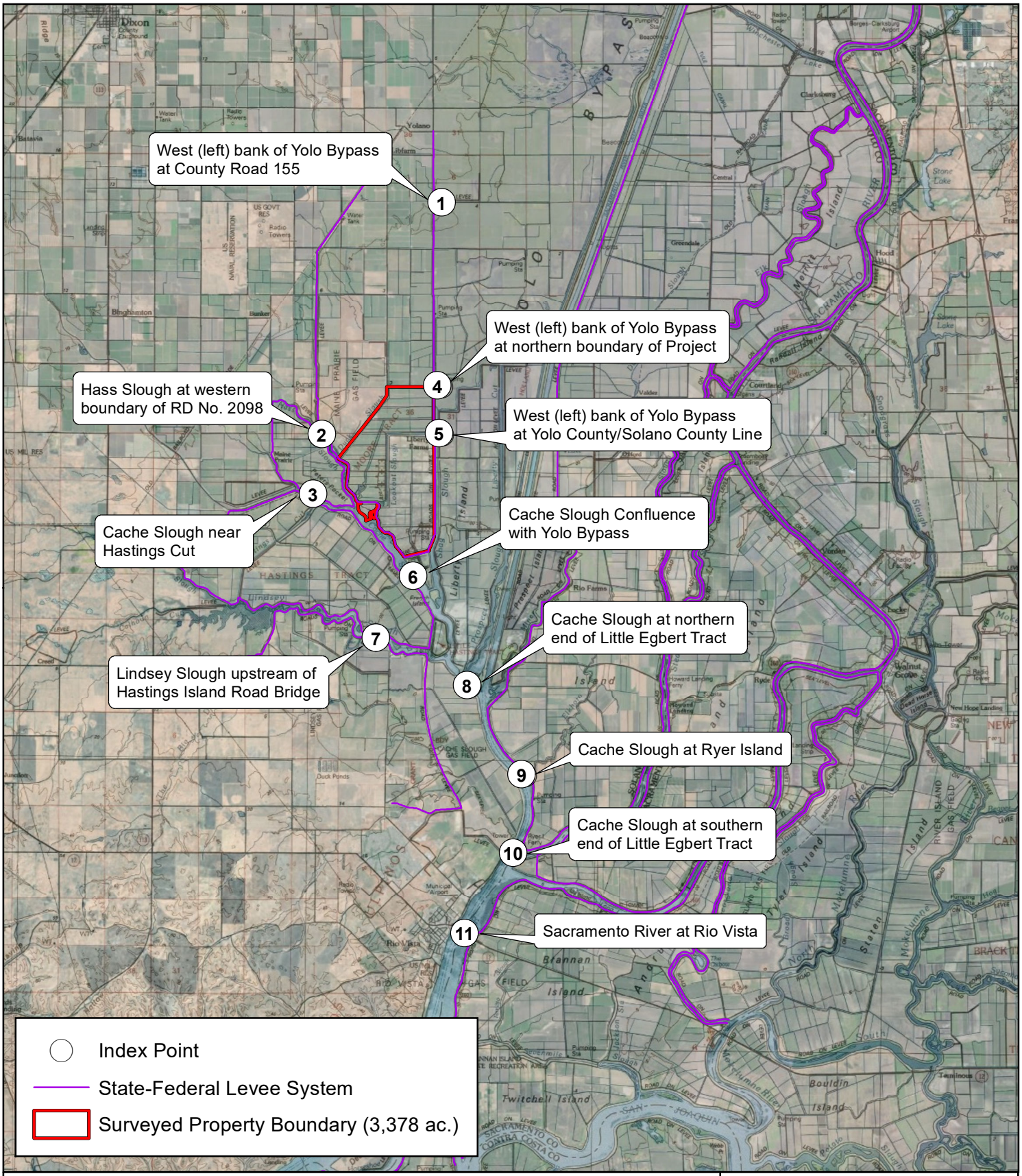


Figure 8
Index Points

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 7,500 15,000
Feet

Ecosystem Investment Partners

Prepared by: ESA

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rogers
Base Date: 10/24/2017
Data Source(s):

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F08_Index_Points.mxd

TABLE 3
100-YEAR FLOOD PERFORMANCE BASELINE CONDITION VS. WITH-PROJECT ALTERATIONS

Location	Baseline WSEL (feet, NAVD 88)	Impact Relative to Baseline WSEL (feet)														
		Concept Plan No.														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
County Road 155	23.85	-0.06	-0.06	-0.07	-0.08	-0.15	-0.06	-0.05	-0.05	-0.14	-0.06	-0.14	-0.12	-0.11	-0.09	-0.05
Northern Project Boundary	20.82	-0.19	-0.18	-0.20	-0.24	-0.66	-0.19	-0.16	-0.15	-0.64	-0.17	-0.64	-0.55	-0.51	-0.40	-0.16
Solano\Yolo County Line	19.91	-0.30	-0.29	-0.32	-0.37	-0.39	-0.29	-0.27	-0.25	-0.35	-0.27	-0.36	-0.31	-0.28	-0.25	-0.27
Hass Slough	18.78	0.03	0.02	0.10	0.32	0.02	0.04	-0.02	-0.02	-0.02	0.01	0.01	0.02	0.02	0.02	0.13
Cache Slough	18.78	0.03	0.02	0.10	0.32	0.02	0.04	-0.02	-0.02	-0.02	0.01	0.01	0.01	0.02	0.02	0.13
Cache Slough at Yolo Bypass	18.77	-0.02	-0.02	0.02	0.11	-0.03	-0.02	-0.02	-0.02	-0.02	0.00	0.00	0.00	0.01	0.02	0.06
Lindsey Slough	18.38	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	-0.01	0.00	0.00
Northern End of Little Egbert Tract	17.85	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	0.00
Ryer Island	16.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Southern End of Little Egbert Tract	14.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Sacramento River at Rio Vista	12.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00

NOTE:
Values shown in blue indicate stage decreases below the Baseline Condition. Values in orange indicate stage increases above the Baseline Condition.

TABLE 4
100-YEAR FLOOD PERFORMANCE FUTURE CUMULATIVE CONDITION VS. WITH-PROJECT ALTERATIONS

Location	Baseline WSEL (feet, NAVD 88)	Impact Relative to Baseline WSEL (feet)													
		Concept Plan No.													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
County Road 155	23.30	-0.02	-0.01	-0.01	-0.02	-0.08	-0.01	*Note: Project Concept Plans 7 through 10 were not evaluated separately under the Future Cumulative Condition as their geometry configurations duplicate Project Concept Plans 1, 2, 5, and 6, respectively (due to the degradation of the cross levee in the Future Cumulative Condition Baseline scenario).*				-0.07	-0.06	-0.06	-0.05
Northern Project Boundary	19.42	-0.06	-0.04	-0.05	-0.10	-0.58	-0.04					-0.52	-0.47	-0.44	-0.35
Solano\Yolo County Line	18.36	-0.08	-0.06	-0.07	-0.13	-0.24	-0.06					-0.23	-0.18	-0.15	-0.14
Hass Slough	17.42	-0.03	-0.03	0.00	0.14	-0.03	-0.02					-0.02	-0.02	-0.02	-0.02
Cache Slough	17.40	-0.03	-0.03	0.00	0.14	-0.03	-0.02					-0.02	-0.02	-0.02	-0.02
Cache Slough at Yolo Bypass	17.38	-0.02	-0.02	-0.02	-0.01	-0.02	-0.02					-0.02	-0.03	-0.03	-0.02
Lindsey Slough	16.92	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03					-0.03	-0.03	-0.03	-0.03
Northern End of Little Egbert Tract	16.74	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03					-0.03	-0.03	-0.03	-0.04
Ryer Island	16.14	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03					-0.03	-0.03	-0.03	-0.04
Southern End of Little Egbert Tract	14.55	0.00	0.00	0.00	0.00	0.00	0.00					0.00	0.00	0.00	0.01
Sacramento River at Rio Vista	12.45	0.00	0.00	0.00	0.00	0.00	0.00					0.00	0.00	0.00	0.00

NOTE:
Values shown in blue indicate stage decreases below the Future Cumulative Condition baseline. Values in orange indicate stage increases above the Future Cumulative Condition baseline.
Concept Plan 15 not shown here as its features are included in the Future Cumulative Condition baseline.

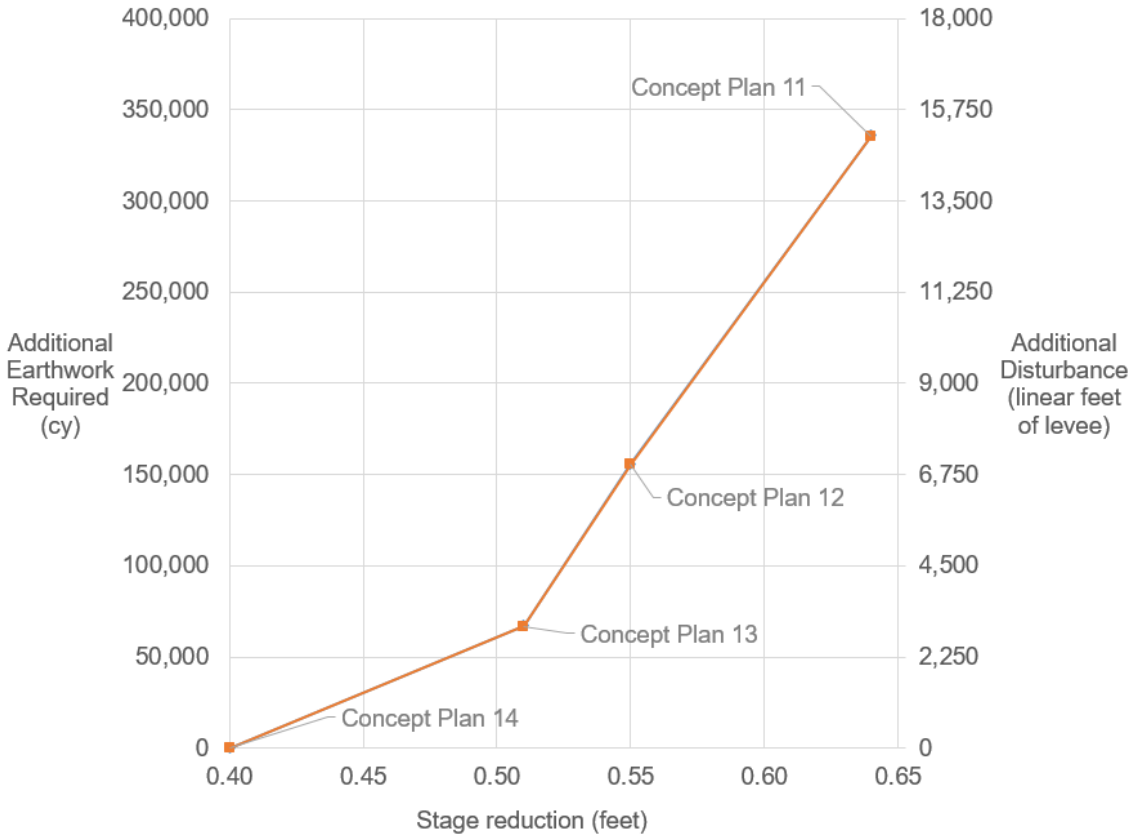
Optimization Findings

In general, the system's sensitivity to changes in the Project configuration are relatively minor. Although the Project will create over 40,000 acre-feet of new floodplain storage during a 1% ACE (100-year) storm event, this volume is dwarfed by the volume of runoff that is routed through the Yolo Bypass during these types of storms. As a result, even significant changes in the overall project configuration have relatively small impacts on flood stages in the Yolo Bypass, and generally minor adverse impacts (if any) in Cache Slough and Hass Slough. In this regard, an optimal Project would be one that is considered to maximize the three optimization objectives without violating the water surface performance constraints in the Yolo Bypass, Cache Slough, and Hass Slough.

In general, it was demonstrated that the Cross Levee could potentially be decommissioned (maximizing Objective 1), but only in cases where a breach at Cache Slough was omitted (failing to meet Objective 2). To reduce the earthwork and environmental impacts along the west levee of the Yolo Bypass, several options were explored iteratively (maximizing Objective 3).

Plans providing stage reductions of 0.4 feet or more at the north end of the Project in the Yolo Bypass were considered favorable in terms of providing positive flood benefits. These include Concept Plan 5, 9, 11, 12, 13, and 14. Of these plans, Concept Plans 11, 12, 13, and 14 would also provide direct hydraulic connectivity between Cache Slough and the Project site. Concept Plans 11, 12, 13, and 14 are all considered to represent potentially optimized plans. As the overall differences in hydraulic performance are relatively similar between Concept Plans 11, 12, 13, and 14, Concept Plan 14 might be considered optimal in that it would minimize earthwork and environmental impacts, even though it may not provide the maximum hydraulic benefit. Alternatively, if the degree to which hydraulic benefit between the three concept plans is considered consequential, Concept Plan 11, 12, or 13 may be considered preferable to Concept Plan 14. **Figure 9** provides a summary of the Concept Plans 11, 12, 13, and 14 and how they rank relative to one another in terms of hydraulic benefit and minimization of earthwork and environmental impacts. Quantities summarized on Figure 9 are considered approximate and are intended only for purposes of comparing relative orders of magnitude between the respective plans.

As the project design progresses through the 30-, 60-, 90-percent, and final design phases, further consideration to how the project is configured may be necessary to account for constructability, long term operations and maintenance, and issues identified during CEQA. Information from the current analysis can be used as a tool to inform modification of the design if necessary.

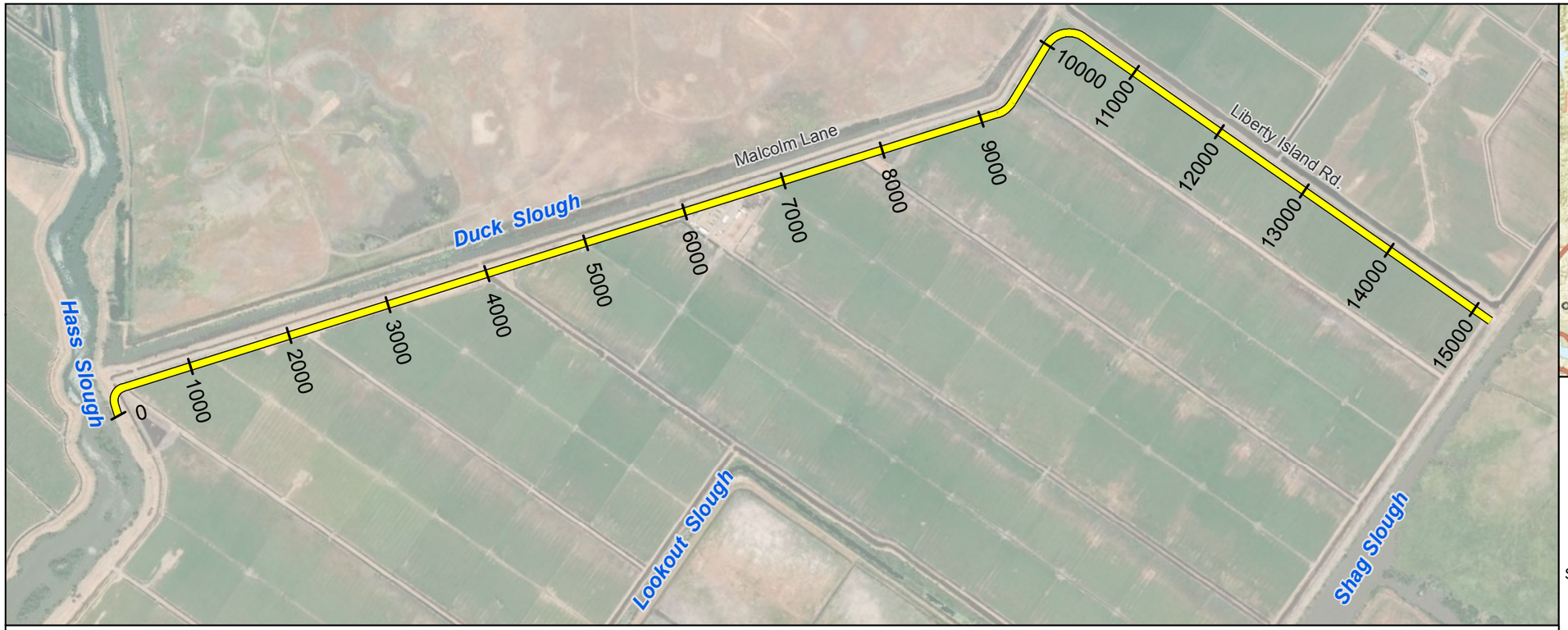


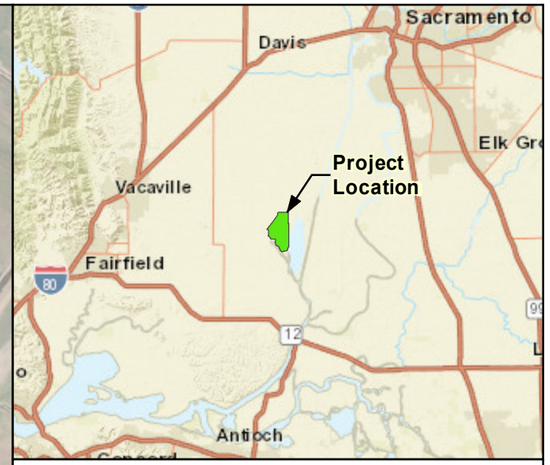
NOTE: All quantities shown here are approximate and presented for illustrating relative orders of magnitude between the resepctive concept plans.

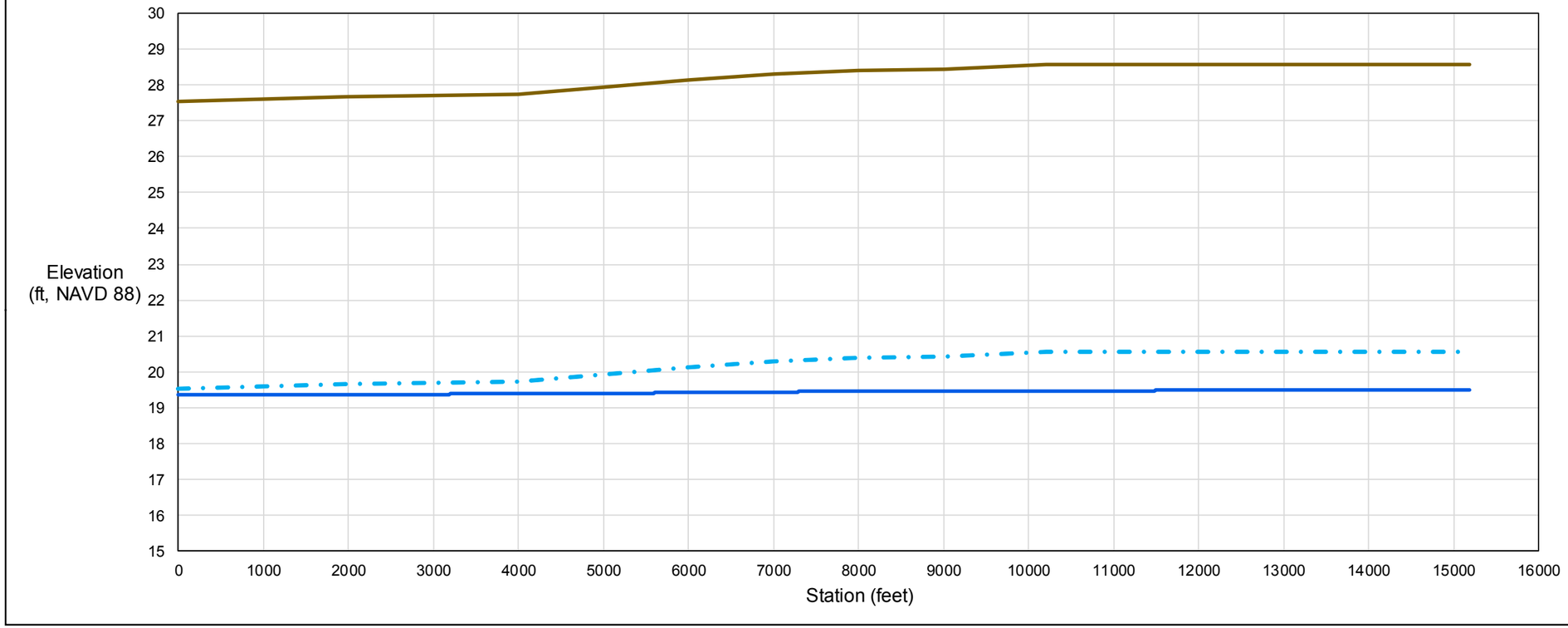
Figure 9
Optimization Performance Comparison at West Levee of Yolo Bypass at northern end of Project

Determination of Design Water Surface Elevation

To establish the design height of the levee, the Project performance for the 1% ACE (100-year) design flow was evaluated (ESA, 2019b). The resultant water surface elevation was compared with the authorized design (1957 Profile), and it was determined that the authorized design profile provides a more conservative design water surface elevation. Although the flow rate for the 1% ACE (100-year) design event and the authorized design flow rate are comparable to one another, the differences seen here are considered to be the product of the stage reductions in the Yolo Bypass created by the Project in conjunction with higher downstream stage assumptions in the 1957 authorized design profile. **Figure 10** shows the with-Project 1% ACE (100-year) design water surface profile along the Project's proposed setback levee alignment plotted relative to the 1957 authorized design profile (projected westward, perpendicular from the existing levee alignment). The with-Project computed 1% ACE water surface profile shown on Figure 10 reflects the Concept Plan 12 analysis, reflecting the middle range of hydraulic performance identified through the optimization analysis.







Ecosystem Investment Partners

LOOKOUT SLOUGH TIDAL HABITAT RESTORATION AND FLOOD IMPROVEMENT PROJECT

SETBACK LEVEE DESIGN WATER SURFACE ELEVATION

NORTH

0 600 1,200 2,400

FEET

- Proposed Setback Levee Alignment
- Proposed Top of Levee
- 1% AEP (100-year) Baseline Condition with-Project Water Surface Elevation
- 1957 Authorized Design Water Surface Profile

PRELIMINARY

WOOD RODGERS

J:\3000-s\3487_Ecosystem_Invest_Partners\3487002 Lookout Slough Prelim Hydraulic Analysis\GIS\Tasks\20190304_DWSE_Exhibit\FXX_100YR_Design_WSE_Exhibit_20180304.mxd 3/4/2019 9:41:20 PM cmilligan

FIGURE 10

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Summary and Conclusion

This report documents the methods, data, and assumptions used to identify a preferred concept plan, establish the design water surface elevation for the Project, and identify the potential impacts associated with a multi-benefit project that meets the objectives of habitat restoration while also improving flood conveyance in the Yolo Bypass. The Project as proposed, has been determined to create negligible adverse impacts to stage or channel velocity, while providing localized reductions in stage within the Yolo Bypass.

The existing system and future hydraulic performance of the project have been described in this report. A fundamental determination of the analysis is that the 1957 authorized design water surface profile shall be used as the basis for design for the Project's setback levee. The design top of levee shall include 6 feet of freeboard, plus 1 additional foot of freeboard for climate resiliency. Analysis of the Future Cumulative Condition also indicates that the Project will achieve superior hydraulic performance relative to the preferred concept plan (Yolo Bypass Option 3) identified in the BWFS.

The analysis described in this report shows that the proposed Project alterations would result in negligible adverse impacts to flood stages in the system. The region-wide system models have also been reviewed to verify that no significant change in the flow distribution at Fremont Weir or the Sacramento Weir would occur as a result of the Project. As the hydraulic impacts of the Project are localized, and generally result in stage decreases for the design events under consideration (including the 1957 authorized design flow), the Project's potential to increase risk within the system is considered to be negligible.

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