YOLO BYPASS DRAINAGE AND WATER INFRASTRUCTURE IMPROVEMENT STUDY

FINAL REPORT

Prepared for: Yolo County

Prepared by:

yolo basin foundation

cbec eco engineering

CONSEROSOLUTIONS

DOUGLAS ENVIRONMENTAL

Project number: 12-1039

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GLOSSARY OF ACRONYMS

Acronym	Meaning
BDCP	Bay Delta Conservation Plan
BMP	Best Management Practices
CDFW	California Department of Fish and Wildlife
CM2	Conservation Measure 2, BDCP
CNRA	California Natural Resources Agency
CVP	Central Valley Project
Dixon RCD	Dixon Resource Conservation District
DOI	U.S. Department of Interior
DWR	California Department of Water Resources
GCID	Glenn-Colusa Irrigation District
GGS	Giant garter snake
HEC-RAS	Hydrologic Engineering Center – River Analysis System
KLOG	Knights Landing Outfall Gates
KLRC	Knights Landing Ridge Cut
NAVD88	North American Vertical Datum of 1988
NAWCA	North American Wetland Conservation Act
NMFS	National Marine Fisheries Service
NRCS	Natural Resource Conservation Service
O&M	Operations and Maintenance
RD 1600	Reclamation District 1600
RD 2068	Reclamation District 2068
RPA	Reasonable and Prudent Alternative
SWP	State Water Project
SYMVCD	Sacramento-Yolo Mosquito and Vector Control District
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USED	United States Engineering Datum
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Service
WRP	Wetlands Reserve Program
YBF	Yolo Basin Foundation
YBWA	Yolo Bypass Wildlife Area

EXECUTIVE SUMMARY

This study identifies drainage and water infrastructure improvements in the Yolo Bypass that benefit farmers and wetlands managers, as well as proposes actions to increase the availability and enhance the quality of data related to these improvements. Yolo County proposed the study to address potential impacts on agriculture and wetlands of proposals by the California Natural Resources Agency and the U.S. Department of the Interior to increase the frequency and duration of inundation in the Yolo Bypass for seasonal fish habitat. While these improvements will not fully address potential impacts, they will help reduce drainage times, improve water delivery, and otherwise increase the likelihood the Yolo Bypass will continue to support multiple important land uses in the future. This study is one of a series of studies commissioned by Yolo County as part of the County's ongoing efforts to document land uses in the Yolo Bypass, analyze potential changes to land uses as a result of fish habitat proposals, and suggest actions to ensure successful integration of land uses. Yolo County thanks the Conaway Preservation Group for providing funding to undertake the study.

The Bay Delta Conservation Plan (BDCP) Conservation Measure 2 (CM2), sponsored by the California Natural Resources Agency and the U.S. Department of the Interior, proposes to construct an operable gate in the Fremont weir to allow increased seasonal floodplain inundation from the Sacramento River to benefit juvenile salmonids and Sacramento splittail. The proposal would also improve fish passage over the Fremont Weir. In addition, the 2009 National Marine Fisheries Service (NMFS) Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project (Biological Opinion) Reasonable and Prudent Alternative (RPA) Action I.6.1 (NMFS, 2009) requires the U.S. Bureau of Reclamation (USBR) and the California Department of Water Resources (DWR) to increase rearing habitat for juvenile salmonids in the lower Sacramento River Basin during the December to April time period. The Biological Opinion includes an initial performance measure of 17,000 to 20,000 acres, on a return rate of approximately one to three years, depending on water year type. Yolo County and other stakeholders are concerned the proposed project will permanently impact agriculture, managed wetland habitat, flood control, and public uses in the Yolo Bypass.

The study team collected information and project ideas from the people who know the Yolo Bypass best: the farmers, landowners, wetlands managers, and water managers with many years of experience working in the Bypass. The state and federal government can use this study to help ensure the successful continuation of farming and wetland management if Yolo Bypass fish habitat proposals are implemented. The improvements also can be implemented independent of any fish habitat projects. The results of this study are intended to assist Yolo County and other stakeholders secure future funding for priority projects or feasibility studies.

The objectives of the study include the following:

- Coordinate with Yolo Bypass stakeholders to characterize existing conditions and constraints; (see Section 2)
- Collect limited field reconnaissance and survey data to support characterization of existing conditions (see Section 2);

- Coordinate with Yolo Bypass stakeholders to identify improvements (see Section 2);
- Prioritize projects based on identified criteria (see Section 3);
- Summarize conceptual projects related to drainage and water infrastructure improvements, including rough cost estimates (see Section 3); and
- Provide recommendations for further studies as needed (see Section 3).

The study team obtained information regarding improvements to drainage and water supply infrastructure from over 15 interviews with landowners, farmers, water managers, wetland managers and others with extensive knowledge and experience with Yolo Bypass and drainage water supply systems. The team contacted as many people as possible from within each management area or property boundary to participate in this study. The team conducted formal interviews in person with detailed maps and by phone. The Yolo Basin Foundation organized a stakeholder meeting in April 2013 to review maps of drainage systems throughout the Bypass and evaluate potential projects. Additionally, the team collected limited field data to verify water operations. The Yolo Basin Foundation organized a second stakeholder meeting in October 2013 to review draft project descriptions, recommended studies, and priorities.

The study team used feedback from participants, research on the relative potential benefits, permitting requirements, and approximate cost estimates to assess initial priorities, as well as other factors for the recommended projects. Recommended projects are intended to benefit agriculture and managed wetlands drainage and water supply operations, but may have some ancillary benefits to fish habitat. The team considered potential overlap with existing efforts in the Yolo Bypass to improve fish habitat, however, for coordination purposes and to assess potential funding sources. These efforts include proposed measures in the BDCP CM2 Yolo Bypass Fisheries Enhancement, NMFS 2009 Biological Opinion RPAs I.6 and I.7, USBR and DWR Yolo Bypass Salmonid Habitat Restoration and Fish Passage EIR/EIS and the Fish Restoration Program Agreement between California Department of Fish and Wildlife (CDFW) and DWR.

Appendix A summarizes the twelve recommended projects. These projects provide unique opportunities to improve drainage and water supply conditions in the Yolo Bypass for agricultural and wetland operations. The projects are separated into location-specific improvements (Projects 1 through 9) and Bypass-wide improvements (Projects 10 through 12). Additionally, four studies were identified for future analysis. The following is a list of projects and studies.

Proposed projects:

- Project 1: Wallace Weir Improvements
- Project 2: Tule Canal Agricultural Crossing/Water Control Structure Improvements
- Project 3: Lisbon Weir Improvements
- Project 4: Conaway Main Supply Canal Augmentation
- Project 5: Davis Wetlands Water Supply Improvements
- Project 6: South Davis Drain Input Reconfiguration
- Project 7: Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration
- Project 8: Yolo Bypass Wildlife Area Public and Operation & Maintenance Road Improvements

- Project 9: Stormwater and Summer Tailwater Re-Use and Supply
- Project 10: Local Agricultural Crossing Improvements
- Project 11: Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency
- Project 12: Westside Tributaries Monitoring

Proposed studies:

- Study 1: Bypass Sedimentation Rate Changes due to Managed Flooding
- Study 2: Vegetation Management with Increased Frequency and Duration of Flooding
- Study 3: Plan to Manage Beaver Canal Damage and Obstructions
- Study 4: Management Entity Model

The study team prioritized these projects based on the team's knowledge and familiarity with the Yolo Bypass, results of the quantitative and qualitative assessments performed on each project, and input from stakeholders. The following projects are recommended in priority order from 1 to 12. 1 is the highest priority and 12 is the lowest priority. The study team based this prioritization on 14 ranking criteria described in the report. A project was assigned a high, medium, or low ranking for each criteria. The prioritization below is based on the total number of "high" rankings that each project received. It is important to emphasize, however, that all projects are recommended for implementation. The prioritization provides information to guide the order in which projects are developed and implemented.

High priority projects:

1. RP-7: Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration
1. RP-8: Yolo Bypass Wildlife Area Public and Operation & Maintenance Road Improvements
3. RP-6: South Davis Drain Input Reconfiguration
3. RP-10: Local Agricultural Crossing Improvements
3. RP-11: Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency

Medium priority projects:

6. RP-3: Lisbon Weir Improvements
7. RP-2: Tule Canal Agricultural Crossing/Water Control Structure Improvements
7. RP-4: Conaway Main Supply Canal Augmentation
7. RP-12: Westside Tributaries Monitoring

Low priority projects:

10. RP-1: Wallace Weir Improvements
11. RP-9: Stormwater and Summer Tailwater Re-Use and Supply
12. RP-5: Davis Wetlands Water Supply Improvements

1 INTRODUCTION

The California Natural Resources Agency (CNRA) and the U.S. Department of the Interior (DOI) are currently developing scenarios to increase the frequency and duration of inundation in the Yolo Bypass to improve seasonal fish habitat. BDCP Conservation Measure 2 proposes to construct an operable gate in the Fremont weir to allow increased seasonal floodplain inundation from Sacramento River water for the benefit of juvenile salmonids and Sacramento splittail, in addition to proposed fish passage improvements. The 2009 NMFS Biological Opinion Reasonable and Prudent Alternative (RPA) Action I.6.1 also requires the USBR and DWR to increase rearing habitat for juvenile salmonids in the lower Sacramento River Basin during the December to April time period with an initial performance measure of 17,000 to 20,000 acres, on a return rate of approximately one to three years, depending on water year type. RPA Action I.6.1 was identified in the June 4, 2009 NMFS Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project (NMFS 2009 Biological Opinion). Yolo County and other stakeholders are concerned a proposed project implementing Conservation Measure 2 or RPA Action 1.6.1. will permanently impact agriculture, managed wetlands habitat, flood control, and other important land uses in the Yolo Bypass.

Irrigated agriculture and managed wetlands comprise major land uses within the Yolo Bypass, contributing to the local economy and habitat for terrestrial species, including some listed species. The local, state and federal government worked with community leaders to create the Yolo Bypass Wildlife Area in 1997 with state and federal funding. The Yolo Bypass Wildlife Area is currently managed as diverse wetland habitat for resident and migratory species along the Pacific Flyway with some 100,000 waterfowl overwintering in the Yolo Bypass Wildlife Area each year (CDFW, 2008). The Yolo Basin Foundation, a non-profit organization, hosts school field trips and a variety of other educational activities in the Yolo Bypass Wildlife Area, providing educational opportunities to local communities. Multiple landowners Bypass-wide provide additional waterfowl habitat through private hunt clubs. Additionally, tens of thousands of acres are farmed or grazed, including thousands of rice acres, providing additional economic and habitat benefits. Finally, the Yolo County Habitat/Natural Community Conservation Plan Joint Powers Agency, comprised of the City of Winters, the City of West Sacramento, the City of Woodland, the City of Davis, UC Davis, and Yolo County, are in the process of completing a countywide habitat conservation plan for selected terrestrial species. The plan includes conservation strategies to protect species, such as giant garter snake, found in the Yolo Bypass.

This study identifies drainage and water infrastructure improvements in the Yolo Bypass that could improve the operations of agriculture and wetlands under current or proposed flooding regimes. Information for the study was obtained through interviews and data collection. The study team interviewed landowners, farmers, water managers and other key stakeholders with knowledge and interest in Yolo Bypass water management in person or by phone. Limited field reconnaissance and surveys were conducted in prioritized areas. From these individual meetings and data collection, the team created maps of existing conditions and water operations across property boundaries. The team also created sub-regions that divide the Yolo Bypass up into geographic areas from north to south for the purposes of compiling a mosaic of information for future planning efforts. In addition, the team identified the potential benefits of projects to future agriculture and wetland management.

This report presents the results of the study, first describing the existing land use functions, drainage and water supply infrastructure schedules, and sub-regional constraints. Sub-regions are described from north to south, divided into regions for coordination with landowners in the following areas: 1) north of Interstate 5, 2) between Interstates 5 and 80 and 3) south of Interstate 80. The study team synthesized recommendations from interviews with the team's regional hydrologic, management and policy expertise to recommend 12 projects and 4 studies. An overview map of the locations of the 12 recommended projects is provided by Figure 1. The team then prioritized projects in a first effort to guide Bypass management and funding opportunities. To improve the availability and quality of data related to proposed beneficial projects, the team also recommended improvements to future collection of westside tributary inflow data.

1.1 BACKGROUND

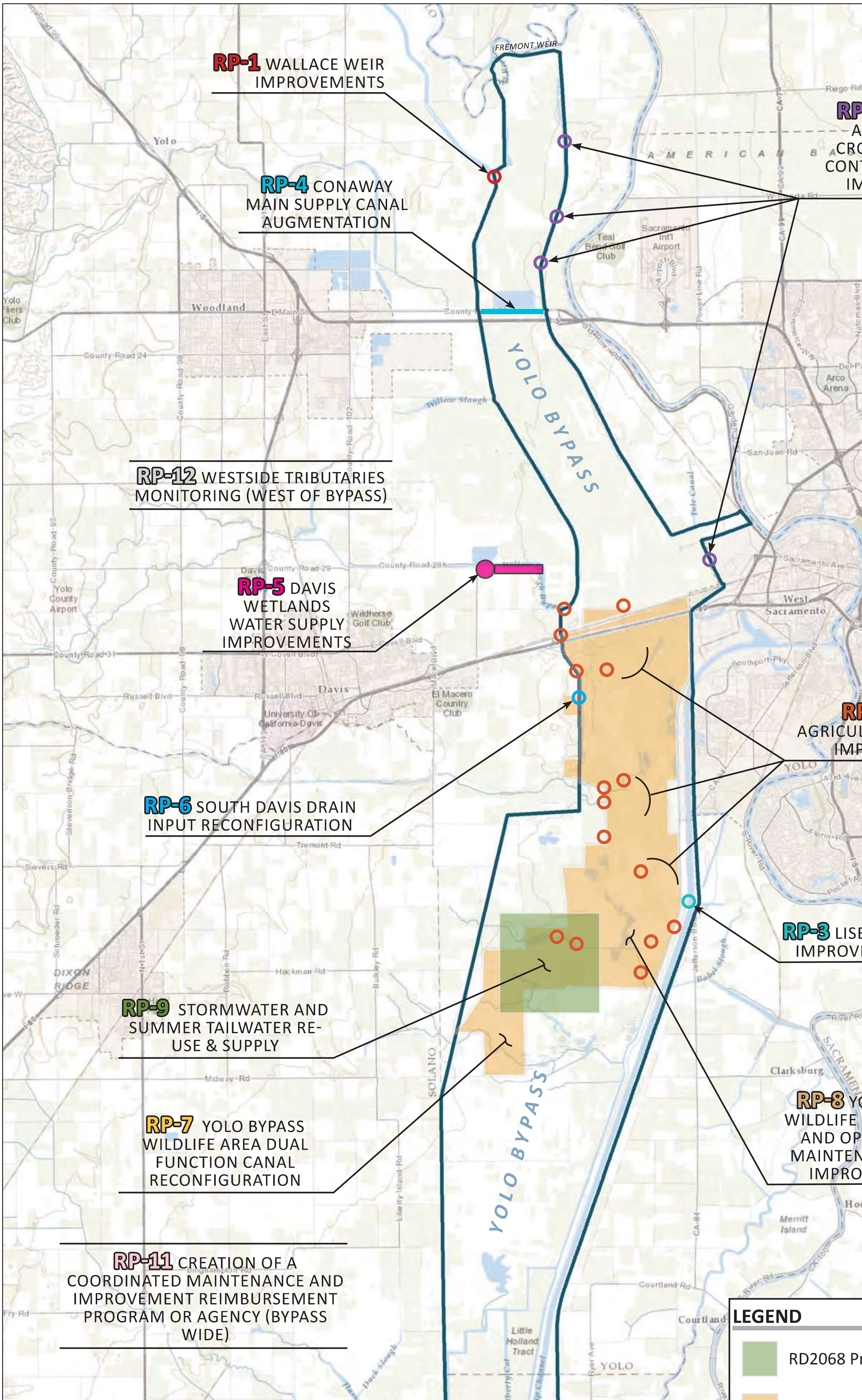
1.1.1 STUDY AREA

The 59,000-acre Yolo Bypass conveys a design flow from 343,000 cfs at Fremont Weir to 500,000 cfs at Rio Vista including inflows from Sacramento Weir (112,000 cfs). In addition, the "westside tributaries" to the Bypass drain the western foothill watersheds and include Putah Creek, Cache Creek, Willow Slough Bypass and the Knights Landing Ridge Cut Canal. The Yolo Bypass also receives inputs of treated wastewater from the cities of Woodland and Davis (typically minor during flooding, but significant during the dry season), and stormwater from the City of West Sacramento (albeit minor during flooding).

The southern terminus of the study was just north of Yolo Ranch where wetland restoration planning efforts are underway. The western terminus was bounded by the Yolo-Solano County Line. The study team coordinated with Solano County as Solano and Yolo County share similar economic and agronomic environments. Solano County has already identified needed drainage and water supply infrastructure improvement projects in the Bypass, however, so Solano County opted not to participate in this study. Additionally, projects identified in this study should be considered in collaboration with other projects under development, such as Putah Creek realignment actions and other restoration projects further upstream in the Putah Creek riparian corridor.

1.1.2 PREVIOUS STUDIES

Many key components leading to the development of this study originate from the Westside Option, a management scenario described by the Yolo Basin Foundation (YBF) with support from others (YBF, 2010a). While the original goal of the Westside Option was to improve rearing habitat for juvenile salmon, it aimed to do so in a way that would minimize impacts on agriculture and wetlands. Specifically, several key objectives outlined in the Westside Option are considered in this study including 1) avoiding negative impacts on the floodway function of the Yolo Bypass, 2) supporting agricultural production as location and timing of flooding affects yield (Howitt et al., 2013) and, 3) supporting


FREMONT WEIR
RP-1 WALLACE WEIR IMPROVEMENTS
RP-4 CONAWAY MAIN SUPPLY CANAL AUGMENTATION
RP-12 WESTSIDE TRIBUTARIES MONITORING (WEST OF BYPASS)
RP-5 DAVIS WETLANDS WATER SUPPLY IMPROVEMENTS
RP-6 SOUTH DAVIS DRAIN INPUT RECONFIGURATION
RP-9 STORMWATER AND SUMMER TAILWATER RE-USE & SUPPLY
RP-7 YOLO BYPASS WILDLIFE AREA DUAL FUNCTION CANAL RECONFIGURATION
RP-11 CREATION OF A COORDINATED MAINTENANCE AND IMPROVEMENT REIMBURSEMENT PROGRAM OR AGENCY (BYPASS WIDE)
YOLO BYPASS
YOLO BYPASS
AMERICAN BASIN
Woodland
Davis
West Sacramento
Clarksburg
Teal Bend Golf Club
Sacramento Int'l Airport
Wildhorse Golf Club
El Macero Country Club
University Of California-Davis
Yolo County Airport
Yolo Fliers Club
DIXON RIDGE
Arco Arena
Little Holland Tract
Merritt Island
SOLANO
YOLO
LEGEND

existing habitat values in the Yolo Bypass, including migratory and resident shorebirds, waterfowl and other terrestrial species. These objectives are consistent with the purpose of this study.

Yolo County's recent study, "Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals" (Howitt et al., 2013) analyzed the potential impacts on agriculture from fish habitat proposals. This study relied on one-dimensional hydraulic modeling results without westside tributary inputs for a range of inundation scenarios (i.e., only assuming Fremont Weir operable gate flows) to analyze impacts on crop yield based on last day of flooding. This was the best available information at the time, but new hydraulic modeling results should be available in 2014. As discussed in this report, better information about west side tributary flows is still needed.) The study also relied on crop data validated by Yolo Bypass farmers and assumptions about drainage and field preparation times provided by in-person interviews with Yolo Bypass farmers. The study analyzed twelve scenarios selected by the authors, as Biological Opinion and BDCP alternatives were and are still not fully developed. Scenarios included five release end dates at Fremont Weir (February 15th, March 24th, April 10th, April 30th, and May 15th) and a "Low-Impact CM2 Scenario" with variable end dates extending natural overtopping events based on water year type and available Sacramento River water. All scenarios were analyzed at two flow rates: 3,000 cfs and 6,000 cfs. The scenarios analyzed differ from actual proposals to varying degrees and do not explicitly represent BDCP CM2 or RPA Action 1.6.1. conceptual future operations. The model developed to support the study can be used to analyze specific alternatives in the future, however.

The study found that 7,700 and 15,800 acres of land used for agricultural production could potentially be impacted, amounting to $200,000 to $8.9 million in total annual losses (in 2008 dollars) to Yolo County depending on the scenario. While not representative of actual BCDP proposed operations, the "Low-impact CM2 Scenario", showed a range of losses from $625,000 to $1.5 million. The study concluded that while some flooding for fish is possible with minimal impacts, flooding in March and April will result in significant yield impacts, and late spring flooding could result in the end to agricultural production on inundated acres. If actions are taken to minimize impacts of proposals and the operational needs of farmers and wetland managers are considered, there may be potential to minimize economic impacts.

Ducks Unlimited prepared a report describing the impact on waterfowl as a result of possible CM2 scenarios outlining four main drivers: 1) recreation hunt/use, 2) income loss, 3) foraging loss due to deep winter flooding, and 4) seed production loss due to late season flooding (Ducks Unlimited, 2012). They found that Yolo Bypass Wildlife Area closures due to Fremont Weir overtopping occurred for 14 days on average during the mid-October to late January duck hunting season during a 13-year period with seven overtopping events from 1997 to 2010. A two- to three-week drying time window after these flood events was estimated before public access was granted. The potential increase in the cost per day of hunting and property value loss due to changes in hunting opportunities were noted. It was also noted that foraging habitat for dabbling ducks, whose populations peak in the Yolo Bypass in February, may be impacted by CM2 deep winter flooding as dabbling ducks require depths less than 18 inches (less than 10 inches preferred). Finally, they reported the impacts on seed production for waterfowl food supply. To promote maximum growth of Swamp Timothy, a prevalent forage species in

the Yolo Bypass Wildlife Area, water operations are managed to flood through February allowing ponds to evaporate in March, monitored through early April and then rapidly drawn down. The preferred vegetation for management on private duck clubs, watergrass and smart weed, require a slow draw down over two to three weeks in mid March and irrigation for two to four weeks in May. Late season draw downs promote undesirable vegetation growth (Ducks Unlimited, 2012).

The most recent description of land use within the Yolo Bypass is included in "Appendix: A Summary of the Agricultural Land Uses and Managed Wetlands in the Sacramento – San Joaquin Delta" (Ducks Unlimited, 2012) to support the Delta Methylmercury Total Maximum Daily Load (TMDL) Nonpoint Sources Workgroup for Managed Wetlands and Irrigated Agriculture (NPS Workgroup) "Knowledge Base for Nonpoint Sources Methylmercury Control Study" (NPS Workgroup, 2012). This study estimates that within the TMDL study area including the North and South Yolo Bypass (in the leveed and non-leveed portions from Fremont Weir to just north of Rio Vista including Yolo and Solano Counties), approximately 5,000 acres are currently used for winter flooded irrigated agriculture, 68,000 acres are used for other irrigated agriculture, and 12,350 acres and 650 acres for seasonal and permanent managed wetlands, respectively. The 16,770-acre Yolo Bypass Wildlife Area managed by the California Department of Fish and Wildlife (CDFW) provides 7,000 acres of habitat to promote an increase in waterfowl and other bird populations, restored using approximately $24 million in state and federal funding since 1997.

These previous efforts and studies have helped managers understand land use and the potential impacts to farming and wetland management associated with increases in the frequency and duration of inundation in the Yolo Bypass.

1.2 GOALS AND OBJECTIVES

This study identifies drainage and water infrastructure improvements in the Yolo Bypass that benefit farmers and wetlands managers, as well as proposes actions to increase the availability and enhance the quality of data related to these improvements. Yolo County proposed the study to help address potential impacts on agriculture and wetlands of proposals by the California Natural Resources Agency and the U.S. Department of the Interior that increase the frequency and duration of inundation in the Yolo Bypass for seasonal fish habitat. While these improvements will not fully address potential impacts, they will help reduce drainage times, improve water delivery, and otherwise increase the likelihood the Yolo Bypass will continue to support multiple important land uses in the future. The results of this study are intended to assist Yolo County and other stakeholders in securing future funding for projects or feasibility studies to benefit Yolo Bypass agriculture and wetland operations.

The objectives identified to meet these goals include the following:

- Coordinate with Yolo Bypass stakeholders to characterize existing conditions and constraints;
- Collect limited field reconnaissance and survey data to support characterization of existing conditions;
- Coordinate with Yolo Bypass stakeholders to identify specific improvements;
- Perform preliminary prioritization based on a simple rationale;

- Provide conceptual project summaries related to drainage and water infrastructure improvements; and
- Provide recommendations for further studies.

2 YOLO BYPASS DRAINAGE AND WATER SUPPLY CHARACTERIZATION AND INITIAL RECOMMENDATIONS

2.1 EXISTING DRAINAGE AND WATER SUPPLY INFRASTRUCTURE, CONSTRAINTS AND IMPROVEMENTS BY GENERAL REGION

To characterize the existing agricultural and wetland management operations in the Yolo Bypass, the study team held numerous interviews with landowners, farmers, water managers, wetland managers and others with extensive knowledge and experience in the system. The study team also held two meetings with stakeholders who were interviewed during the process to develop and confirm recommendations and to facilitate conversation among stakeholders regarding land management. The team contacted as many people as possible from within each management area or property boundary to participate in this study, resulting in 15 formal interviews and several other phone or email exchanges with various parties knowledgeable of drainage and water supply functions in the Yolo Bypass.

The following section summarizes the existing drainage and water supply operations and recommended improvements by three general regions: 1) Fremont Weir to Interstate 5 causeway; 2) Interstate 5 to Interstate 80; and 3) Interstate 80 to just north of Yolo Ranch. The study team included all improvements in this section that stakeholders recommended, but the team also prioritized the recommended improvements as discussed in Section 3.4. Discussion of selected projects for further development is provided in Section 3 and Appendix A.

In addition to floodwater spilling over the Fremont Weir, the Yolo Bypass receives rainfall runoff, agricultural tailwater drainage, bypass flood flows, stormwater and treated wastewater effluent from several locations, primarily originating from the west. Four main tributaries, hereafter referred to as the westside tributaries, convey variable amounts of runoff, stormwater and flood flows: the Knights Landing Ridge Cut Canal, Cache Creek, Willow Slough via the Willow Slough Bypass, and Putah Creek.

The Fremont Weir, located between river miles 81.7 and 83.4, and built in 1924 to reduce Sacramento River levels and minimize flooding, is a fixed concrete weir constructed by US Army Corps of Engineers. It is 9,120 feet long, with an earthfill section dividing it into two parts. The crest of the concrete weir section is at elevation 33.5 feet (no vertical datum given), and the crown of the earthfill section is at an elevation of 47.0 feet (no vertical datum given) (U.S. Army Corps of Engineers 1955). It currently overtops when the Sacramento River exceeds a range of 32.1 to 32.9 ft elevation, NAVD88. The Yolo Bypass Management Strategy (Chapter 2 – Existing Conditions in the Yolo Bypass, Jones & Stokes, 2001) provides information about the historical daily inflow hydrology to the Yolo Bypass for these four tributaries from 1968 to 1998. cbec recently updated this hydrologic dataset through 2011 for a DWR modeling effort (cbec, 2012). During the period from 1968 to 2011, or 44 years, Fremont Weir spilled or

"overtopped" during 29 of those years or 2 out of 3 years (66% of years) according to the updated hydrology dataset. The study "Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals" evaluated a shorter timeframe of 26 years (1984 and 2009) because of concern about the accuracy of the data from 1968 to 1983, during which the Fremont Weir spilled during 15 of those years or 58% of years. Typical overtopping events do not result in complete inundation of the Yolo Bypass.

See Appendix B of this report for a complete summary of existing knowledge about the westside tributaries, low flow hydrology as estimated or described by the Yolo Bypass Management Strategy (herein, Management Strategy) (Jones & Stokes, 2001), and recommendations for validating these estimation equations or for future data collection.

2.1.1 NORTHERN YOLO BYPASS – FREMONT WEIR TO INTERSTATE 5

2.1.1.1 North of Knights Landing Ridge Cut Cross Canal

Existing Function and Constraints

The northern Yolo Bypass is bounded by United States Army Corps of Engineers (USACE) project levees to the east and west. The approximately 1,400-acre CDFW Fremont Weir State Wildlife Area conveys flood flows just south of the Fremont Weir, currently set to overtop when the Sacramento River exceeds 32.9 ft NAVD88 (33.5 ft USED). According to recent DWR surveys, the crest elevation varies from 32.1 to 32.9 ft elevation, NAVD88. Scour channels have formed across the Fremont Weir State Wildlife Area, with LiDAR based land elevations that range from 31 feet NAVD88 at the northwest corner to 20 feet NAVD88 at the southeast corner near the Tule Canal (DWR, 2005).

Immediately south of the State Wildlife Area, TeVelde Ranch farms approximately 1,700 acres. This area is on a row crop rotation of tomatoes and corn planted ideally in April or early to mid-May of each year. Planting by mid-May requires a least a month of field preparation and 2-4 weeks to allow fields to drain (Howitt et al., 2013). The corn cultivated here is used for silage, or harvested with the cob, husk, and leaves, which can be harvested at higher moisture and thus can be planted relatively late (J. Brennan, personal communication). Land elevations range from 25 feet NAVD88 to 16 feet NAVD88 from northwest to southeast respectively (DWR, 2005). Irrigation supply to the TeVelde Ranch is sourced from the KLRC as backwater behind Wallace Weir supplemented by water from up to seven wells. Supply is conveyed in a canal approximately 100 feet wide northward that continues into the State Wildlife Area. At the northern property line of the TeVelde property, a smaller canal approximately 25 feet wide conveys supply eastward toward an agricultural crossing on the Tule Canal where a pipe through the levee gravity feeds water to RD1600 east of the Bypass levee (see Figure 2). All fields on TeVelde Ranch are leveled to drain from northwest to southeast toward the Tule Canal.

The RD 1600 canal system partially depicted in Figure 2 drains back to the Tule Canal south of a second agricultural crossing where water is pumped into the Tule Canal in the winter and flows by gravity in the summer. While areas just east (outside) of the Bypass levee are not flooded during overtopping events, these areas sit on "heavy ground" with high clay content and can experience seepage when flow is

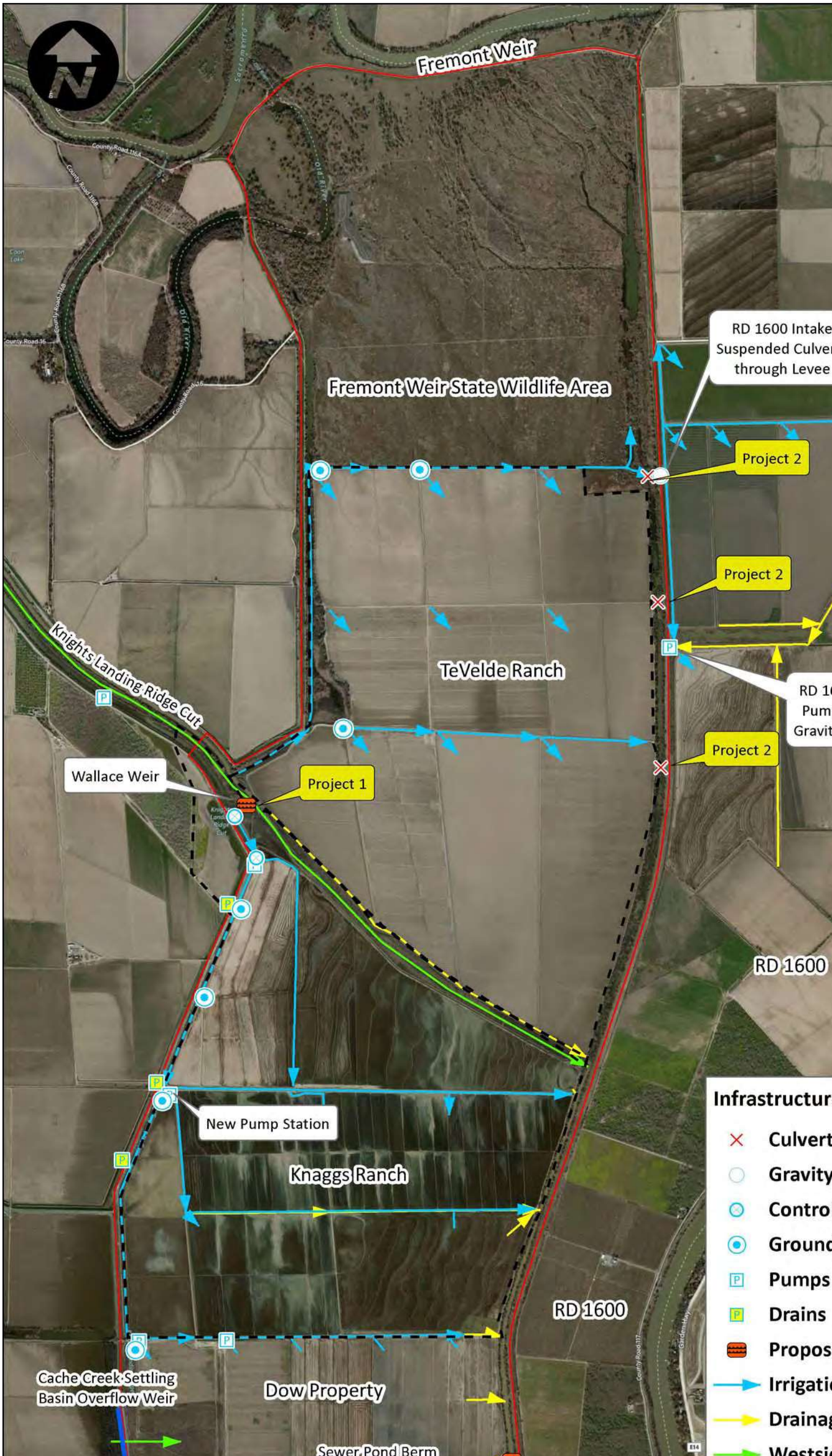
receding down the Tule Canal that can potentially prolong field preparation and productivity in these areas. Sacramento River Ranch, a 3,600-acre mitigation bank between the east Bypass levee and Sacramento River, is owned by Wildlands, Inc. with potential for wetlands, agricultural and species mitigation (map available online at http://www.wildlandsinc.com/map).

Three agricultural crossings exist on the Tule Canal north of the KLRC (see Figure 2). The northernmost crossing is at the north property line of the TeVelde property, the second is about 0.5 mile south, and the third is another 0.6 mile south. The northernmost agricultural crossing is generally not used as a road but rather as a berm to impound water upstream for supply to RD 1600. The middle crossing is the most heavily utilized and the south crossing is primarily used by operations on the Sacramento River Ranch east of the levee. The middle and south crossings have 36-inch culverts that provide for hydraulic connectivity of the Tule Canal during the summer period.

Improvements

Further research is needed to assess the extent of benefit to agriculture and wetlands as a result of improvement to the three agricultural crossings north of KLRC. TeVelde Ranch may benefit from a Bypass-wide recommendation to enhance key agricultural crossings (e.g. along the Tule Canal as discussed above) for improved access and drainage and reduced maintenance, as well as potential involvement in a Coordinated Maintenance and Improvement Reimbursement Program as suggested for the entire Bypass. See Appendix A and Section 3.2 for details on recommended projects.

The three agricultural crossings north of KLRC have been identified as impediments to fish passage by several other efforts working to improve fish habitat in the Yolo Bypass. Specifically, the BDCP Conservation Measure 2 identifies a related project "Component Project 9: New or Replacement Impoundment Structures and Agricultural Crossings at the Tule Canal and Toe Drain" as a Phase 1 (Years 1 – 5) Category 3 Project. Additionally, NOAA Fisheries and DWR's Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan has identified seasonal road crossings and agricultural impoundments in the northern Yolo Bypass as locations for improvement to satisfy the NMFS 2009 Biological Opinion RPA I.6.1 (Appendix C: Yolo Bypass Actions).


Fremont Weir
Fremont Weir State Wildlife Area
RD 1600 Intake
Suspended Culver
through Levee
Project 2
Project 2
Project 2
TeVelde Ranch
Knights Landing Ridge Cut
Wallace Weir
Project 1
RD 1600
New Pump Station
Knaggs Ranch
RD 1600
Cache Creek Settling
Basin Overflow Weir
Dow Property
Sewer Pond Berm
Infrastructur
Culvert
Gravity
Contro
Ground
Pumps
Drains
Propos
Irrigati
Drainag

2.1.1.2 Knights Landing Ridge Cut Cross Canal to Interstate 5

Existing Function and Constraints

Knaggs Ranch farms two parcels in the Bypass, which are primarily used to cultivate rice. Additionally, Knaggs is currently in the process of buying a property just south of the current property line. Improvements to the irrigation and drainage system at Knaggs are currently underway, including installation of a new main pump station ("New Pump Station" on Figure 2), extensive canal cleaning and rebuilding as well as field leveling to accommodate multiple uses such as habitat enhancement. In addition to rice farming, Knaggs participates in the National Audubon Society shorebird habitat variable drawdown program and is in the third year of a Yolo Bypass Floodplain Fishery Enhancement Pilot Study to evaluate winter rearing habitat requirements and preferences of juvenile salmonids on rice fields (UCD & DWR, 2012).

Knaggs Ranch is primarily supplied by diversions through two control structures near Wallace Weir and by supplemental well water (see Figure 2). Wallace Weir road deck elevations on the permanent structure sit at 28.4 feet NAVD88, with 2013 earthen berm elevations sloping down to approximately 24 feet NAVD88 on the western end. Field elevations at the northwest corner of the Knaggs property sit at 24 ft NAVD88 and slope to the east on a field-by-field basis to about 10 feet NAVD88 near the Toe Drain at the southeast corner. After the recent system improvements, rice farming operations on Knaggs are able to flood fields in a two- to three-day period to compete with weeds, but prior operations flooded fields in a 10- to 15-day period. Planting proceeds in about a 3-week sequence. After about 110 to 120 days from seeding, all drain boards are pulled and fields drain over an approximately 3-week period. Harvest occurs at approximately 145 days from seeding, or 30 days after drainage. Fields are then flooded as soon as possible after harvest for waterfowl management. From February through March, Knaggs implements a variable drawdown regime for shorebird habitat management. During flood periods, impacts to Knaggs are primarily in the vicinity of Cache Creek Overflow Weir. Some scour occurs on the north side of a berm just north of the City of Woodland historic sewer ponds (see Figure 1). Additionally, seepage due to ponded water in the Cache Creek Settling Basin impacts Knaggs' farming operations by delaying planting of western fields and may result in salt extrusion to soils in the Bypass.

Improvements

Knaggs managers have identified improvements to Wallace Weir as necessary to improve water supply management. A specific example of the need for improvement at this location occurred in early spring 2012. The timing and magnitude of available upstream runoff and diversions to flood rice fields in the Glenn-Colusa Water District can typically occur sooner than in the Yolo Bypass. Due to upstream diversions around the time when the earthen berm was installed, water levels in the Wallace Weir diversion pool were inadequate for diversion into the Knaggs supply system. This was exacerbated by minimal runoff immediately after weir installation delaying Knaggs diversion until water levels rose to an adequate level. These instances can delay planting dates. An improvement at Wallace Weir would be to install an adjustable height structure for improved control to allow earlier or more reactive

impoundment (e.g. to runoff events) if necessary. See Appendix A and Section 3.2 for details on recommended projects.

Several BDCP Conservation Measure 2 projects target similar needs to improve water supply facilitated by Wallace Weir or to change seasonal operations to facilitate seasonal habitat needs. Specifically, the following were identified as BDCP Conservation Measure 2 Component Projects relevant to Wallace Weir potential future operations:

- Component Project 3: Fish-Rearing Pilot Project at Knaggs Ranch (not to exceed 10 acres) - (Phase 1 or before, Category 1 Action)
- Component Project 4: Expanded Fish Rearing at Knaggs Ranch - (Phase 1 or 2, Category 3 Action)
- Component Project 13: Use of Supplemental Flow through Knights Landing Ridge Cut - (Phases 1 and 2, Category 3 Action)

Finally, Knaggs Ranch may benefit from a Bypass-wide recommendation to replace key agricultural crossings (e.g. along the Tule Canal as discussed above) for improved access and drainage and reduced maintenance, as well as potential involvement in a Coordinated Maintenance and Improvement Reimbursement Program as suggested for the entire Bypass in Appendix A and Section 3.2 of this report.

2.1.2 CENTRAL YOLO BYPASS –INTERSTATE 5 TO INTERSTATE 80

2.1.2.1 Conaway Ranch

Existing Function and Constraints

Conaway Ranch (Conaway) farms approximately 6,500 acres in the Yolo Bypass (see Figure 3), primarily as rice. Approximately 1,400 acres have been entered in the Natural Resource Conservation Service (NRCS) Environmental Quality Incentive Program Bay Delta Initiative for Waterbird Habitat for heterogeneous mudflut habitat by variable field by field drawdown. Additionally, Conaway is managed for giant garter snake (GGS) habitat.

Conaway is supplied primarily by Sacramento River lifted by the Sacramento River Pumping Station with a capacity of 400 cfs. The Tule Canal Siphon conveys flow under the Toe Drain to the Conaway Cross Canal. The siphon is undersized, however, compared to pump and canal capacity for 400 cfs. The Cross Canal has a bottom width of approximately 50 to 75 feet and side slopes of 2 horizontal to 1 vertical or flatter, running immediately south of County Road 22 (see Figure 3). Additionally, Cache Creek summer low flows through the Settling Basin are diverted under County Road 22 into the Cross Canal. The Conaway Main Canal supplies water southward along the toe of the west Bypass levee, with three agricultural crossings accessing from outside the Bypass (Figure 3). Water is generally supplied and drained in ditches from the north to south, then west to east direction. Land elevations slope from approximately 25 feet NAVD88 at the northwest corner to 15 feet at the southeast corner near the Toe Drain (DWR, 2005). Three main drains exit the closed system with single 42 to 54 inch culverts with slide gates, the largest being at the Toe Drain just north of Swanston Ranch. The ditch along the southern

boundary of Conaway functions as a dual supply and drainage pathway. Conaway managers are currently studying internal drainage constraints with a report scheduled to be completed spring of 2014.

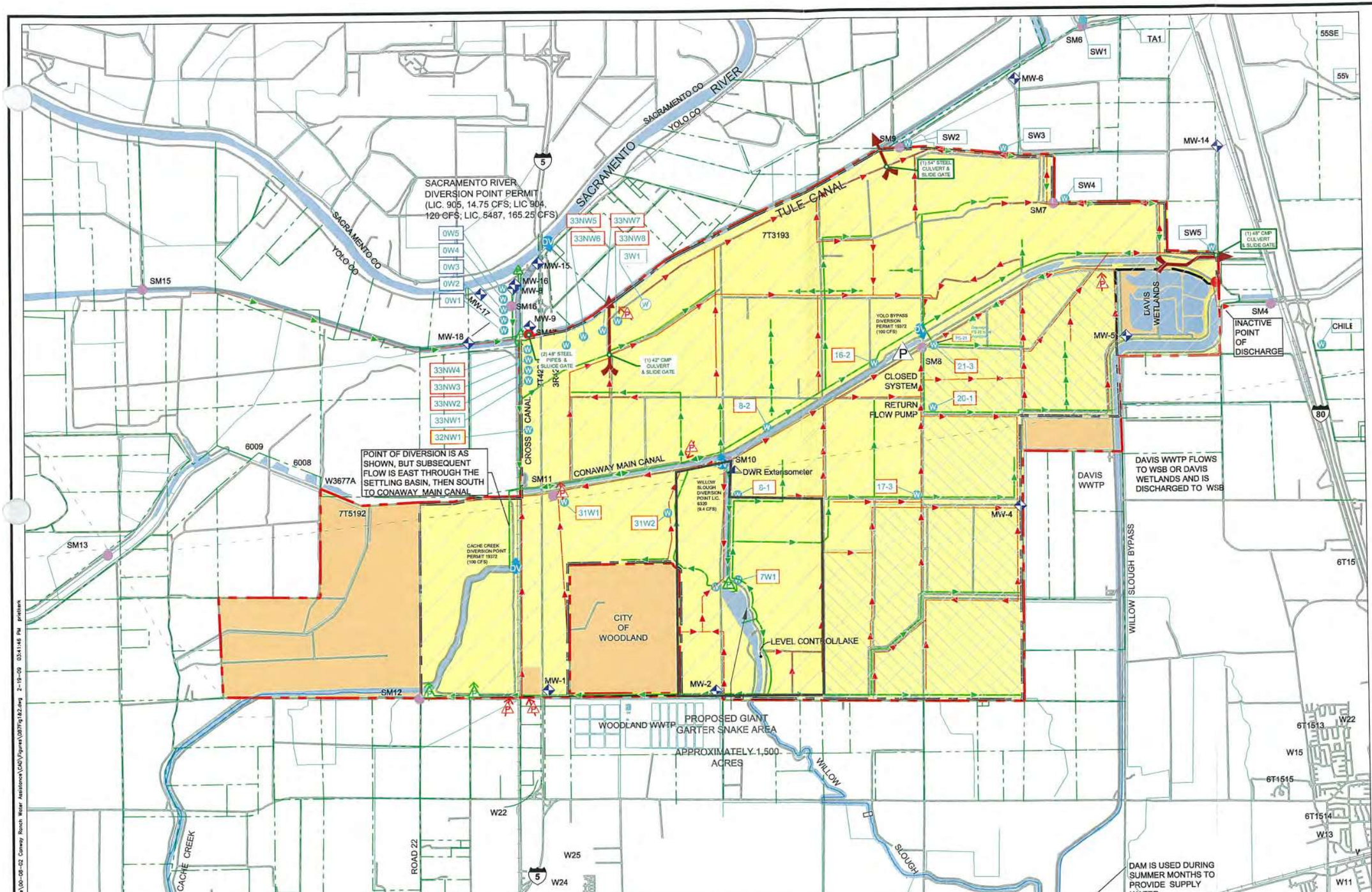
Maintenance operations on Conaway include maintaining canals and ditches on a field-by-field basis dependent on yearly or seasonal needs. Beaver activity causes drainage impediments that can require removal on a weekly or more frequent basis especially during flood and drain periods. The earthen berm on the south side of the Conaway Cross Canal requires repair after flood events due to scour caused by the concentration of high velocity flows within the constrained area between the Toe Drain and the parallel berm in this vicinity. Bypass inundation also results in siltation within the Cross Canal, resulting in a need for canal rehabilitation. Cross Canal berm rehabilitation can be delayed by late flood events which have the potential to impact supply to the entire ranch inside and outside the Yolo Bypass. It should be noted that water management on Conaway Ranch includes future supply to the Davis-Woodland Water Project, though the two systems will be structurally separate. See the Davis-Woodland Water Supply Project Final Environmental Impact Report for details (City of Davis, 2007).

Improvements

The main infrastructure project suggested to improve supply conditions on the Conaway Ranch includes reinforcing the Cross Canal with concrete lining along the eastern half of the southern berm to reduce maintenance needs after Yolo Bypass flood events and improve the security of supply. An alternative to secure Conaway's irrigation supply at the Cross Canal involves modifying the Tule Canal Siphon Intake to a design flow of 400 cfs and constructing a box culvert facility across the Bypass, sealed from flood inundating flows, to minimize scour and siltation issues. See Appendix A and Section 3.2 for details on recommended projects.

Conaway Ranch lies within Reclamation District 2035, and receives surface water from the Sacramento River Pumping Station. The pump intake is currently unscreened and therefore could possibly entrain anadromous salmonids. RD 2035 entered into an agreement with the Woodland Davis Clean Water Agency to jointly finance, construct and operate a new water intake facility that would be compliant with fish screening and Central Valley Flood Protection Board encroachment permitting. The Conaway Preservation Group and the cities are pursuing funding for this project, so it is not included in the list of recommended projects in this report. It is a good candidate for the list of projects if it is not funded in the next year. More information about additional specific drainage constraints and suggested improvements should become available after the completion of Conaway's internal drainage study in spring of 2014.

Drainage could also be improved by implementing electronic controls on main drain slide gates to allow for remote-controlled operation as access to the manually control slide gates is often not possible during floods. In addition, the Conaway Ranch may benefit from a Bypass-wide recommendation to replace key agricultural crossings for improved access and drainage and reduced maintenance, as well as potential involvement in a Coordinated Maintenance and Improvement Reimbursement Program as suggested for the entire Bypass in Appendix A .


SACRAMENTO RIVER
DIVERSION POINT PERMIT
(LIC. 905, 14.75 CFS; LIC 904,
120 CFS; LIC. 5487, 165.25 CFS)
SACRAMENTO RIVER
SACRAMENTO CO
YOLO CO
TULE CANAL
SM15
SM16
SM9
SM6
SM7
SM8
SM10
SM11
SM12
SM13
SM4
INACTIVE
POINT
OF
DISCHARGE
MW-1
MW-2
MW-4
MW-5
MW-6
MW-9
MW-14
MW-15
MW-16
MW-17
MW-18
SW1
SW2
SW3
SW4
SW5
TA1
55SE
7T3193
7T5192
6009
6008
W3677A
33NW5
33NW6
33NW7
33NW8
3W1
0W5
0W4
0W3
0W2
0W1
33NW4
33NW3
33NW2
33NW1
32NW1
31W1
31W2
7W1
16-2
21-3
20-1
8-2
8-1
17-3
(1) 54" STEEL CULVERT & SLIDE GATE
(1) 48" CMP CULVERT & SLIDE GATE
(2) 48" STEEL PIPES & SLUICE GATE
(1) 42" CMP CULVERT & SLIDE GATE
YOLO BYPASS DIVERSION PERMIT 19372 (100 CFS)
CLOSED SYSTEM
RETURN FLOW PUMP
DAVIS WETLANDS
DAVIS WWTP
DAVIS WWTP FLOWS TO WSB OR DAVIS WETLANDS AND IS DISCHARGED TO WSB
POINT OF DIVERSION IS AS SHOWN, BUT SUBSEQUENT FLOW IS EAST THROUGH THE SETTLING BASIN, THEN SOUTH TO CONAWAY MAIN CANAL
CONAWAY MAIN CANAL
CROSS CANAL
DWR Extensometer
WILLOW SLOUGH DIVERSION POINT LIC. 6329 (9.4 CFS)
CACHE CREEK DIVERSION POINT PERMIT 19372 (100 CFS)
CITY OF WOODLAND
WOODLAND WWTP
PROPOSED GIANT GARTER SNAKE AREA
APPROXIMATELY 1,500 ACRES
LEVEL CONTROL/LAKE
WILLOW SLOUGH BYPASS
WILLOW SLOUGH
CACHE CREEK
ROAD 22
DAM IS USED DURING SUMMER MONTHS TO PROVIDE SUPPLY
W22
W25
W24
W15
W13
W11
6T15
6T1513
6T1515
6T1514
80
5

2.1.2.2 Swanston Ranch

Existing Function and Constraints

Swanston Ranch is an approximately 2,400-acre area with several parcels under United States Fish and Wildlife Service (USFWS) conservation easements. Several private duck club owners utilize the area for hunting purposes. Farming primarily occurs in the southeastern parcels. One parcel is also owned by CDFW. The irrigation supply system, originally designed for rice farming, operates by lifting water from the Toe Drain into a canal that runs northward through the Thompson property, as well as by control at the risers in the Willow Slough low flow channel (see Figure 4). The Swanston Ranch temporary agricultural crossing impounds water in the Toe Drain for diversion and consists of three culverts, one six-foot open culvert, and two four-foot culverts with boards at the intakes and earth fill. Water supply is also supplemented by wells.

Once the system is closed in the summer, no water is pumped from the Toe Drain. In the fall, fields are flooded as early as possible in late September to fully charge the system for mid-October duck hunting season. Pumping into the fields typically ceases by mid-December when the system is fully charged and as the duck hunting season comes to a close in January. High tides, especially during king tide periods in December, improve supply but can also cause high velocities that scour the Swanston temporary agricultural crossing shown on Figure 4. In the spring, water is typically drained off the fields around April to comply with mosquito abatement. Swanston wetland managers have expressed interest in managing for brood pond, or semi-permanent wetland habitat used for waterfowl rearing, where water would be left to evaporate or fed into such areas into the summer.

Drainage after large flood events on Swanston Ranch is primarily concentrated southward along the western levee toe then eastward in the Willow Slough low flow channel, along the railroad abutments toward the Toe Drain. Additionally, floodwaters recede overland to the Toe Drain. Access from the western levee to the main internal road system (Figure 4) is often restricted for consecutive days when the Willow Slough Bypass is conveying flood flows from upstream, reducing the number of hunting days on Swanston. This crossing has eight 48-inch culverts in parallel with an earth deck. See Appendix B for more detail regarding Willow Slough inflows. Land elevations slope from about 14 feet NAVD88 at the northwest corner of the Calfee property to 11.5 NAVD88 feet at the railroad abutments along the railroad tracks. An historic drainage pathway from the southeast corner of the Dougherty property connects to the Toe Drain immediately upstream of the Interstate 80 causeway. An additional historical pathway exists under the Interstate 80 and railroad abutments on the western edge of the Bypass. This location is filled in with sediment and does not perform a significant drainage function. Frequent maintenance operations are required on Swanston Ranch to keep canals free from blockages created by beavers during the flood and drain periods and annual maintenance is needed to clean canals of vegetation and sediment.

The Swanston Ranch group of landowners and managers are in the process of developing a mutual water company to utilize cost sharing to address maintenance, supply and drain operations on a per

acre basis. This process and organization may serve as a model for other regions in the Bypass in the future to deal with land and water management.

Improvements

Improvements at Swanston Ranch include replacing priority agricultural culvert crossings to reduce maintenance needs due to beaver blockages and to improve access during periods when Willow Slough Bypass conveys flow from the west. Some crossing locations along the main access road have existing control structures that should be assessed for conveyance. Existing culvert crossings, such as (but not limited to) those shown on Figure 3 can be replaced with railcar crossings with concrete abutments. This improvement falls under the Bypass-wide recommendation to replace key agricultural crossings for improved access and drainage and reduced maintenance (see Appendix A). In addition, Swanston Ranch may benefit from potential involvement in a Coordinated Maintenance and Improvement Reimbursement Program as suggested for the entire Bypass in Appendix A. See Section 3.2 for details on recommended projects.

Notes: Red circles denote potential culvert crossings for replacement under Project 11: Local Agricultural Crossing Improvements. Aerial courtesy of BingMaps, 2009.

cbec eco engineering

Yolo Bypass Drainage and Water Infrastructure Improvement Study

Swanston Ranch – Existing Function

Project No. 12-1039	Created By: AMS	**Figure 4**

2.1.3 CITY OF DAVIS INPUTS TO THE YOLO BYPASS

2.1.3.1 North of Interstate 80

Existing Function and Constraints

The Yolo Bypass receives winter stormwater and summer tailwater returns or effluent from the Willow Slough Bypass, Davis Wetlands and Davis Wastewater Treatment Plant (see Figure 5 for a regional map of the general drainage patterns from the City of Davis). Channel A is a main drainage pathway conveying winter stormwater from most of Davis north of Interstate 80 as well as summer tailwater returns from fields in the vicinity. Summer tailwater typically proceeds directly into the Willow Slough Bypass. In the fall and winter, water is lifted at a pump near the junction of Channel A with the Willow Slough Bypass and conveyed to the City of Davis Wetlands (Davis Wetlands). Constraints are associated with the ability to pump water out of Channel A up to a smaller canal that routes water from the south side of the Willow Slough Bypass to the north side and into the Davis Wetlands (Figure 5). During the summer and fall months, the water is too low in the channel for the pump as designed. A secondary issue, currently faced in the winter, is channel conveyance capacity. Once the stormwater ponds fill to a certain level, water backs up into the conveyance channel and overflows at low areas. The current conveyance configuration can also result in poor water quality entering the Bypass and flooding at the Swanston Ranch west levee access. Some wastewater treatment plant effluent is also treated in the Davis Wetlands. First flush rain events carrying higher concentrations of pollutants are sometimes conveyed for treatment in the Davis Wetlands, but not all events.

Improvements

Improvements to City of Davis drainage diversion where Channel A meets the Willow Slough Bypass may improve water quality conditions in the Yolo Bypass. Replacing and modifying water conveyance structures along the Channel A input to Willow Slough for diversion to the Davis Wetlands for treatment may enhance the reliability of capturing first flush events originating in Channel A. See Table A-1 for a comparative description of this potential project and Section 3.2 for details on recommended projects.

2.1.3.2 South of Interstate 80

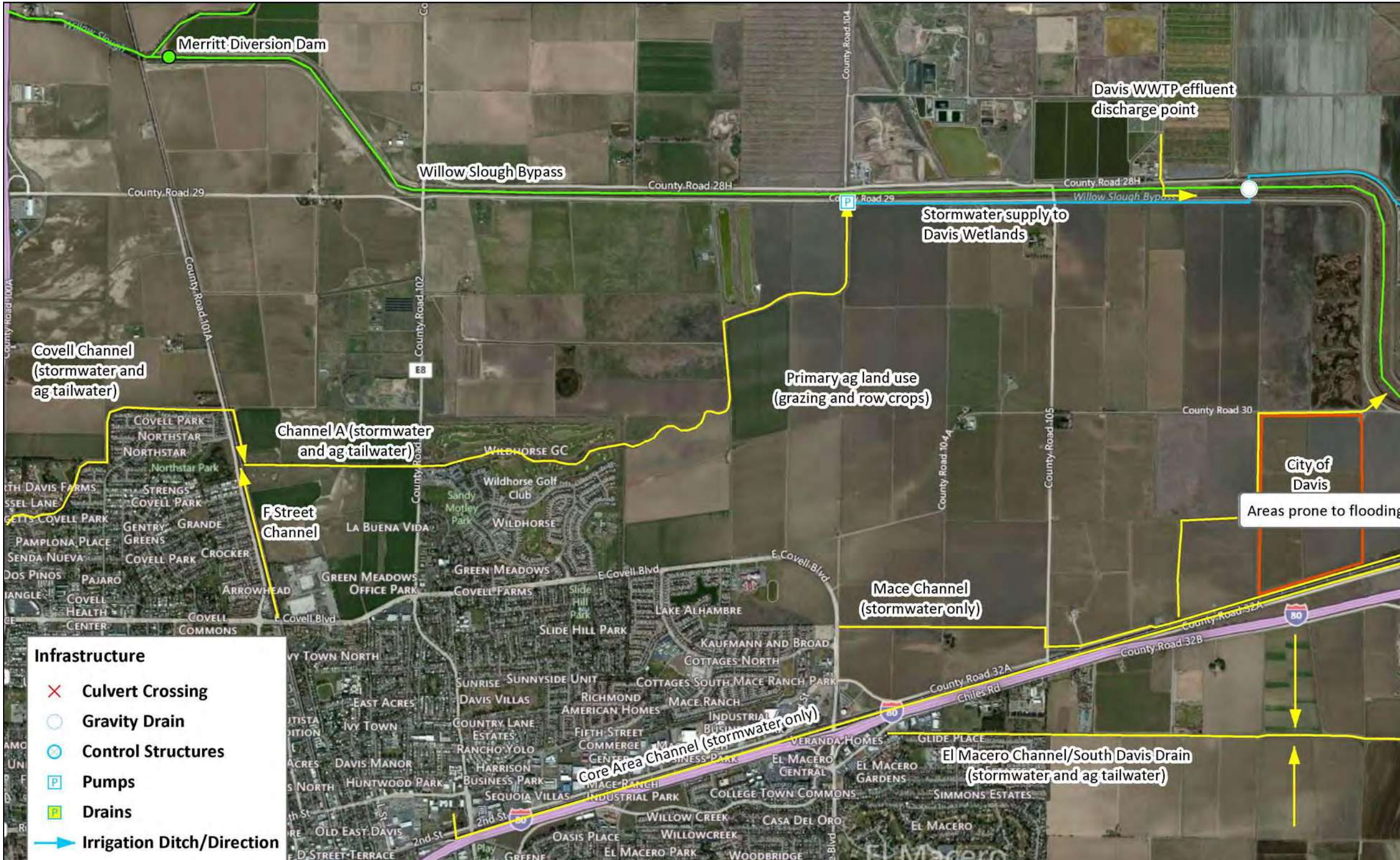
Existing Function and Constraints

South Davis stormwater and agricultural tailwater runoff from surrounding fields are conveyed by the El Macero Channel or South Davis Drain (see Figure 5). This channel runs from Davis to the Yolo Bypass west levee where the El Macero Pumping Station operates two 250 HP pumps and one 40 HP pump during winter months to drain stormwater runoff. It drains agricultural tailwater through the levee into the Bypass. The pumped water can overwhelm the ability of the Yolo Bypass Wildlife Area to drain effectively, creating ponded conditions and wet soil conditions. This can impact access for public use and O&M on some roads on the west side of the Yolo Bypass Wildlife Area. It can also limit the ability to drain as needed for optimum moist soil management. Moist soil management practices are used by Yolo

Bypass Wildlife Area and duck club managers to encourage growth of seed-producing native wetland plants by mimicking seasonal wet and dry cycles of natural wetlands. Moist-soil habitats are wet during spring, dry during summer, and wet again during fall and winter. The Yolo Bypass Wildlife Area system is typically already at capacity when the El Macero pumps are turned on in the winter. These impacts to the system are due to the road configuration, flood time water levels and canal capacity and condition (e.g. location of beaver blockages, vegetation thickness and canal capacity loss due to sedimentation). In addition, if runoff rates exceed the ability of these pumps to convey water into the Yolo Bypass, accumulation can occur on adjacent farmland area and potentially impact winter or early spring farming operations for winter wheat and rice. This scenario is common in many locations in the Yolo Bypass as pumping outside water into the Bypass impacts operations.

Improvements

The suggested improvement at this location near the South Davis Drain includes lowering an existing gravity drainage pipe to relieve flood pressure. With the current configuration, the gravity drain culvert south of the South Davis Drain sits at a relatively high elevation. By lowering this culvert, drainage pressure on the El Macero pumps could potentially be reduced. In addition, this entry point is further south of the main public and O&M access roads to the Yolo Bypass Wildlife Area. Changes to canal configurations (e.g. converting dual function supply and drain canals to separate canals) in the Yolo Bypass Wildlife Area could cause culvert drain lowering at the west levee to be unnecessary. See Section 2.1.4.1 below for more details on Yolo Bypass Wildlife Area operations and suggested improvements and Section 3.2 for details on recommended projects.


Merritt Diversion Dam
Willow Slough Bypass
Davis WWTP effluent discharge point
Stormwater supply to Davis Wetlands
Covell Channel (stormwater and ag tailwater)
Channel A (stormwater and ag tailwater)
Primary ag land use (grazing and row crops)
F Street Channel
Mace Channel (stormwater only)
City of Davis
Areas prone to flooding
Core Area Channel (stormwater only)
El Macero Channel/South Davis Drain (stormwater and ag tailwater)
County Road 29
County Road 28H
County Road 104
County Road 101A
County Road 102
County Road 105
County Road 104A
County Road 30
County Road 32A
County Road 32B
E Covell Blvd
Chiles Rd
2nd St
Infrastructure
Culvert Crossing
Gravity Drain
Control Structures
Pumps
Drains
Irrigation Ditch/Direction

2.1.4 SOUTHERN YOLO BYPASS –INTERSTATE 80 TO NORTH OF YOLO RANCH

2.1.4.1 Northern Yolo Bypass Wildlife Area – North of Lisbon Weir

Existing Function and Constraints

The Yolo Bypass Wildlife Area is a 16,770-acre area of farmland, managed wetlands and pasture. The existing supply and drainage infrastructure for this area has been mapped by Ducks Unlimited in coordination with Wildlife Area managers in recent years (Figure 6, Petrik, 2012). The land is managed for multiple uses with varying water supply and drainage needs during the year. There are approximately 6500 acres of managed wetlands located throughout the Yolo Bypass Wildlife Area. Rice farming is done on 1500-acre Glide Causeway Ranch, under a lease with DeWit Farms.

The Toe Drain serves as the main supply source for fall flood up of the managed wetlands from October to December, that is necessary to maintain water levels throughout the winter as well as during the spring and early summer months for moist soil management. Moist soil habitat that produces seed and other food for waterfowl are wet during spring, dry during summer, and wet during fall and winter. The US Army Corps of Engineers initially funded drainage and supply infrastructure facilities and habitat restoration through Section 1135 funds. Ducks Unlimited and the California Waterfowl Association improved the wetlands infrastructure later using grants from the North American Wetland Conservation Act (NAWCA).

Rice grown on Glide Causeway Ranch immediately south of Interstate 80 (located completely within Yolo Bypass Wildlife Area) and bounded to the east and west by managed wetlands, requires spring flooding and fall drainage and then a post-harvest flood up while the adjacent wetlands typically require spring drainage and fall flooding. The Glide Causeway Ranch rice fields are also managed for winter waterfowl and summer shorebird habitat (CDFW, 2008). Coordinating the timing and location of these multiple uses often presents management challenges, especially because several main conveyance pathways function as dual drainage and supply canals (purple arrows on Figure 6).

Beaver blockage removal, vegetation maintenance and sediment removal to maintain conveyance in canals occurs on a weekly to yearly basis depending on specific location and management needs. Canals oriented north-south typically require less maintenance than those oriented east-west due to scouring flows from inundation. Spraying for noxious weeds, including water primrose, occurs twice per year. Removal of silt occurs on an as needed basis. Beaver blockages are removed on an as needed basis, but can be needed weekly or sub-weekly. In the vicinity of the historic railroad trestles in the lower part of the Yolo Bypass Wildlife Area, canal maintenance is particularly challenging due to elevated beaver activity (see Figure 6).

Lisbon Weir creates a tidal backwater pool in the Toe Drain that provides the primary irrigation source for the Yolo Bypass Wildlife Area. Water is lifted by a series of pumps located throughout the Yolo Bypass Wildlife Area as described in the Yolo Bypass Wildlife Area Land Management Plan (CDFW, 2008), denoted in Figure 6. The elevated pool created by the Lisbon Weir holds the water that flows in

during high tide. Lisbon Weir consists of a porous rock structure with a crest elevation ranging from 5.0 feet at the crest thalweg to approximately 5.8 feet NAVD88 along the cobble crest as surveyed in the late spring of 2013 by cbec staff. Three steel flapgates to the immediate west of the rock structure trap water at low tides and have an overtopping elevation of approximately 4.7 feet NAVD88.

Lisbon Weir is owned by CDFW and managed and maintained by the Mace Irrigation System agreement (CDFW, and AKT (Los Rios Farms and Alhambra Pacific Joint Venture)). In most years (especially after major flood events), Los Rios performs maintenance operations on the rock structure. An excavator is walked out from the east levee and reclaims cobbles from the pool downstream of the weir placing them back on the crest. This effort typically takes one day with one operator and one supervisor plus planning efforts. The crest elevation of the rock is based on the working knowledge of the managers and operators. Rock is replaced approximately every 4 to 5 years or as needed. This effort takes approximately 2 to 3 days plus planning. The last time rock was replaced, 5 loads were added to the crest. These operations are relatively low cost and easily implemented by Los Rios.

Nine drainage canals convey water toward the Toe Drain between the railroad tracks north of I80 above Lisbon Weir. Two main drainage pathways are open channel connections to the Toe Drain (see Figure 6). One pathway is Putah Creek's straight channel east of the Los Rios Check Dam, a flash-board riser dam. The other pathway is the dual canal north of the Putah Creek outflow with the main lift pumps for the Yolo Bypass Wildlife Area. During periods of flooding, Putah Creek flows out of bank upstream of the Los Rios Check Dam for flows greater than 1,000 cfs with the boards removed, requiring periodic road maintenance within the Yolo Bypass Wildlife Area. The stop logs (or boards) controlling the Los Rios check dam are removed by December 1 each year as mandated by the Putah Creek Accord.

A CEQA analysis for a Lower Putah Creek realignment is currently underway with funding from the California Department of Fish and Wildlife (CDFW) Ecosystem Restoration Program. This grant is managed by the Yolo Basin Foundation (YBF) and is currently in the concept design planning stages. The realignment would move Putah Creek flows through the Tule Ranch south to the tidal wetlands just south of Lisbon Weir. This action is in the Salmonid Biological Opinion, Lower Putah Creek Enhancement (RPA I.6.3)

Several drains have culvert crossings or control structures (sluice gates/stop logs) at the Toe Drain depending on whether the canal functions as a dual supply/drain or solely as a drain. Culvert outfalls to the Toe Drain on the Yolo Bypass Wildlife Area are typically 36 to 48 inches in diameter from main drains and 18 to 24 inches from local field drains.

Public and O&M access during flood periods is a key concern and constraint for Yolo Bypass managers. Specific locations, with low lying road elevations such as the "Rice Corner" and the "Y" on Figure 6, or locations 1 and 2 on Figure A-5, have restricted access during the early stages of flooding. As the Ducks Unlimited (2012) study found, Fremont Weir overtopping impacts public access to the Yolo Bypass Wildlife Area, with an average of 14 days of closures during the duck hunting season from mid-October to January. This is usually followed by 2 to 3 weeks of drying time before public access is resumed.

Drainage from South Davis via the El Macero Channel (South Davis Drain) also contributes to flooding along the main driving route for public and O&M access.

Improvements

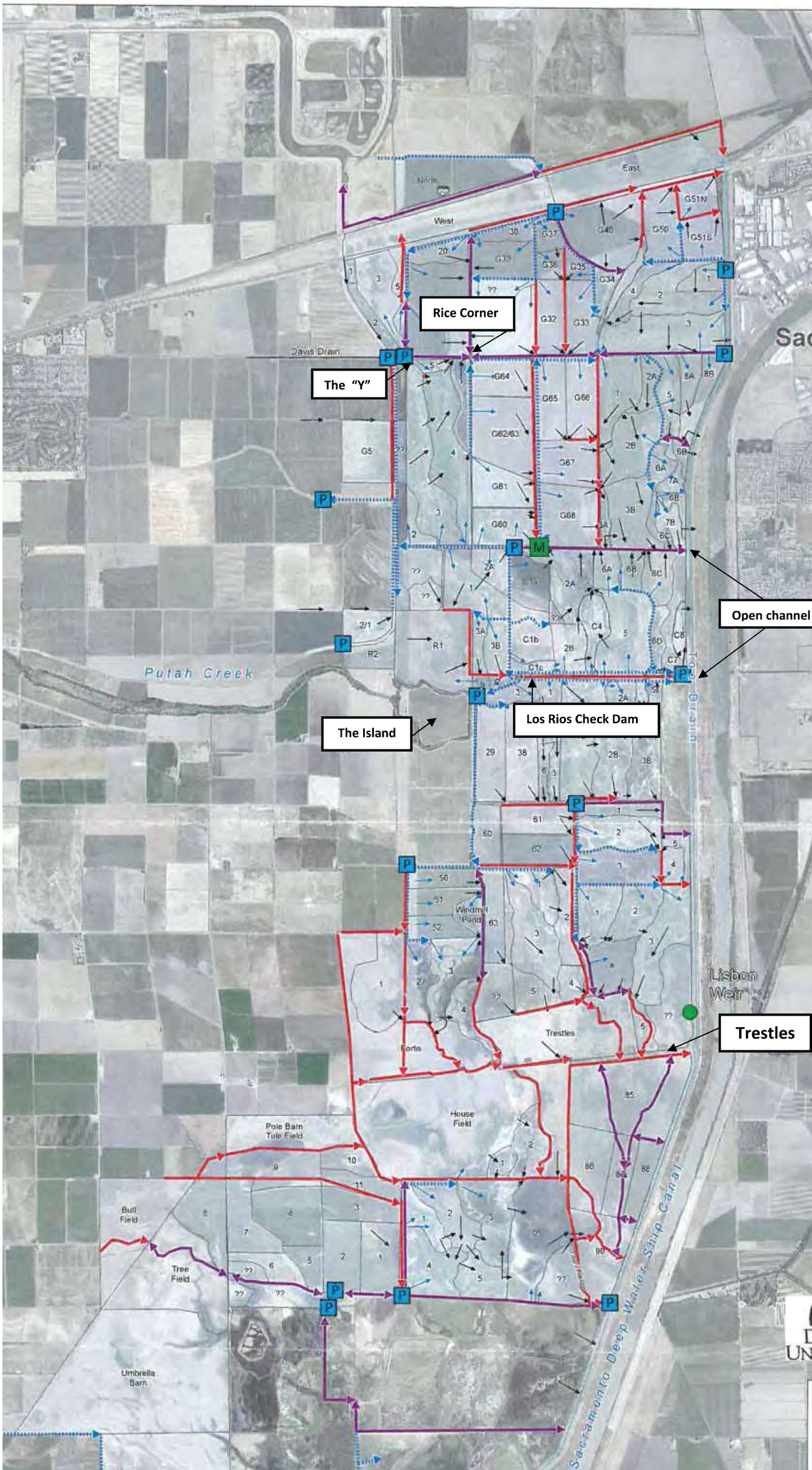
Several improvements have been suggested to benefit the multiple uses within the Yolo Bypass Wildlife Area. The following improvements are summarized in Appendix A, Table A.1 and synthesized into more detailed project descriptions in and Section 3.2.

Suggested O&M improvements include augmenting the gravel on the main public access and O&M roads, raising low roads inundated during early stages of flooding (e.g. at the "Rice Corner"), expansion of the drainage canals and installation of larger diameter culverts along the Toe Drain, and reconfiguration of the dual supply and drainage canals. Reconfiguration of the canals consists of creating separate parallel ditches to facilitate multiple uses with variable temporal and spatial operational needs. Main dual pathways suggested for reconfiguration are prioritized in Appendix A, Figure A-7. In addition, the "Second Lift" along the dual supply to Los Rios has been identified for replacement to improve supply, see Figure A-7.

Improvements to key agricultural crossings will increase access and facilitate equipment crossing. Several agricultural crossings have been identified in prioritized order for improvement and are included in Appendix A, Figure A-10. At the "Rice Corner" and the "Y", low road elevations combined with the convergence of three dual drains and a single supply canal present operational challenges. Reconfiguration would alleviate flooding of roads as well as improve operations of water delivery and drainage. At the existing rail car crossing to the "Island", the rip-rap abutments to the rail car crossing do not support heavy equipment access to the "Island" and need improvement or replacement. At the Los Rios Check Dam, suggested improvements include increasing the maximum load (currently 20 tons) and widening the existing deck (currently 16 feet wide) to facilitate equipment crossing. The existing Check Dam crossing has one handrail; some equipment can only cross in one direction. Equipment typically transported includes: discers, mowers and excavators. Rice production could be planned in the future on the fields immediately south of the Check Dam, thus rice harvesters would also need to be transported. An additional 2 to 4 feet in width on this crossing would improve safety and operations.

Changes at Lisbon Weir could potentially improve summer supply availability or drainage given favorable tides in conjunction with other drainage improvements mentioned above. Potential changes include installing an adjustable height structure as well as more flap gates or easily removable gates, enhancing the gate technology to control gate operations remotely, and increasing the Lisbon pool capacity by dredging or widening the Toe Drain in this vicinity.

Other efforts have also identified Lisbon Weir for improvement, specifically BDCP Conservation Measure 2 Component Project 10: Lisbon Weir Improvements (Phase 1, Category 3 Action) and the NMFS 2009 Biological Opinion RPA Action I.6.4 to improve the reliability of agricultural diversions and reduce maintenance requirements while providing better fish management opportunities in Putah Creek and the Toe Drain (NMFS, Appendix 2A, 2009).


Rice Corner
The "Y"
Open channel
Los Rios Check Dam
The Island
Trestles
Putah Creek
Davis Drain
Tule Drain
Sacramento Deep Water Ship Canal
Lisbon Weir
Windmill Pond
House Field
Pole Barn Tule Field
Bull Field
Tree Field
Umbrella Barn
Trestles
East
West
North
G5
G60
G61
G62/63
G64
G65
G66
G67
G68
G30
G32
G33
G34
G35
G36
G37
G40
G50
G51N
G51S
C1b
C1c
C4
R1
R2

2.1.4.2 Los Rios Farms

Existing Function and Constraints

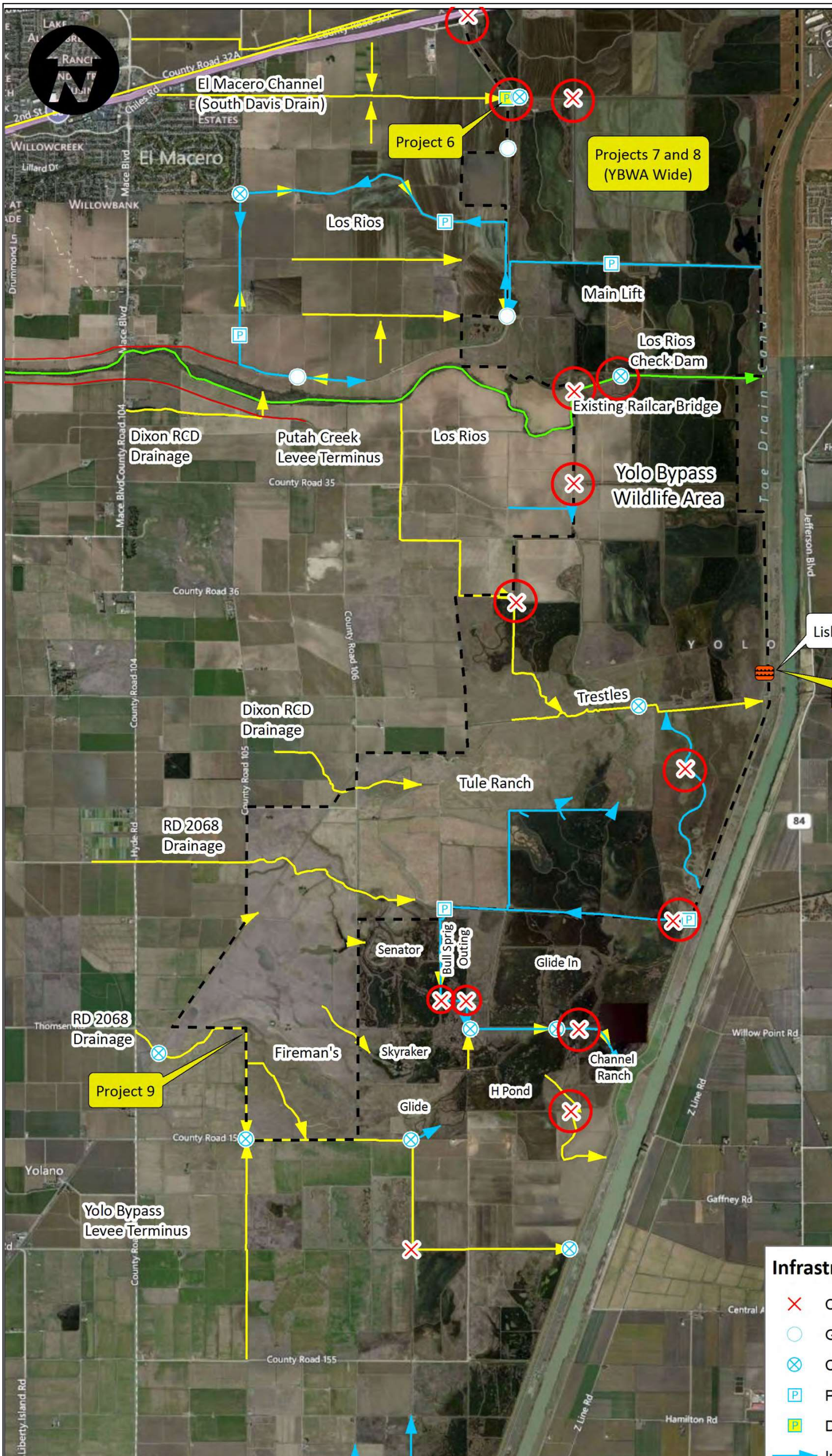
Los Rios Farms owns and manages farmland, seasonal and permanent wetlands, riparian habitat, and grassland communities. Los Rios is located west of the Yolo Bypass Wildlife Area and is bisected by Putah Creek. Los Rios Farms also leases land from CDFW to produce tomatoes, grain crops and rice. Los Rios further grazes cattle north of the trestles on the Tule Ranch as directed by CDFW for vegetation management in wetland ponds and adjacent uplands. Water for these operations is diverted from Putah Creek starting in the spring through July 15th and from the Toe Drain. Well water is also pumped for irrigation.

Summer water from the Toe Drain is lifted at the Main Lift in the Yolo Bypass Wildlife Area (see Figure 7) and moved toward the west levee to irrigate several thousand acres outside the west levee of the Bypass. The pumped water is moved south and through the levee (Figure 7). A dual drain and supply channel runs a loop with a control structure at the corner near the El Macero Country Club. Two central drainage ditches convey tailwater back toward the Yolo Bypass west levee.

The South Davis Drain runs through Los Rios Farms with pumps at the west Bypass levee as discussed in previous sections. A drainage ditch runs along the western levee toe with a drain pipe through the levee and into the Yolo Bypass Wildlife Area approximately 0.5 mile south of the El Macero Pumps.

Improvements

Los Rios Farms irrigation operations could benefit from improvements at Lisbon Weir. In the vicinity of the South Davis Drain, the gravity drain 0.5 mile south of the El Macero Pumps could be modified to a lower elevation to alleviate flood pressure in the region to the north, inside and outside the Bypass. See Table A-1 for a comparative description of the Libson Weir. Improvements to agricultural crossings mentioned in Section 2.1.4.1 (Yolo Bypass Wildlife Area – North of Lisbon Weir, refer to above section), especially the existing railcar crossing over Los Rios Check Dam on Figure 7, could benefit Los Rios drainage. The improvements could facilitate efficient drainage to the Toe Drain and reducing backwater effects that may propagate to the El Macero Pumps and the existing gravity drain. Improvements at the Los Rios Check Dam would also make it possible to bring larger equipment over the crossing.


El Macero Channel
(South Davis Drain)
Project 6
Projects 7 and 8
(YBWA Wide)
Los Rios
Main Lift
Los Rios
Check Dam
Existing Railcar Bridge
Dixon RCD
Drainage
Putah Creek
Levee Terminus
Los Rios
Yolo Bypass
Wildlife Area
Trestles
Dixon RCD
Drainage
Tule Ranch
RD 2068
Drainage
Senator
Bull Sprig
Outing
Glide In
RD 2068
Drainage
Fireman's
Skyraker
Channel
Ranch
H Pond
Glide
Project 9
Yolano
Yolo Bypass
Levee Terminus
El Macero
Willowcreek
Willowbank
County Road 32A
Chiles Rd
County Road 35
County Road 36
County Road 104
County Road 105
County Road 106
County Road 155
Mace Blvd
Hyde Rd
Liberty Island Rd
Toe Drain
Jefferson Blvd
Willow Point Rd
Z Line Rd
Gaffney Rd
Hamilton Rd
84
Y O L O

2.1.4.3 Southern Yolo Bypass Wildlife Area - Tule Ranch

Existing Function and Constraints

The Tule Ranch is an approximately 9,000-acre area located completely within the Yolo Bypass Wildlife Area (CDFW, 2008) south of Putah Creek. Tule Ranch is a combination of pasture, row and field cropland, wetlands, vernal pools and riparian areas. Schene Cattle Company grazes cattle on the Tule Ranch through a lease with CDFW. The area is depicted on the Ducks Unlimited Yolo Bypass Wildlife Area Water Conveyance Map (Petrik, 2012, Figure 6). The water supply to the Tule Ranch is sourced from the Toe Drain below Lisbon Weir or from west side drainage originating from the Dixon RCD drainage system or Reclamation District 2068 (RD 2068) (see Figure 7).

Mechanical vegetation and silt removal are primary management concerns in these areas, as discussed for the northern Yolo Bypass Wildlife Area. Late spring flooding of pastureland drowns out desirable annual rye grass and promotes cockle burr and sweet clover growth. Fields with extensive cockle burr are a nuisance for wetland managers and farmers and have low value for grazing cattle. Cockle burr requires mechanical removal adding to maintenance costs.

Improvements

Tule Ranch operations in the southern Yolo Bypass Wildlife Area would benefit from a Bypass-wide recommendation to replace key agricultural crossings for improved access and drainage and reduced maintenance as well as potential involvement in a Coordinated Maintenance and Improvement Reimbursement Program as suggested for the entire Bypass in Appendix A, Table A.1. In addition, a noxious weed program to offset potential changes in the timing and duration of flooding would be favorable to Yolo Bypass Wildlife Area farmers and managers. Finally, Lower Putah Creek Realignment efforts should be considered in conjunction with the suggested improvements to Tule Ranch operations.

2.1.4.4 Southern Duck Clubs

Existing Function and Constraints

Several private duck clubs provide wetland habitat and hunting opportunities south of the Yolo Bypass Wildlife Area. Supply and drainage infrastructure in this area are shown on Figure 7. The Toe Drain serves as the main supply source to flood these fields from October to December during wetland flood-up and hunting season as well as during the spring and early summer months for moist soil management. Additional drainage water from the west flows out of the RD 2068 service area. Drainage within the system proceeds to a main ditch along the northern border of H Pond then through Channel Ranch to the Toe Drain (Figure 7). Several of the drainage and supply infrastructure facilities and other habitat improvements were funded through North American Wetland Conservation Act (NAWCA) grants.

Duck club operations vary from limited (e.g. allowing ponds to evaporate after hunting season) to proactive (e.g. accessing multiple times to clean out canals and remove drain boards) during the spring depending on the ownership. A caretaker for the Senator Duck Club manages water operations on that parcel and to some extent on other parcels. Beavers are very active in the area requiring frequent, sometimes daily, blockage removal especially during fall flood-up and spring drawdown. Vegetation and sediment maintenance are also primary management concerns in this area.

Improvements

Improvements to drainage conditions in this vicinity include enlarging the H Pond drain that exits through Channel Ranch and replacing the downstream-most culvert agricultural crossing on that drain with a railcar crossing (see Figure 7) to open up conveyance during inaccessible periods and reduce maintenance costs. In addition, several drains within the individual parcels could be widened. Since each parcel operates relatively independently, drainage and supply conflicts commonly arise. This area could benefit from the Bypass-wide recommendation for further study, such as identifying the potential to develop a management entity or a mutual water company. In addition, individual owners could potentially benefit from involvement in a Coordinated Maintenance and Improvement Reimbursement Program.

2.1.4.5 Westside Drainage from Dixon RCD

Existing Function and Constraints

The Dixon RCD drainage area conveys winter runoff and agricultural tailwater to two locations leading to the Yolo Bypass (see Figure 7): 1) to Putah Creek through the south Putah Creek levee approximately 1.25 miles downstream of the County Road 104 bridge and 2) into the Pole Barn Tule Field in the Yolo Bypass Wildlife Area (noted on Figure 7). The Dixon RCD drainage area is well upstream of the Yolo Bypass, however, during flood events, water surface elevations in the Yolo Bypass and Putah Creek are elevated so much that they restrict the ability of the two areas listed above to drain efficiently.

Improvements

No specific improvements have been identified. Yolo Bypass land managers' involvement in a Coordinated Maintenance and Improvement Reimbursement Program as suggested for the entire Bypass in Appendix A, Table A.1, however, may improve drainage conditions especially to the Pole Barn Tule Field in the Yolo Bypass Wildlife Area. In addition, Lower Putah Creek Realignment efforts should evaluate future management at the Dixon RCD drainage outfalls.

2.1.4.6 Westside Drainage from RD 2068

Existing Function and Constraints

RD 2068 manages contracts for drainage with Dixon RCD and the Main Prairie Water District in addition to the 13,200 acres within its actual service area. Thus, RD 2068 provides water conveyance for an area

of approximately 30,000 acres, the majority of which is outside of the RD 2068 service area. Approximately 2,160 acres or 16% of the 13,200 acres in the RD 2068 service area lie within Yolo County (Figure 7). Four main drains lead to the Yolo Bypass or surrounding area from RD 2068, three of which discharge within Yolo County:

1) At the east end of Hackman Rd. into the Tule Ranch (Yolo Bypass Wildlife Area) with an easement to the Toe Drain
2) At the east end of Midway Rd. via a control structure
3) To Shag Slough via a drainage pumping station at the southern extent of Yolo Ranch
4) To Hass Slough (outside of the Yolo Bypass), primarily during the winter months.

Improvements

Potential supply improvements to benefit RD 2068 and Yolo Bypass Wildlife Area users include the reuse of drainage water within RD 2068 and diversion of excess drain water, when available, for use by CDFW at or near the Midway Road area. Potential users of the RD 2068 recycled drain water need it for early fall and winter flood up. Water is typically available for use in the Yolo Bypass Wildlife Area mid-May through early November. It is most reliable during the irrigation season and during times when storm water is present.

2.2 ADDITIONAL BYPASS WIDE MANAGEMENT CONSIDERATIONS

2.2.1 MOSQUITO ABATEMENT

The control of vectors such as mosquitoes is a Yolo Bypass-wide management concern as the Yolo Bypass is close to population centers. The Sacramento-Yolo Mosquito and Vector Control District (SYMVCD) provides mosquito abatement services to Sacramento County and Yolo County. The SYMVCD operates under a system of Best Management Practices (BMPs) including physical, biological and chemical control. SYMVCD promotes a proactive management approach by meeting with farmers and wetland managers to produce local plans for drainage and maintenance. Additionally, the District provides ditch maintenance equipment and personnel to improve conditions in problematic breeding areas. Maintenance of vegetation and sediment within the Yolo Bypass is a key concern, including maintaining mosquito fish swales for biological control and disking fields in mosaic patterns to promote clumps of cattail rather than large stands. The reduction of pesticide use is also a key management goal.

A few locations within or near the Yolo Bypass have been identified as problematic drainage areas by the SYMVCD. The first is on the Colusa Drain at the Yolo-Colusa County Line near Dunnigan. During rice water drainage in August/September within the Colusa Drain outside of Yolo County, approximately 3 to 4 weeks before the Yolo Bypass farmers drain irrigated rice fields to prepare for harvest, the Wallace Weir backwater causes water to back up into the Teal Ridge Duck Club property and requires mosquito abatement actions (see Figure 8A). The second is near the constriction under the Interstate 80 causeway on the Toe Drain (see Figure 8B). The third is on the duck clubs in the southern Bypass where supply and

drainage are limited by a lack of the cooperative water management system between several landowners (see Figure 8C). Actions described in Section 3 and Appendix A may help improve drainage conditions in these areas and potentially reduce the need for mosquito abatement activities.

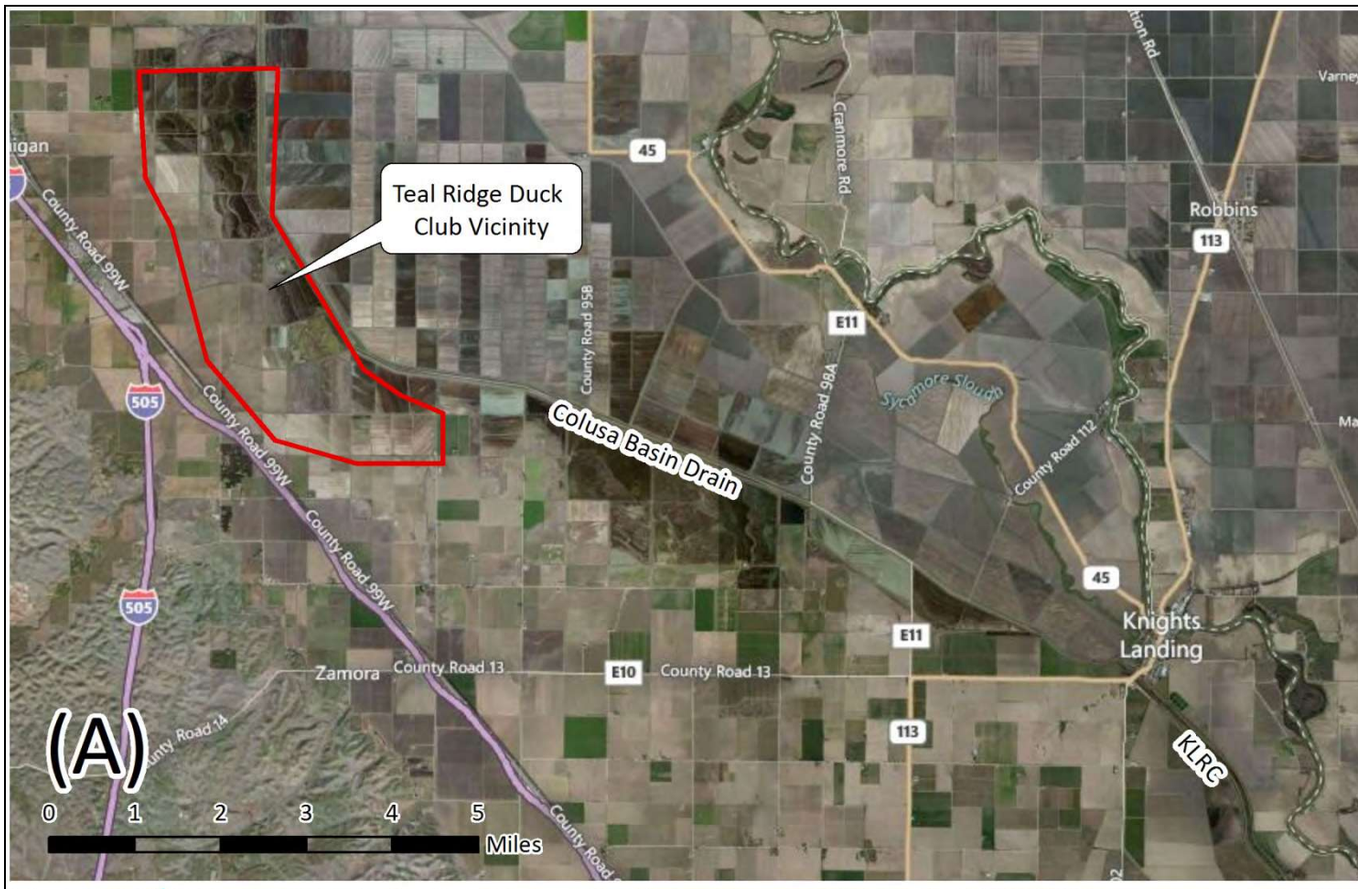
2.2.2 METHYLMERCURY PRODUCTION

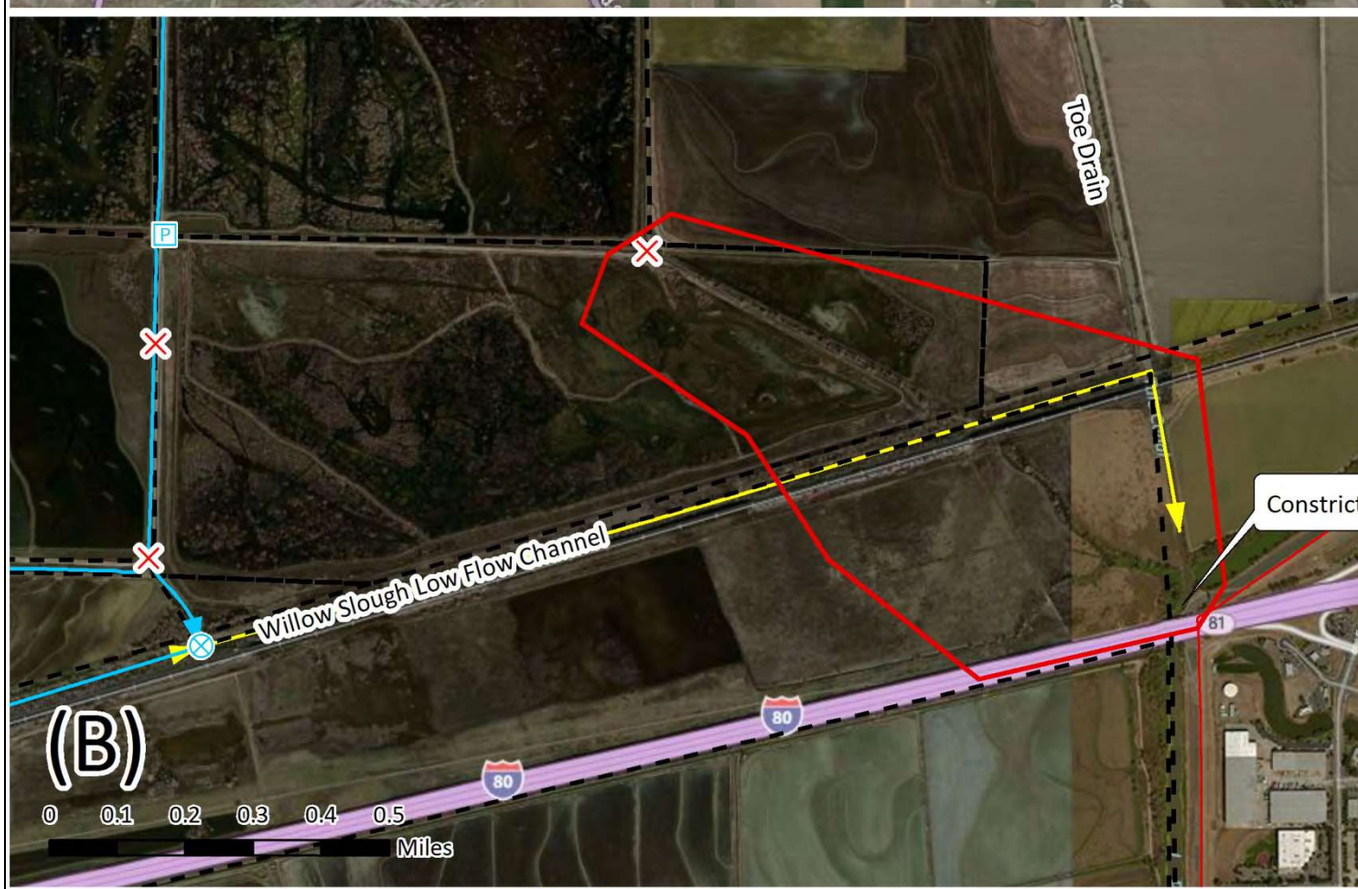
Methylmercury (MeHg) is a bioavailable neurotoxin to living organisms. It is present in the sediment and waterways of the Sacramento – San Joaquin River Delta. The biogeochemical processes driving mercury transport and transformations in surface waters are complicated, involving transport from air, tributaries, and sediments. Processes include methylation and demethylation in water and sediments, sediment-associated transport, and bioaccumulation in complex food webs.

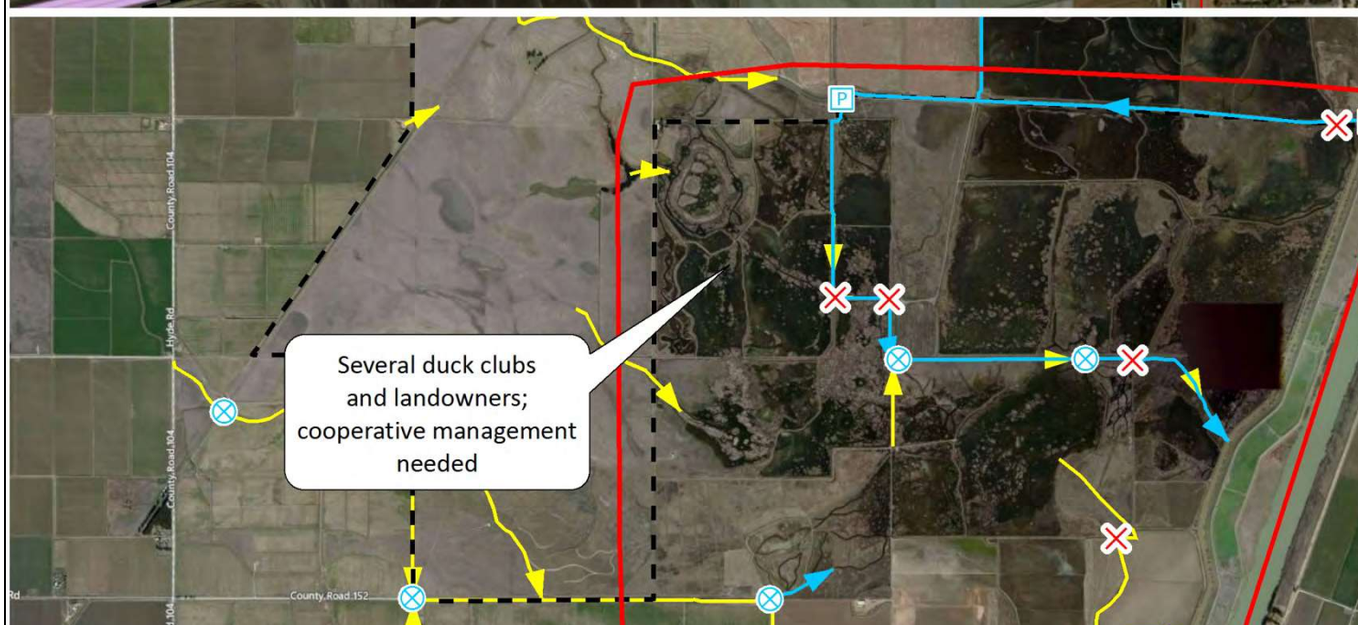
The Central Valley Regional Water Quality Control Board developed requirements for the Sacramento – San Joaquin Delta Estuary Methylmercury Total Maximum Daily Load (TMDL), to ensure that discharges to the Sacramento – San Joaquin River Delta have acceptable or lower concentrations of methylmercury (MeHg). The Board planned implementation in two phases. Phase 1, initiated October 2011 with expected completion of October 2020, is intended to focus on studies and pilot projects to develop management practices to control MeHg inputs into the Delta. Phase 2, intended to begin in 2022 and complete in 2030, will focus on implementing methylmercury control programs for dischargers as well as inorganic mercury reduction programs (Water Board, 2011).

To develop a Control Study workplan for the Phase 1 TMDL requirements, the Delta Methylmercury TMDL Nonpoint Source Workgroup for Managed Wetlands and Irrigated Agriculture (NPS Workgroup) was formed. The NPS Workgroup has recently produced reports synthesizing existing data, identifying key knowledge gaps, and proposing management strategies for the future. These reports include *Knowledge Base for Nonpoint Sources Methylmercury Control Study* (August, 2012), as well as the *Methylmercury Control Study Workplan Outline* (September 2012), which plans to prioritize studies based on issues of concern and provide guidance on developing cost-benefit analyses.

MeHg issues are important to consider during potential project implementation as future changes to agricultural discharge management will likely be required with TMDL implementation. In addition, future changes to the Yolo Bypass flooding regime as a result of BDCP CM2 or other actions may affect methylation rates or spatial distribution. Pulsed systems (e.g. seasonal wetlands and floodplains) tend to methylate more than tidal wetlands, which typically show net zero methylation (Stephen McCord, personal communication). The degree to which patterns like this can be managed by land use type is still under development by the NPS Workgroup.


Teal Ridge Duck Club Vicinity
Colusa Basin Drain
County Road 99W
County Road 95B
County Road 98A
Sycamore Slough
County Road 112
Cranmore Rd
Robbins
Knights Landing
Zamora
County Road 13
County Road 14
KLRC
45
505
E11
E10
113
(A)
0 1 2 3 4 5
Miles


Toe Drain
Willow Slough Low Flow Channel
Constrict
80
81
(B)
0 0.1 0.2 0.3 0.4 0.5
Miles


Several duck clubs and landowners; cooperative management needed
County Road 104
County Road 152
Hyde Rd

3 SELECTED PROPOSED IMPROVEMENTS

3.1 SUMMARY OF RECOMMENDED PROJECTS AND STUDIES

On April 9, 2013, the study team held a meeting to discuss specific improvements suggested by interested stakeholders during individual outreach meetings. The purpose of this meeting was to ask for stakeholder feedback regarding the identified improvements and to verify the initial findings of the study. Following that meeting, the study team continued to collaborate with additional participants by phone and email correspondence, as well as follow up with additional questions based on the initial findings. Table A-1 summarizes the main improvements identified as potentially beneficial to supply and drainage infrastructure.

As part of an initial effort to assess relative priority, the study team used feedback from participants and research into the potential benefit, permitting requirements and rough cost estimates, among other factors, for the recommended projects. Projects recommended through this study are intended to benefit agriculture and managed wetlands drainage and supply operations; however, potential overlap with existing efforts in the Yolo Bypass intended to improve fish habitat was considered for coordination purposes. These efforts include proposed measures in the BDCP's CM 2, the NMFS 2009 Biological Opinion RPAs I.6 and I.7, USBR and DWR Yolo Bypass Salmonid Habitat Restoration and Fish Passage EIR/EIS and the Fish Restoration Program Agreement between CDFW and DWR.

Appendix A provides one-page project summaries of twelve Recommended Projects from Table A.1. Some projects were suggested during the interview process and may provide unique opportunities to improve drainage and supply conditions in the Yolo Bypass for agricultural and wetland operations. Some projects overlap with concurrent efforts to improve fish habitat in the Bypass as noted in Table A.1 (e.g. BDCP, RPAs I.6 and I.7, and the Fish Restoration Program Agreement). The projects are separated into location-specific improvements (Projects 1 through 9) and Bypass-wide improvements (Projects 10 through 12). Additionally, four studies were identified for future analysis as described in Table A.1 and listed below. Details regarding the studies are provided in Table A.2.

Recommended Projects (RP) include:

- RP-1: Wallace Weir Improvements
- RP-2: Tule Canal Agricultural Crossing/Water Control Structure Improvements
- RP-3: Lisbon Weir Improvements
- RP-4: Conaway Main Supply Canal Augmentation
- RP-5: Davis Wetlands Water Supply
- RP-6: South Davis Drain Input Reconfiguration
- RP-7: Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration
- RP-8: Yolo Bypass Wildlife Area Public and Operation & Maintenance Road Improvements
- RP-9: Stormwater and Summer Tailwater Re-Use and Supply
- RP-10: Local Agricultural Crossing Improvements

- RP-11: Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency
- RP-12: Westside Tributaries Monitoring

Recommended Studies (RS) include:

- RS-1: Bypass Sedimentation Rate Changes due to Managed Flooding
- RS-2: Vegetation Management with Increased Frequency and Duration of Flooding
- RS-3: Plan to Manage Beaver Canal Damage and Obstructions
- RS-4: Management Entity Model

The projects and studies listed above are described in more detail in the following section.

3.2 DETAILS OF RECOMMENDED PROJECTS

The study team is recommending each of these projects as a result of conversations with landowners, farmers, wetland managers and other stakeholders in the Yolo Bypass, based on existing constraints and improvements described in Section 2 above. A brief description of each project is provided below.

3.2.1 RP-1: Wallace Weir Improvements

(See Project Sheet RP-1 in Appendix A)

Replacement of the existing earthen Wallace Weir will allow for greater year-round control of water surface elevation within the KLRC and Colusa Basin Drain. It is an aging structure and the earthen section must be installed and removed on a yearly basis, using very labor-intensive methods to meet requirements for flood conveyance in the Bypass. The current system does not optimize irrigation on up to 4,000 acres in the Yolo Bypass north of Interstate 5. The Wallace Weir is also the southernmost structure in the Colusa Basin Drain/KLRC. The next control structure upstream in this water system is the Davis Weir located at the southeast corner of the Colusa National Wildlife Refuge, forty miles upstream from the Wallace Weir. The historical Davis Weir was replaced with an operable bladder dam in 2010 by Glenn Colusa Irrigation District (GCID), which gives the GCID the capacity to control flow recirculation within their district. Upgrades to the Wallace Weir would make it possible to more easily balance water levels with the Davis Weir.

Upgrading Wallace Weir will allow for coordination of the two weirs, improving system performance and providing multiple management benefits in terms of the ability to balance water levels and flows between the two weirs. It will also allow water to be managed for potential fisheries and waterfowl habitat south of Wallace Weir. The existing configuration could be replaced with a gated structure. Sliding gates could augment the operation of the weir and a permanent access road crossing could be installed on top of the structure. The new weir could consist of a series of tilt up gate structures, or flash boards, spanning the majority of the channel. These could be lifted easily at time of flow regulation for irrigation purposes. At the end of the irrigation season, the gates could be lowered or removed for the purposes of flood conveyance. On one side of the channel, three sluice gate structures could be installed

to provide flow regulation for irrigation. Alternatively, a more automated, but more costly, method could be implemented using a rubber bladder dam.

3.2.2 RP-2: Tule Canal Agricultural Crossing/Water Control Structure Improvements

(See Project Sheet RP-2 in Appendix A)

Four agricultural structures currently span the Tule Canal, to provide agricultural access for farm machinery from the west to the east of the Tule Canal and impound water for irrigation. In the winter, some of these structures are washed out due to higher flood flows in the Yolo Bypass and must be replaced every spring. Existing agricultural crossing structures include multiple small diameter culverts placed in the channel and backfilled with earth/granular material to allow machinery access. Existing structures include re-buildable earthen crossings for RD 1600 at the north end of Tule Canal and for Swanston Ranch just south of the Sacramento Bypass. A 25-foot wide canal at the property line between the Fremont Weir State Wildlife Area and TeVelde Ranch conveys water supply eastward towards the northerly earthen crossing on the Tule Canal, at which point a pipe through the levee delivers water by gravity to RD 1600 east of the Bypass levee. This feature is washed out by flood flows and is sometimes blocked by beaver activity. The Swanston Ranch structure includes an earthen dam with culverts and flashboard risers with a rock base to secure the culverts in the Tule Canal after the earthen fill is removed or washed out. Additionally, various minor crossings exist for east-west access tracks that could also be included in the improvement plans, as shown on the project sheet for RP-2.

Improvements could include placement of concrete or bottomless arch culverts (ARMCO or similar), with a larger diameter than the existing structure, overlaid with more permanent road access built from granular road-base or asphalt material. Replacement with more permanent solutions would reduce maintenance activities for farmers, improve fish passage along the Tule Canal/Toe Drain, and drainage of wetlands in certain areas.

3.2.3 RP-3: Lisbon Weir Improvements

(See Project Sheet RP-3 in Appendix A)

Currently the Lisbon Weir consists of a 100-foot wide rock weir placed across the Toe Drain in the southern Yolo Bypass. It is a critical part of the irrigation system for surrounding agricultural land and wetlands. Annual maintenance of the rock weir is necessary when it is degraded by flood flows. Sometimes maintenance is hampered by excessive flows in the Toe Drain. In conjunction with three tide (flap) gates on the west side, the rock weir is used to regulate upstream water levels. The weir creates the pool that serves as the first lift for the pumps that raise the water supply for farming and filling managed wetlands. The series of three flap gates allows flood tides to surcharge the Toe Drain upstream of the weir. Ebb tides are able to pass back over the weir if surcharge elevations exceed the weir crest elevation. While the flap gates on the west side of the weir allow for some fish passage upstream on a flood tide, fish may benefit from additional passage improvements.

Improvements could include placement of an operable variable height weir (Obermeyer or similar) approximately 100 feet wide, similar to the Davis Weir in Colusa County (GCID). Concrete

sidewalls/abutments would be required. Agricultural and wetland benefits could occur due to greatly reduced frequency of maintenance and improved temporal control of upstream water levels. The existing flap gates could be replaced with a more fish-passage friendly design.

3.2.4 RP-4: Conaway Main Supply Canal Augmentation

(See Project Sheet RP-4 in Appendix A)

A substantial portion of the water supply for the 17,000-acre Conaway Ranch comes from the Sacramento River via the Conaway Main Supply Canal. Existing high velocity flow scours holes in an earthen berm south of the main supply canal (see Figure A-4), particularly during Bypass flooding. Regular maintenance (preferably before the irrigation season in April) is needed to repair the berm and ensure canal integrity, but is dependent on local drainage conditions and access. Future increases in flooding frequency (as proposed by elements of the Central Valley Flood Protection Plan (CVFPP), RPA Action 1.6.1., and the Bay Delta Conservation Plan (BDCP)) could increase maintenance and repair frequency or make maintenance difficult prior to the irrigation season. If inundation duration is extended as proposed, the inability to adequately maintain the earthen berm could jeopardize the water supply for large farming operations.

Improvements could include repair/replacement of up to 7,900 linear feet of ditch from the Toe Drain, heading west to the western boundary of the Bypass. Proposed methods could include re-grading the ditch, filling scour holes, and re-lining the ditch with reinforced gunite/concrete lining. An alternative project is also proposed to replace the open ditch with three-celled, 6-feet-tall by eight-foot-wide (3 cells x 6’ x 8’) box culvert. This latter project would minimize filling of the conveyance with silt and sand from Yolo Bypass flows. Access points (manholes) would be constructed along the facility to allow for inspection and maintenance, as necessary. Benefits could include substantially improved water supply reliability for agriculture and reduced maintenance costs.

3.2.5 RP-5: Davis Wetlands Water Supply

(See Project Sheet RP-5 in Appendix A)

The existing supply to the Davis Wetlands originates from agricultural tailwater and stormwater from the City of Davis. This is part of a treated wastewater effluent system. As such, the wetlands are inundated for periods at any time of the year. In contrast, typically, managed wetlands in the Bypass are only flooded from November to March. The ability to pump water out of Channel A up to a smaller canal that routes water from the south side of the Willow Slough Bypass to the north side and into the Davis Wetlands is constrained. During the summer and fall months, the water is too low in the channel for the pump as designed. Channel conveyance capacity is a secondary issue in the winter months. Once the stormwater ponds fill to a certain level, water backs up into the conveyance channel and overflows at low areas. The current conveyance configuration can also result in poor water quality entering the Bypass and flooding at the Swanston Ranch west levee access. Future supply may be reduced from some city sources due to updated wastewater discharge requirements.

Improvements include capturing first flush events during the October-November period by reconfiguring the pump design to lift water from Channel A to the Davis Wetlands supply canal. This reconfiguration would also enhance access to the summertime agricultural irrigation runoff, improving existing habitat and potentially helping to treat some of the sediments or other constituents resulting from the runoff. The size of the channels could be increased to improve conveyance in the winter months.

Capturing fall first flush events and summer agricultural runoff would primarily benefit the lower aquatic ecosystems (i.e. lower levels of potential sediments and nutrients to benefit aquatic species). Other benefits include increased habitat availability for waterfowl and shorebirds in the existing wetlands. Additionally, west levee access could potentially be improved if upstream conveyance to the Davis Wetlands is upsized.

3.2.6 RP-6: South Davis Drain Input Reconfiguration

(See Project Sheet RP-6 in Appendix A)

The west Yolo Bypass levee creates a drainage barrier that requires frequent pumping, leading to flooding issues both in and outside of the Yolo Bypass. The City of Davis has a pump station (Southeast Davis Drain Pumps) that is used to lift drain water into the Bypass at a cost to the city. Drainage is poor along the west Bypass levee for farm fields just west of the levee. A drainage ditch at the west levee toe runs parallel to the levee. The closeness of this ditch potentially compromises the levee stability. Drain pumping during storm runoff and during times of high agricultural runoff creates flooding problems for the Yolo Bypass Wildlife Area, flooding roads and restricting public access. Continuous high flows related to agricultural runoff make management of water levels in adjacent wetlands difficult. Managing water levels in these ponds is key to creating high quality habitat during the winter and fall months. Future increased inundation and an elevated Toe Drain Canal surface could continue to impede drainage from west to east.

There is an existing gravity drain pipe through the west levee near the South Davis drain pumps. It is placed too high for adequate gravity drainage. A new drain pipe at the appropriate elevation could be installed for drainage when the Bypass is not flooded. Another alternative would be to dig a new drain ditch along the west levee. A low lift pump could be installed to recycle the drain water into an existing farm irrigation canal. The new drain ditch could be located so that it does not jeopardize the west levee. The drain ditch would greatly reduce the city of Davis' pumping costs, improve farm field drainage, improve levee stability, and reduce Yolo Bypass Wildlife Area flooding.

3.2.7 RP-7: Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration

(See Project Sheet RP-7 in Appendix A)

The existing system was originally designed for agricultural operations with several dual supply/drain canals that can cause issues for coordinated water management in a multi-use area. The system currently, however, also supplies and drains water for managed wetlands in the YBWA. When agricultural operations need water supply for irrigation, wetlands may need to drain. Such circumstances create a situation where it is not possible to manage wetland ponds individually.

Individual management of ponds is a key feature to creating diverse habitat while also managing vegetation, minimizing mosquito larvae populations and controlling avian disease during specific times of the year. Existing drain outlet elevations and tides at Lisbon Weir dictate how rapidly drainage can occur. If Toe Drain surface water levels are elevated as a result of future increases in the duration and frequency of Yolo Bypass flooding, drainage from west to east would be further impeded.

Improvements could include rehabilitating existing canals and constructing new drainage and supply canals to facilitate wetland and farming operations, especially in early spring. Timing of wetland drawdown in early spring is important for the germination of nutritious wetland plants and is also important for controlling mosquito populations. Timing is also critical for controlling the germination and growth of noxious weeds. Quick drainage following flooding is important for public access and operation and maintenance of facilities. Canal improvement will accelerate the winter flood up of managed wetlands and therefore improve early season migratory bird habitat. A faster flood up also would allow for removal of the Los Rios check dam prior to the December 1 deadline to improve access to the creek for fall run Chinook salmon. A more detailed feasibility analysis will be required to fully identify which canals will need to be reconfigured.

3.2.8 RP-8: Yolo Bypass Wildlife Area Public and Operation & Maintenance Road Improvements

(See Project Sheet RP-8 in Appendix A)

The existing elevations along roadways at the "Rice Corner" and "Y" restrict public access during early stages of flooding (see Figure A-8). These are important access points for public use and operation and maintenance of water supply and drainage structures. These roads flood as Toe Drain levels rise making the entire west side of the YBWA (4,600 acres) inaccessible for public use even during relatively small flood events. Not all existing operation and maintenance roads are gravel or all-weather roads that allow access immediately after a flooding event. Future increases in the duration and frequency of flooding will increase the need for maintenance of these roads as flood waters recede. The Discover the Flyway program for schools relies on access to the west side of the YBWA. The number of students served by the program decreases even during relatively small flood events. The impact will increase if the duration and frequency of flooding increases. Access to the west side of the YBWA is also important for other public uses including hunting and wildlife viewing.

Improvements include raising access roads and surfacing with "all-weather" materials as shown on Figure A-8. Benefits include improved public and operation and maintenance access.

3.2.9 RP-9: Stormwater and Summer Tailwater Re-Use and Supply

(See Project Sheet RP-9 in Appendix A)

The existing configuration of canals and pumps does not maximize water supply to potential contracted users when available as a result of winter storms or summer tailwater runoff since it is not possible to transfer, divert, or pump water efficiently to various parts of the system using the current infrastructure. Improvements include several control structure installations or upgrades, one pump station installation

and one upgrade, as well as canal creation and improvements. Benefits include improved summer and/or winter supply to potential contracted users, and potential habitat and water quality improvements.

3.2.10 RP-10: Local Agricultural Crossing Improvements

(See Project Sheet RP-10 in Appendix A)

Existing local agricultural crossings consist of rudimentary culvert and fill materials that require persistent maintenance to minimize blockages due to beaver activity and invasive aquatic vegetation. Certain existing agricultural crossings experience access restrictions during flood events.

Improvements to culvert crossings include replacing existing crossings with clear span decks consisting of either rail car bridges or other structural techniques. Benefits include reduced maintenance costs, improved water delivery, drainage for agriculture and managed wetlands, and improved conveyance during flooding and low water operations. Control of mosquito populations may also improve. Landowners and wetland managers indicated that rail car bridges generally are less likely to be blocked by beaver dams than culverts. Improvements to water control structures may consist of similar clear span decks with concrete abutments with the addition of sluice gates or flashboard riser combination gates. These gates can be removed in the winter for improved drainage by creating a larger flow conveyance area.

3.2.11 RP-11: Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency

(See Project Sheet RP-11 in Appendix A)

Existing agricultural operations and wetland managers control vegetation and siltation in irrigation and drainage canals at landowners' expense even though the Yolo Bypass provides system wide benefits as part of the Sacramento River Flood Control project. Existing agriculture and managed wetland canals, crossings, fields and pumps require frequent maintenance, including removal of silt, invasive aquatic vegetation, and beaver blockages. Removal of flood debris on bridges, crossings, streambanks, and fields is also necessary after large flood events. Future increased inundation and frequency of flooding could increase maintenance needs and costs incurred to landowners and managers.

Landowners could participate in the maintenance and improvement program through a state funded reimbursement process. Or, the state or special district could hire a dedicated labor force and purchasing equipment through grants or other funding sources. The program would need to be managed by one or two full time staff, probably a general manager, and a labor/engineering supervisor. If the program includes a dedicated labor force, operating costs could significantly increase. Alternatively, a Yolo Bypass "Keeper" approach could be adopted, similar to the Putah Creek Streamkeeper, a position created by the Putah Creek Accord in 2000. System-wide benefits would include improved conveyance during flooding, improved water supply operations for proposed fish habitat management, improved drainage of lands on the receding limb of the hydrograph, and improved access during and after flood events. Public and private landowners in the Bypass would benefit from

reduced maintenance costs and improved access.

3.2.12 RP-12: Westside Tributaries Monitoring

(See project sheet RP-12 in Appendix A.)

Since westside tributary inflows play an important role in Bypass inundation, understanding the timing and magnitude of inflows is needed to determine their relative influence compared to larger inflows from the Fremont and Sacramento Weirs. Better data is needed to synthesize past and future hydrology datasets for the purposes of modeling existing conditions and future management scenarios. For example, discussion on future management scenarios has included the consideration of modifying the inundation regime for the Yolo Bypass during flood events. In terms of balancing habitat and agricultural objectives, the magnitude, frequency, duration, timing, depth, area, and rate of change of floodplain inundation are all critical parameters to understand thoroughly. The westside tributary inflows affect these parameters significantly. A brief summary of available data for each tributary is provided below:

- Flow estimates entering the Yolo Bypass at Knights Landing Ridge Cut (KLRC), were approximated prior to 2009 based on Colusa Drain flows at Highway 20, rough rainfall runoff estimates for the un-gauged portion of Colusa Basin, and flows to the Sacramento River via the Knights Landing Outfall Gates (Outfall Gates). This resulted in flow estimates with large uncertainty. In 2009, flow gauging on KLRC downstream of the Outfall Gates (CDEC ID RCS) was initiated by DWR North Central Region Office (NCRO).
- Flow estimates entering the Yolo Bypass at the Cache Creek Settling Basin have been based on USGS gauged flows on Cache Creek just downstream of I-5 since 1903 without any routing and attenuation (i.e. compensating for changes to the hydrograph shape due to channel geometry or storage in the Cache Creek Settling Basin). This resulted in flow estimates with large uncertainty. Beginning in 2009, the USGS gauged total outflows from the Settling Basin. Flow measurements for Cache Creek are based solely on the USGS gauge on Cache Creek where water enters the western side of the Bypass. These measurements do not account for storage or attenuation in the Settling Basin.
- Data for flows entering the Yolo Bypass via the Willow Slough Bypass are based on scaled Interdam Runoff estimates for Putah Creek since the Willow Slough Bypass has never been gauged.
- Flows entering the Yolo Bypass at Putah Creek are based on Putah Diversion Dam (PDD) total outflow (low flow plus flood flow releases) 20 miles upstream along with seepage loss estimates and conditional criteria when Monticello Dam is spilling. Only low flows (i.e., less than 100 cfs) are gauged on Putah Creek by Solano County Water Agency (SCWA) downstream of PDD at several locations.
- Flow estimates entering the Yolo Bypass at the Cache Creek Settling Basin have been based on USGS gauged flows on Cache Creek just downstream of I-5 since 1903 without any routing and attenuation (i.e. compensating for changes to the hydrograph shape due to channel geometry or storage in the Cache Creek Settling Basin). This resulted in flow estimates with large uncertainty. Beginning in 2009, the USGS gauged total outflows from the Settling Basin. Flow measurements for Cache Creek are based solely on the USGS gauge on Cache Creek where

water enters the western side of the Bypass. These measurements do not account for storage or attenuation in the Settling Basin.

A summary of improvements and potential benefits for each tributary follows. See Appendix B for more details:

- Knights Landing Ridge Cut: DWR NCRO should continue the RCS monitoring program, continue to refine the low flow rating curve, and extend the rating curve for flows above 1,600 cfs. Future funding for continued monitoring at this location needs to be confirmed with DWR. In addition, a more accurate method for approximating inflows into the Yolo Bypass prior to 2009 needs to be performed via desktop analysis.
- Cache Creek: In addition to operating the USGS gauging station just downstream of I-5, the USGS should continue monitoring the total outflow from the Cache Creek Settling Basin. Future funding for continued monitoring at this location should be confirmed with the USGS. In addition, a more accurate method for approximating inflows into the Yolo Bypass prior to 2009 needs to be performed via desktop analysis.
- Willow Slough Bypass: The main recommendation here is to install flow and stage monitoring stations along the Willow Slough Bypass. Once data has been collected for several years, the assumptions from the Management Strategy using scaled Interdam Runoff can be validated and potentially modified.
- Putah Creek: The US Bureau of Reclamation and Solano Irrigation District (SID) Putah Diversion Office (PDO) have been monitoring and recording flows on Putah Creek between Monticello Dam and Lake Solano. More recently, SCWA has been monitoring low flows (i.e., less than 100 cfs) and stages at eight stations along Putah Creek from the PDD to Los Rios Check Dam primarily during the growing season to verify fish pulse flows. Locations within the Yolo Bypass are not suitable for flow rating above 100 cfs due to backwater conditions from the Toe Drain. It is recommended that monitoring is expanded at the I-80 station by rating it for higher flows for historical verification and for use in future modeling efforts. It is also recommended that the outflows to Putah Creek (i.e., releases and flood flows) be reported and archived on a subdaily time step rather than just daily. Further validation of the Interdam Runoff (between Monticello Dam and Putah Diversion Dam) is also recommended.

The tributary inflows to the Bypass are extremely important elements of any future studies. Currently, inflows for all these tributaries are estimates at best. Westside tributary inflows play a major part in inundation of the Bypass prior to the Fremont Weir spilling. It is critical to better understand their relative contribution, so that future monitoring and modeling studies accurately represent realistic inundation conditions in the Bypass.

3.3 DETAILS OF RECOMMENDED STUDIES

3.3.1 RS-1: Bypass Sedimentation Rate Changes due to Managed Flooding

Future increased duration and frequency of flooding could increase sedimentation rates. Stakeholders have expressed interest in a better understanding of the potential for increased sedimentation in canals and associated increased maintenance efforts and costs.

This study would develop a methodology and assess existing sedimentation rates in the Toe Drain/Tule Canal, and existing ditches throughout the Bypass. Future potential changes to sediment rates could potentially be inferred from hydrologic data and model results. Sedimentation near west side tributaries should be considered, as east side flooding could impact velocities and settling rates upstream.

3.3.2 RS-2: Vegetation Management with Increased Frequency and Duration of Flooding

Farming practices in the Yolo Bypass help maintain waterways and keep fields free of woody riparian vegetation, directly benefiting the flood conveyance function of the entire system. Future conversion of agricultural lands to habitat other than managed wetlands could lead to vegetation proliferation at unknown rates in the designated floodway and potential for more manual vegetation thinning to maintain flood conveyance.

This study would develop a methodology to assess the type and growth patterns of vegetation on lands within a managed flooding context similar to proposed scenarios under CM2 or other scenarios. In the study the following could also be assessed: 1) changes in forage value of wetland and grassland plants, 2) effect on the growth of vegetation needed for nesting cover, 3) effect on conveyance capacity and 4) maintenance of ditches.

3.3.3 RS-3: Plan to Manage Beaver Canal Damage and Obstructions

Beavers can damage or impede drainage and supply pathways by blocking water control structures with lodge construction and creation of burrows. Existing water supply and drainage operations remove mammal blockages and damage to canals as needed. This study would develop a plan to improve protocols and resources for managing beaver impacts to water systems.

3.3.4 RS-4: Management Entity Model

Coordinated water management, especially between smaller private landowners operating land for similar uses (e.g. small private duck clubs), poses a challenge. Some landowners have begun the mutual water company development process to facilitate efficient use of resources and management activities based on per/acre assessment fees. This study would develop a model of a coordinated water management plan for landowners and other Bypass stakeholders.

3.4 PRELIMINARY PROJECT PRIORITIZATION

The study team prioritized these projects based on the team's knowledge and familiarity with the Yolo Bypass, results of the quantitative and qualitative assessments performed on each project, and input from stakeholders. In a stakeholder meeting held on October 11, 2013, participants reviewed the preliminary priorities and ranking system and provided comments. The team made changes to the priorities where appropriate based on feedback both at the stakeholder meeting and subsequent follow up. It should be noted that these priorities are designed to provide guidance only. A project can move forward, regardless of priority, only if funding is available and the landowner is willing. The projects also may change as a result of further conversations with landowners, farmers, wetland managers, resource managers and state and federal agencies.

3.4.1 Prioritization Methodology

The study team identified 14 criteria on which to rate the recommended projects. Criteria were either subjective, based on study team experience and conversations with stakeholders, or quantitative, based on current available data. Criteria are listed in priority order based on the goal of this study: to identify drainage and water infrastructure improvements in the Yolo Bypass that benefit farmers and wetlands managers. The Bypass has a complex set of operational and management constraints and functions, however, so the study team considered additional criteria. Three tiers were created. The tiered criteria are listed below, and are ranked in a tabular matrix on each individual project sheet in Appendix A for RP-1 through RP-12:

- Tier 1
    - Agricultural benefit: an overall assessment of a combination of several criteria such as the ability to irrigate and drain more efficiently, access and maintain land, and prepare land for growing crops and harvest.
    - Migratory waterfowl or shorebird benefit: an overall assessment of a combination of several criteria such as the ability to flood up and drain habitat at various seasonal intervals, access and maintain land.
- Tier 2
    - "Shovel readiness": an assessment of the amount of feasibility or design preparatory work needed to begin the project.
    - Ease of permitting: an assessment of the anticipated complexity of obtaining the permits required to construct or implement the project.
    - Potential for matching funding: an assessment of the potential to obtain matching funding for agencies or entities with potentially mutual interests in the project.
    - Eligibility for grants: an assessment of the potential for grant funding to construct the project from agencies or other entities.
    - Estimated benefit acreage: a preliminary quantitative estimate of the number of acres that could potentially benefit from project implementation.
    - Cost estimate: a preliminary quantitative estimate of project implementation costs based on preliminary project descriptions.

- Tier 3
    - Flood benefit: an assessment of perceived project potential to reduce flood impacts. Lower flood stage and reduced maintenance costs.
    - Listed species benefit: an assessment of perceived project potential to benefit listed species.
    - Public benefit: an assessment of perceived acres of project wetlands for public hunting, bird watching, etc.
    - Water quality benefit: an assessment of perceived project potential to benefit or improve water quality of tributaries and supply sources or existing Yolo Bypass water bodies.
    - Other environmental benefit: an assessment of perceived project potential to benefit ecological or environmental resources in the Yolo Bypass.

The tiered criteria in each project sheet RP-1 through RP-12 were ranked as either 1) not benefiting the Yolo Bypass, 2) benefiting the Yolo Bypass to some degree (low, medium or high) or 3) unknown benefit at this time. The number of each criteria ranking was summed up in Appendix A, Table A.1, which lists all tiered criteria and projects for an overall project ranking.

3.4.2 Preliminary Prioritization Results

The following projects are recommended in priority order from 1 to 12. 1 is the highest priority and 12 is the lowest priority. This prioritization is based on the total counts of high only. However, it is important to emphasize that ALL projects are recommended for completion but the process outlined here is an attempt to prioritize in case funding is insufficient to complete all projects imminently. See Figure 9 for the summary or rankings from Appendix A, Table A.1:

High priority projects:

1. RP-7: Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration
1. RP-8: Yolo Bypass Wildlife Area Public and Operation & Maintenance Road Improvements
3. RP-6: South Davis Drain Input Reconfiguration
3. RP-10: Local Agricultural Crossing Improvements
3. RP-11: Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency

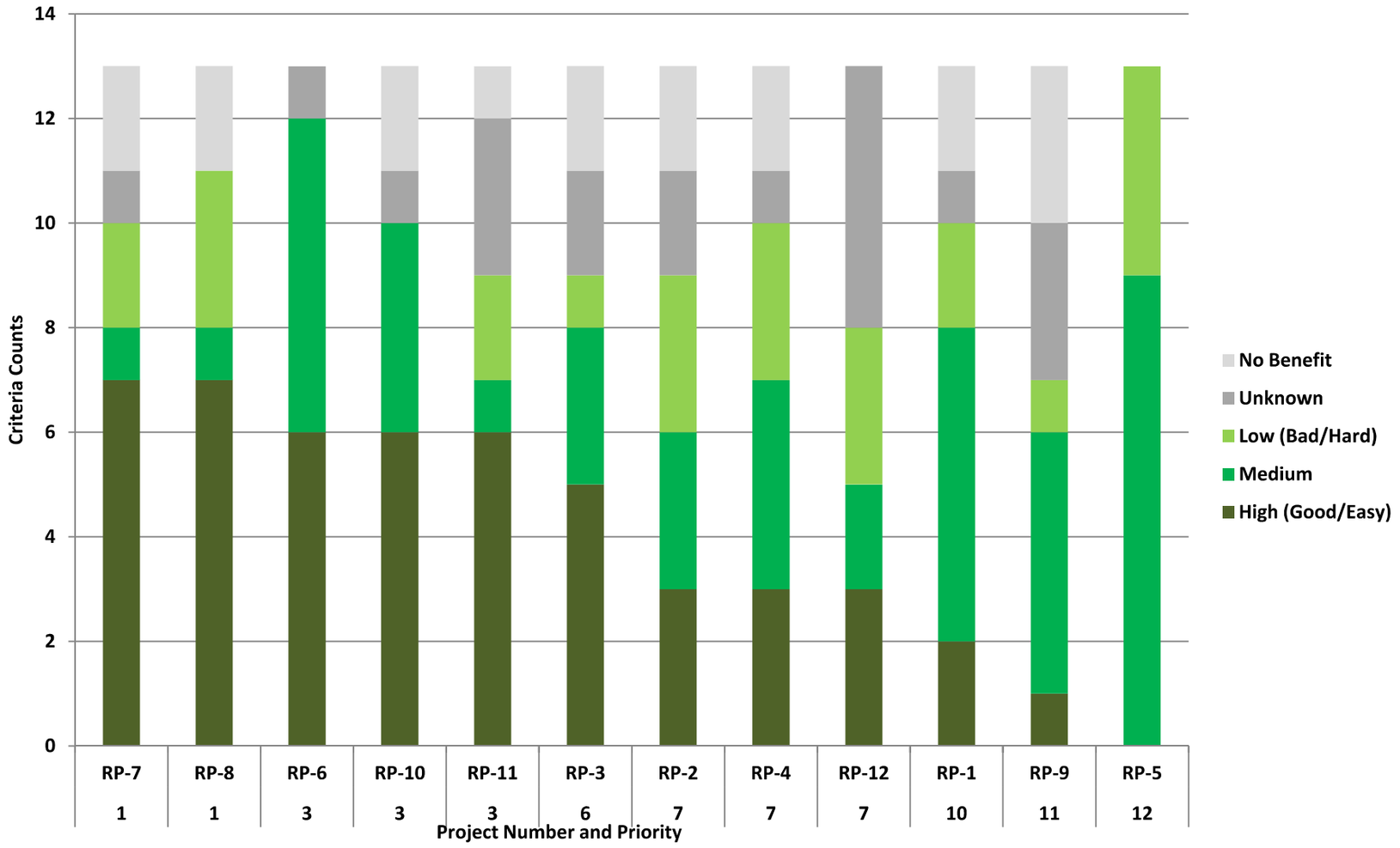
Medium priority projects:

6. RP-3: Lisbon Weir Improvements
7. RP-2: Tule Canal Agricultural Crossing/Water Control Structure Improvements
7. RP-4: Conaway Main Supply Canal Augmentation
7. RP-12: Westside Tributaries Monitoring

Low priority projects:

10. RP-1: Wallace Weir Improvements
11. RP-9: Stormwater and Summer Tailwater Re-Use and Supply
12. RP-5: Davis Wetlands Water Supply Improvements

These projects should all be recommended to funding agencies in order to accelerate projects with potential benefit to farmers, wetland managers, the environment, and the public generally. These projects should also be considered for addition to the Project List supported by the Coalition for Delta Projects.



Notes: Listed by sum of high counts from Appendix A, Table A.1

Yolo Bypass Drainage and Water Infrastructure Improvement Study

Preliminary Project Prioritization Results

Project No. 12-1039 | Created By: AMS | **Figure 9**

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APPENDIX A

RECOMMENDED PROJECT AND STUDY SUMMARIES AND PRIORITIZATION

YOLO BYPASS DRAINAGE AND WATER INFRASTRUCTURE IMPROVEMENT STUDY

TABLE A.1

Prioritization Matrix
April 2014

Priority of Criteria	PROJECT METRIC	Recommended Project											
		RP-1 – Wallace Weir Improvements	RP-2 – Tule Canal Agricultural Crossings/Water Control Structure Improvements	RP-3 – Lisbon Weir Improvements	RP-4 – Conaway Main Supply Canal Augmentation	RP-5 – Davis Wetlands Water Supply	RP-6 – South Davis Drain Input Configuration	RP-7 – Yolo Bybass Wildlife Area Dual Function Canal Reconfiguration	RP-8 – Yolo Bybass Wildlife Area Public and Operations and Maintenance Road Improvements	RP-9 – Stormwater and Summer Tailwater Re-Use and Supply	RP-10 – Local Agricultural Crossing Improvements	RP-11 – Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency	RP-12 – Westside Tributaries Monitoring
1	Agricultural benefit [1]	M	M	H	H	L	H	H	H	M	H	H	L
1	Migratory waterfowl or shorebird habitat benefit [2]	M	No	H	H	M	H	H	H	M	H	H	L
2	"Shovel readiness" [3]	No	No	No	No	L	M	M	H	L	M	No	M
2	Ease of permitting [4]	M	H	M	M	M	M	H	H	H	H	M	L
2	Potential for local matching funding [5]	M	U	U	U	M	H	L	L	U	M	L	H
2	Eligibility for grants [6]	H	H	M	L	M	M	H	H	U	H	U	H
2	Estimated benefit acreage [7]	M	M	H	H	M	H	H	H	U	H	H	H
2	Cost estimate [8]	M	M	M	M	M	M	L	M	M	M	M	M
3	Flood benefit [9]	L	L	L	L	M	H	H	No	M	M	H	U
3	Listed species benefit	H	H	H	M	L	M	U	No	No	U	U	U
3	Public benefit (hunting, education, access, etc) [10]	No	L	H	M	M	H	H	H	M	H	H	U
3	Water quality benefit	L	L	No	L	M	M	No	L	No	No	U	U
3	Other environmental benefit	U	U	U	No	L	U	No	L	No	No	L	U
	High (Good/Easy)	2	3	5	3	0	6	7	7	1	6	6	3
	Medium	6	3	3	4	9	6	1	1	5	4	1	2
	Low (Bad/Hard)	2	3	1	3	4	0	2	3	1	0	2	3
	Unknown	1	2	2	1	0	1	1	0	3	1	3	5
	No (Benefit)	2	2	2	2	0	0	2	2	3	2	1	0
Final Ranking[11]		**10**	**7**	**6**	**7**	**12**	**3**	**1**	**1**	**11**	**3**	**3**	**7**

[1] Agricultural benefit is an overall subjective assessment of a combination of several criteria such as the ability to irrigate and drain more efficiently, access and maintain land, and prepare land for growing crops and harvest.

[2] Migratory waterfowl or shorebird habitat benefit is an overall subjective assessment of a combination of several criteria such as the ability to flood up and drain habitat at various seasonal intervals, access and maintain land.

[3] Low "shovel readiness" means that little preparatory work (feasibility or design) has been undertaken. High means that designs could quickly and easily be produced.

[4] Ease of permitting relates to the overall anticipated complexity of obtaining the permits required to construct the project (High is easier).

[5] Low < 10%, 10% < Medium < 30%, High > 30%

[6] Low < 10%, 10% < Medium < 30%, High > 30%. Matching funds from landowners, local government or other organizations.

[7] Low < 3,000 acres, 3,000 acres < Medium < 6,000 acres, High > 6,000 acres acres must be in Yolo County.

[8] For Cost Estimate evaluation criteria, H, or High (Good/Easy), means that the cost is low. L, or Low (Bad/Hard), means that the cost is high. Low > $3,000,000 and $3,000,000 > Medium > $100,000 and High < $100,000.

[9] Lower flood stage. Reduced maintenance costs.

[10] Acres of project wetlands for public hunting, bird watching, etc.

[11] Ranking based on high criteria.

YOLO BYPASS DRAINAGE AND WATER INFRASTRUCTURE IMPROVEMENT STUDY:

TABLE A.2

Recommended Studies
April 2014

Number	Study Name	Description of Existing and Future Need	Study Components
RS - 1	Bypass Sedimentation Rate Changes due to Managed Flooding	• Future increased inundation area, duration and frequency of flooding could increase sedimentation rates	• Develop methodology and study existing sedimentation rates in the Toe Drain/Tule Canal and existing ditches throughout the Bypass. • Sedimentation near west side tributaries should be considered, as east side flooding could impact velocities and settling rates upstream.
RS - 2	Vegetation Management with Increased Frequency and Duration of Flooding	• Future conversion of agricultural lands to habitat other than managed wetlands could allow vegetation proliferation at unknown rates in the designated floodway	• Develop methodology and study the type and growth patterns of vegetation on lands within a managed flooding context similar to current proposed scenarios. - Assess changes in forage value of wetlands and grassland plants. - Assess the effect on the growth of vegetation needed for nesting cover. - Assess the effect on carrying capacity/maintenance of ditches.
RS - 3	Plan to Manage Beaver Canal Damage and Obstructions	• Beavers can impede drainage and supply pathways with lodge construction and creation of burrows • Existing water supply and drainage operations remove mammal blockages damage to canal as needed.	• Develop a plan to improve protocols and resouces for managing beaver impact to water systems.
RS - 4	Management Entity Model	• Coordinated water management, especially between smaller private landowners operating land for various or similar uses poses a challenge • Some landowners in the Yolo Bypass have begun this process in to facilitate efficient use of resources and management activities based on per acre assessment fees	• Develop guidelines for landowners interested in establishing a Mutual Water Company or other management entity.

Recommended Project 1 (RP-1):

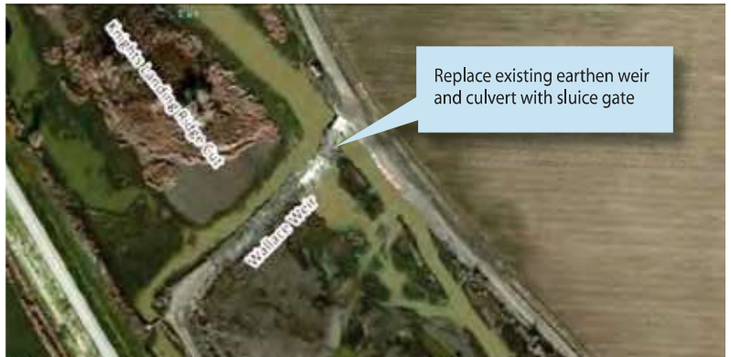
Wallace Weir Improvements

Location:

Terminus of the (Knights Landing) Ridge Cut (KLRC) and west levee of the Yolo Bypass (Bypass), approximately three miles north of Interstate 5 and five miles northeast of the City of Woodland.

Recommendations:

Replace or modify the existing Wallace Weir earthen and concrete structure used to manage irrigation flows from the KLRC into the Bypass with a sluice gate structure.



RECOMMENDED PROJECT #1						Wallace Weir Impro
Project Metric	No	Yes			Un-known	
		Low	Med	High		
Agricultural benefit			X			Improved spring wate
Migratory waterfowl or shorebird habitat benefit			X			Improved control for s
"Shovel readiness"	X					Needs completion of f
Ease of permitting			X			This project would req Declaration or an Envi for the Existing Facilitie Exemptions (Class 1 or Clean Water Act Nation an Encroachment Perm
Potential for local matching funding			X			Landowners benefiting matching funds.
Eligibility for grants				X		Multi-benefit aspects c availability of matchin
Estimated benefit acreage			X			Over approximately 4,
Cost estimate			X			Up to $500,000 if serie sophisticated approac
Flood benefit		X				Improvements to the v bypass inundation.
Listed species benefit				X		Will minimize upstrean stranding. Improved c fish habitat.
Public benefit (hunting, education, access, etc)	X					Improvements to the v bypass inundation.
Water quality benefit		X				Some reduction in turb
Other environmental benefit					X	

Description of Problem:

Replacement of the existing earthen Wallace Weir will allow for greater year-round control of water surface elevation within the KLRC and Colusa Basin Drain. It is an aging structure and the earthen section must be installed and removed on a yearly basis, using very labor-intensive methods to meet requirements for flood conveyance in the Bypass. The current system does not optimize irrigation on up to 4,000 acres in the Yolo Bypass north of

Description of Improvements and Potential Benefit:

Upgrading Wallace Weir will allow for coordination of the two weirs, improving system performance and providing multiple management benefits in terms of the ability to balance water levels and flows between the two weirs. It will also allow water to be managed for potential fisheries and waterfowl habitat south of Wallace Weir. The existing configuration could be replaced with a gated structure. Sliding gates could augment the operation of the weir and a permanent

Recommended Project 2 (RP-2):

Tule Canal Agricultural Crossing/ Water Control Structure Improvements

Location:

Four locations along Tule Canal within the Yolo Bypass, north of Interstate 80.

Recommendations:

Replace current agricultural crossings with more permanent solutions.

Figure A-2. Tule Canal/Toe Drain crossings and control berms

Description of Problem:

Four agricultural structures currently span the Tule Canal to provide agricultural access for farm machinery from the west to the east of the Tule Canal and impound water for irrigation. In the winter, some of these structures are washed out due to higher flood flows in the Yolo Bypass and must be replaced every spring. Existing agricultural crossing structures include multiple small diameter culverts placed in the channel and backfilled with earth/granular material to allow machinery access. Existing structures include re-buildable earthen crossings for RD 1600 at the north end of Tule Canal and for Swanston Ranch just south of

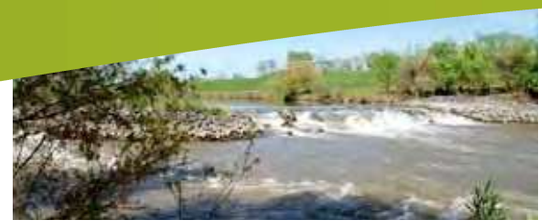
Description of Improvements and Potential Benefit:

Improvements could include placement of concrete or bottomless arch culverts (ARMCO or similar) with larger diameter than the existing structure, overlaid with more permanent road access built from granular road-base or asphalt material. Replacement with more permanent solutions would reduce maintenance activities for farmers, improve fish passage along the Tule Canal/Toe Drain, and drainage of wetlands in certain areas.

RECOMMENDED PROJECT #2	Tule Canal Agricultural Cross					
Project Metric	No	Yes			Un-known	
		Low	Med	High		
Agricultural benefit			X			Reduced maintenance of fields after inundati
Migratory waterfowl or shorebird habitat benefit	X					
"Shovel readiness"	X					Needs completion of c
Ease of permitting				X		These agricultural cros likely qualify for the Ex Categorical Exemption disturbance within the Agreement from the C Water Act Nationwide Encroachment Permit be required.
Potential for local matching funding					X	Need to have further c
Eligibility for grants				X		Multi-benefit aspect o Passage Improvement
Estimated benefit acreage			X			Approximately 2,000 t
Cost estimate			X			Total = $2,330,000: 3 x gates – 25' wide = $10 and a crossing above i Lisbon Weir improvem abutments of railcar cr
Flood benefit		X				Reduced risk of blocka
Listed species benefit				X		Improved fish passage
Public benefit (hunting, education, access, etc)		X				
Water quality benefit		X				Some minor reduction required.

Recommended Project 3 (RP-3):

Lisbon Weir Improvements



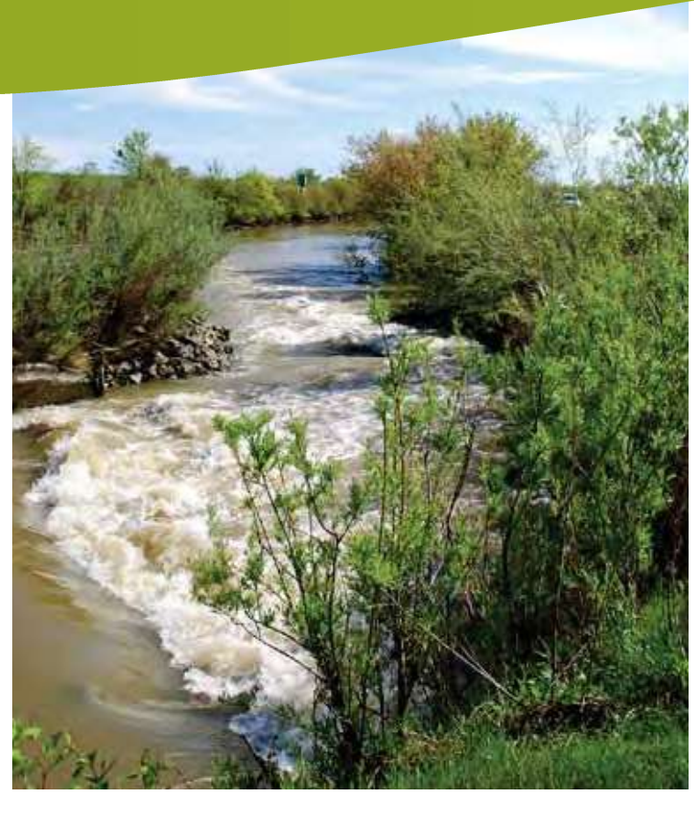
Location:

The Toe Drain adjacent to Yolo Bypass Wildlife Area, approximately 6.5 miles south of Interstate 80.

Recommendations:

Replace current rock weir with operable variable height weir and improved flap gates.

Figure A-3. Lisbon Weir area



Description of Problem:

Currently the Lisbon Weir consists of a 100-foot wide rock weir placed across the Toe Drain in the southern Yolo Bypass. It is a critical part of the irrigation system for surrounding agricultural land and wetlands. Annual maintenance of the rock weir is necessary when it is degraded by flood flows. Sometimes maintenance is hampered by excessive flows in the Toe Drain. In conjunction with three tide (flap) gates on the west side, the rock

Description of Improvements and Potential Benefit:

Improvements could include placement of an operable variable height weir (Obermeyer or similar) approximately 100 feet wide, similar to the Davis Weir in Colusa County (GCID). Concrete sidewalls/abutments would be required. Agricultural and wetland benefits could occur due to greatly reduced frequency of maintenance and improved temporal control of upstream water levels. The existing flap gates could be replaced with a more fish-passage friendly design.

RECOMMENDED PROJECT #3	Lisbon Weir Improv					
Project Metric	No	Yes			Un-known	
		Low	Med	High		
Agricultural benefit				X		Improved supply for fa improved drainage on
Migratory waterfowl or shorebird habitat benefit				X		Improved supply for m
"Shovel readiness"	X					A feasibility study con needed to identify alte and fish passage.
Ease of permitting			X			This project would req Declaration or an Envi for the Existing Facilitie Exemptions (Class 1 or a Streambed Alteratio and Wildlife, a Clean W of Engineers, and an E Protection Board.
Potential for local matching funding					X	Need to have further d
Eligibility for grants			X			Multi-benefits aspect c eligibility for grants.
Estimated benefit acreage				X		Approximately 21,000
Cost estimate			X			$1,700,000 - $2,500,00
Flood benefit		X				Improved managemen
Listed species benefit				X		Improved fish passage
Public benefit (hunting, education, access, etc)				X		Improved drainage to
Water quality benefit	X					
Other environmental benefit					X	

Recommended Project 4 (RP-4):

Conaway Main Supply Canal Augmentation

Location:

Conaway Ranch immediately south of County Road 22, in the Yolo Bypass.

Recommendations:

Concrete line a section of the main supply canal. Alternately, pipe main supply across the Bypass in this location.

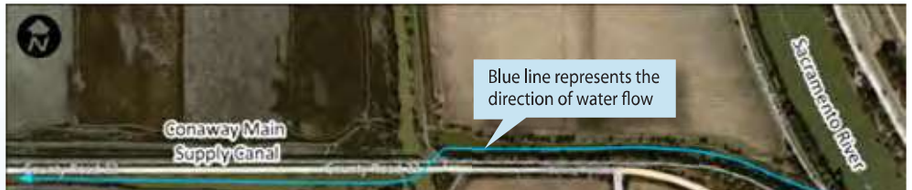
Figure A-4. Conaway Main Supply Canal area

Description of Improvements and Potential Benefit:

Improvements could include repair/replacement of up to 7,900 linear feet of ditch from the Toe Drain, heading west to the western boundary of the Bypass. Proposed methods could include re-grading the ditch, filling scour holes, and re-lining the ditch with reinforced gunite/concrete lining. An alternative project is also proposed to replace the open ditch with three-celled, 6-feet-tall by eight-foot-wide (3 cells x 6' x 8') box culvert. This latter project would minimize filling of the conveyance with silt and sand from Yolo Bypass flows. Access points (manholes) would be constructed along the facility to allow for inspection and maintenance, as necessary. Benefits could include substantially improved water supply reliability for agriculture and reduced maintenance costs.

Description of Problem:

A substantial portion of the water supply for the 17-acre Conaway Ranch comes from the Sacramento River via the Conaway Main Supply Canal. Existing high velocity flow scours holes in an eastern berm south of the main supply canal (see Figure A-4), particularly during Bypass flooding. Regular maintenance (preferably before the irrigation season in April) is needed to



RECOMMENDED PROJECT #4	Conaway Main Supply Cana					
Project Metric	No	Yes			Un-known	
		Low	Med	High		
Agricultural benefit				X		Improved supply relial
Migratory waterfowl or shorebird habitat benefit				X		Improved supply relial
"Shovel readiness"	X					Feasibility study and d
Ease of permitting			X			This project would req Exemption or a Negati Facilities or the Replac (Class 1 or 2 Exemptio Alteration Agreement Clean Water Act Natio an Encroachment Perm the canal may be GGS
Potential for local matching funding					X	Need to discuss with C
Eligibility for grants		X				
Estimated benefit acreage				X		Up to and potentially e
Cost estimate		X				$5,200,000 for 7,900 li of open, concrete linec
Flood benefit		X				
Listed species benefit			X			Improved water suppl bypass fish habitat.
Public benefit (hunting, education, access, etc)			X			Landowners currently
Water quality benefit		X				Lower turbidity water
Other environmental benefit	X					

Recommended Project 5 (RP-5):

Davis Wetlands Water Supply

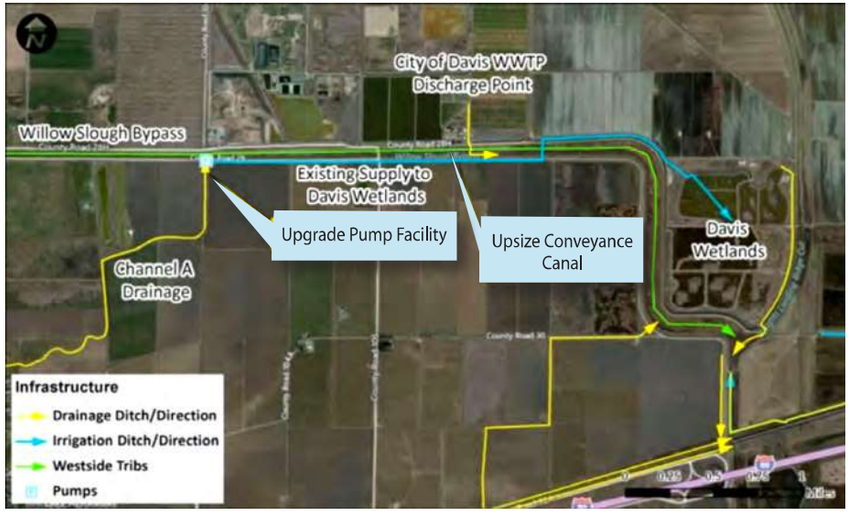
Location:

The Davis Wetlands is immediately north of the Willow Slough Bypass, outside of the Yolo Bypass (see Figure A-5 below).

Recommendations:

Upgrade Channel A supply channel and pump to Davis Wetlands. Potentially route some Willow Slough Bypass floodwater to wetlands.

Figure A-5. Davis Wetlands Supply Canal area



Description of Problem:

The existing supply to the Davis Wetlands originates from agricultural tailwater and stormwater from the City of Davis. This is part of a treated wastewater effluent system. As such, the wetlands are inundated for periods at any time of the year. In contrast, typically, managed wetlands in the Bypass

Description of Improvements and Potential Benefit:

Improvements include capturing first flush events during the October-November period by reconfiguring the pump design to lift water from Channel A to the Davis Wetlands supply canal. This reconfiguration would also enhance access to the summertime agricultural irrigation runoff, improving existing habitat and potentially helping to treat some of the sediments or other constituents resulting from the runoff. The size of the channels could be increased to improve conveyance in the winter months.

Capturing fall first flush events and summer agricultural runoff would primarily benefit the lower aquatic ecosystems (i.e. lower levels of potential sediments and nutrients to benefit aquatic species). Other benefits include increased habitat availability for waterfowl and shorebirds in the existing wetlands. Additionally, west levee access could potentially be improved if upstream conveyance to the Davis Wetlands is upsized.

RECOMMENDED PROJECT #5						Davis Wetlands Wat
Project Metric	No	Yes			Un-known	
		Low	Med	High		
Agricultural benefit		X				Some improved acces
Migratory waterfowl or shorebird habitat benefit			X			Improved supply for m
"Shovel readiness"		X				Level of design by City
Ease of permitting			X			This project would req Facilities, the Replacem Projects Categorical Ex Class 33 Exemption, w into the project. This p Agreement from the C Water Act Nationwide
Potential for local matching funding			X			City of Davis could pot an eligible expenditur matching funding is co future of wetlands ope
Eligibility for grants			X			Project lacks multiple program. Need to rese
Estimated benefit acreage			X			Up to and potentially e Wetlands and 3,600+ a duck clubs.
Cost estimate			X			$1,200,000
Flood benefit			X			Reduced flooding at w
Listed species benefit		X				Could benefit giant ga
Public benefit (hunting, education, access, etc)			X			Improved access for pu improvements. Public
Water quality benefit			X			Potential water quality
Other environmental benefit		X				Some minor benefits c

Recommended Project 6 (RP-6):

South Davis Drain Input Reconfiguration

Location:

Near the junction of the El Macero Channel (South Davis Drain) and the Yolo Bypass

Recommendations:

Lower the gravity drain pipe through levee 0.5 mile south of the El Macero pump station, owned and operated by the City of Davis (Figure A-6).

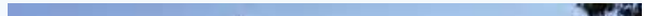
Figure A-6. South Davis Drain area

Description of Improvements and Potential Benefit:

There is an existing gravity drain pipe through the west levee near the Davis drain pumps. It is placed too high for adequate gravity drainage. A new drain pipe could be installed for drainage when the Bypass is not flooded.

Another alternative would be to dig a new drain ditch along the west levee. A low lift pump could be installed to recycle the drain water into an existing farm irrigation canal. The new drain ditch could be located so that it does not jeopardize the west levee. This alternative would greatly reduce the Davis pumping costs, improve farm field drainage, improve levee stability, and reduce Yolo Basin Wildlife Area flooding.

Description of Problem:



RECOMMENDED PROJECT #6	South Davis Drain Input R					
Project Metric	No	Yes			Un-known	
		Low	Med	High		
Agricultural benefit				X		Potential to improve d
Migratory waterfowl or shorebird habitat benefit				X		Improved drainage for
"Shovel readiness"			X			Relatively simple desig
Ease of permitting			X			This project would req Facilities or the Replac (Class 1 or 2 Exemptio Alteration Agreement a Clean Water Act Nati depending upon the l jurisdictional wetlands Valley Flood Protectior through the levee is in
Potential for local matching funding			X			Need future discussion indicated willingness t
Eligibility for grants			X			Matching fund availab funding.
Estimated benefit acreage				X		Up to and potentially e
Cost estimate			X			$750,000
Flood benefit				X		Potential to reduce flo
Listed species benefit					X	Could improve giant g
Public benefit (hunting, education, access, etc)				X		Improved drainage to
Local economy benefit				X		Related to improved m
Water quality benefit	X					

Recommended Project 7 (RP-7):

Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration

Location:

Yolo Bypass Wildlife Area south of I-80. (See Figure A-7 on reverse).

Recommendations:

Construct up to 90,000 linear feet of parallel supply and drain canals for 8 conveyance pathways (see area numbers on Figure A-7 on reverse). Replace pumps of concern ("Second Lift" on Figure A-7). Lower elevations of drain outlets in Toe Drain if feasible. Improve trash racks to reduce maintenance at pumps.

Description of Problem:

The existing system was originally designed for agricultural operations with several dual supply/drain canals that can cause issues for coordinated water management in a multi-use area. The system currently, however, also supplies and drains water for managed wetlands in the YBWA. When agricultural operations need water supply for irrigation,

wetlands may need to drain. Such circumstances create a situation where it is not possible to manage wetland ponds individually. Individual management of ponds is a key element of creating diverse habitat while also managing vegetation, minimizing mosquito larvae populations and controlling avian disease during specific times of the year. Existing drain outlet elevations and tides at Lisbon Weir dictate how rapidly drainage can occur. If Toe Drain surface water levels are elevated as a result of future increases in the duration and frequency of Yolo Bypass flooding, drainage from west to east would be further impeded.

Description of Improvements and Potential Benefit:

Improvements could include rehabilitating existing canals and constructing new drainage and supply canals to facilitate wetland and farming operations, especially in early spring. Timing of wetland drawdown in early spring is important for the germination of nutritious wetland plants and is also important for controlling mosquito populations. Timing is also key for controlling the germination and growth of noxious weeds. Quick drainage following flooding is important for public access and canal improvement will accelerate the winter flood up of managed wetlands and therefore improve early season migratory bird habitat. A faster flood up also would allow for removal of the Los Rios check dam prior to the December 1 deadline to improve access to the creek for fall run Chinook salmon. A more detailed feasibility analysis will be required to fully identify which canals will need to be reconfigured.

RECOMMENDED PROJECT #7	YBWA Dual Function Canal					
Project Metric	No	Yes			Un-known	
		Low	Med	High		
Agricultural benefit				X		Improved supply for fa
Migratory waterfowl or shorebird habitat benefit				X		Improved supply for m
"Shovel readiness"			X			Relatively simple desig
Ease of permitting				X		This project would req Minor Alterations to La This project would also from the California De Act Nationwide Permit Encroachment Permit
Potential for local matching funding		X				The Yolo Basin Founda Wildlife area are the or not have sufficient fun
Eligibility for grants				X		Given that the YBWA is aspects of the project, listed plants, animals a multiple opportunities organizations.
Estimated benefit acreage				X		Up to and potentially e
Cost estimate		X				Area 1: $4,000,000. Are Area 4: $1,000,000. Are Area 8: $205,000.
Flood benefit				X		Improved drainage du
Listed species benefit					X	
Public benefit (hunting, education, access, etc)				X		Improved drainage to
Water quality benefit	X					
Other environmental benefit	X					

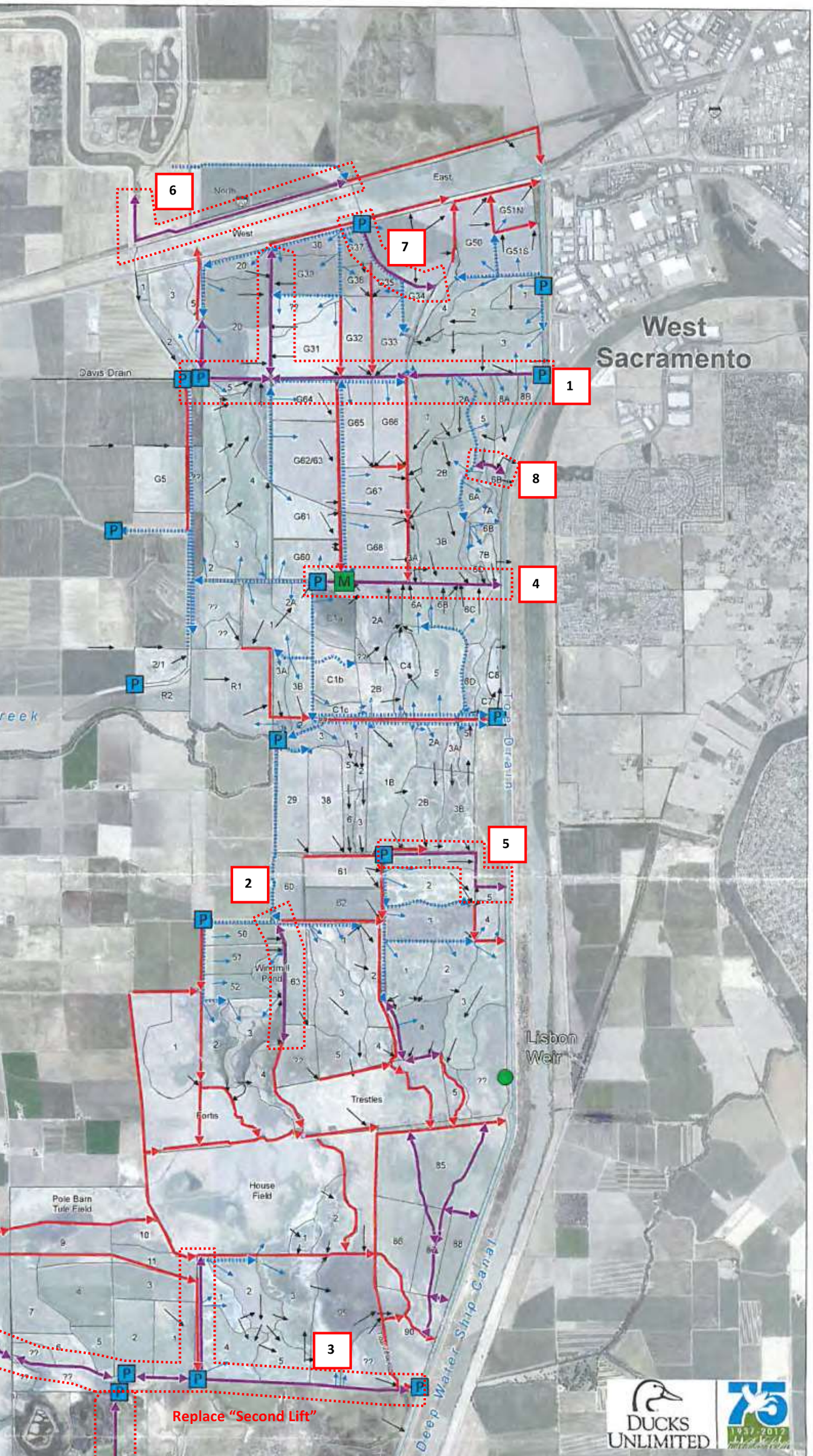

6
7
1
8
4
5
2
3
West Sacramento
Davis Drain
Lisbon Weir
Deep Water Ship Canal
Tule Drain
Windmill Pond
Trestles
Forts
House Field
Pole Barn Tule Field
Replace "Second Lift"
DUCKS UNLIMITED

Figure A-7

Recommended Project 8 (RP-8):

Yolo Bypass Wildlife Area Public and Operation & Maintenance Road Improvements

Location:

Yolo Bypass Wildlife Area south of I-80. (See Figure A-8 on reverse)

Recommendations:

Raise 6 miles of primary low lying public access road locations inundated during early stages of flooding (e.g. at the "Rice Corner" and the "Y"). Augment key O&M roads with gravel to make "all-weather" roads.

Road in YBWA. **See Figure A-8 on reverse.**

Description of Improvements and Potential Benefit:

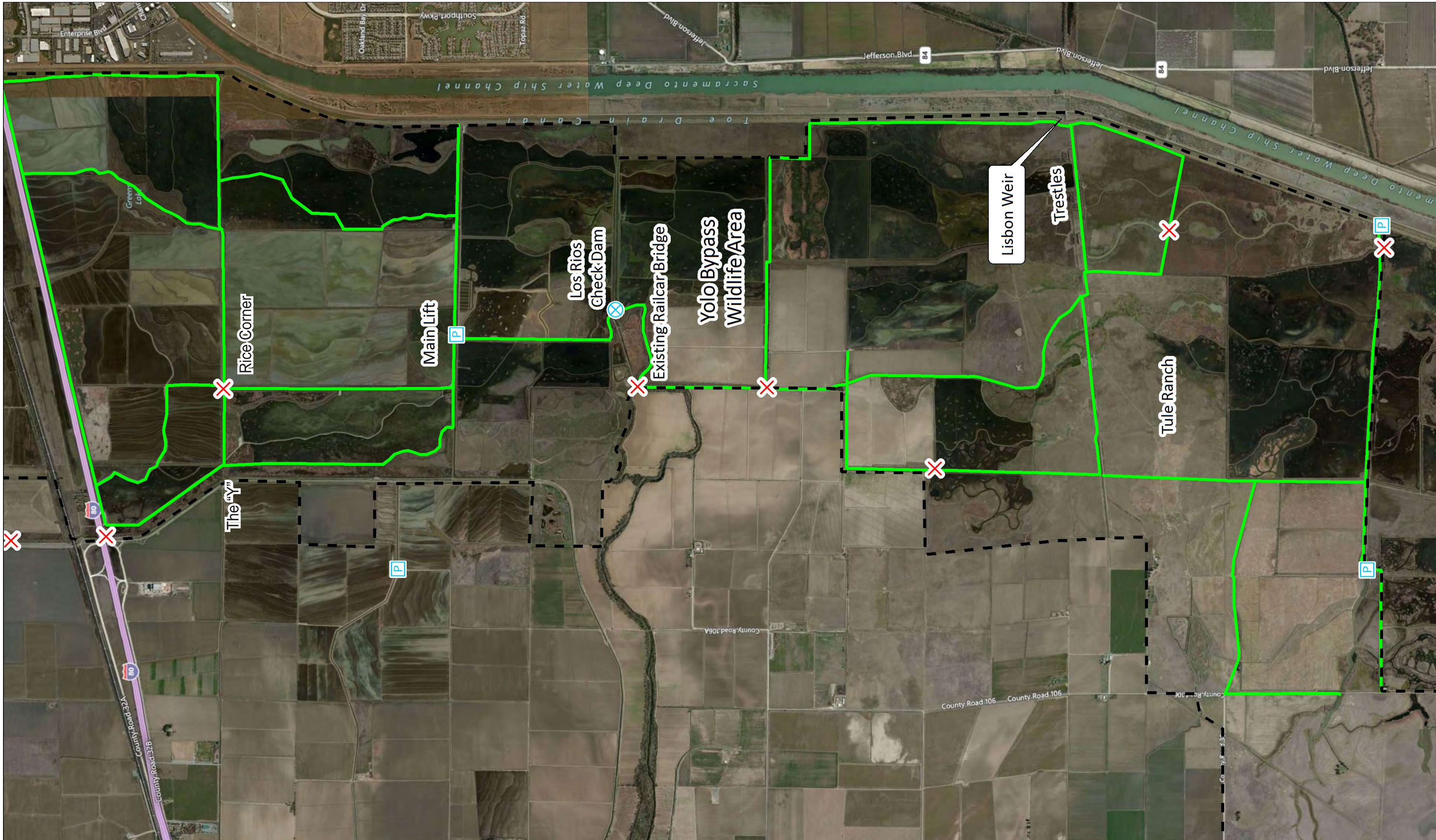
Improvements include raising access roads and surfacing with "all-weather" materials as shown on Figure A-8. Benefits include improved public and operation and maintenance access.

Description of Problem:

The existing elevations along roadways at the "Rice Corner" and "Y" restrict public access during early stages of flooding (see Figure A-8 on reverse). These are important access points for public use and operation and maintenance of water supply and drainage structures. These roads flood as Toe Drain levels rise making the entire west

RECOMMENDED PROJECT #8	YBWA Public and O&M Roa					
Project Metric	No	Yes			Un-known	
		Low	Med	High		
Agricultural benefit				X		Improved O&M access
Migratory waterfowl or shorebird habitat benefit				X		Improved O&M access
"Shovel readiness"				X		Relatively simple desig
Ease of permitting				X		This project would req Existing Facilities, the R to Land Categorical Exe also likely require an En Protection Board.
Potential for local matching funding		X				Yolo Basin Foundation area are the only poten have sufficient funds f
Eligibility for grants				X		Given that the YBWA is aspects of the project, are listed plants, anima multiple opportunities organizations.
Estimated benefit acreage				X		Up to and potentially e
Cost estimate			X			6 miles of road, clean d
Flood benefit	X					
Listed species benefit	X					
Public benefit (hunting, education, access, etc)				X		Improved public and C
Water quality benefit		X				Reduced runoff of fine
Other environmental benefit		X				Reduced vehicular imp

Figure A-8



Yolo Bypass Wildlife Area
Tule Ranch
Trestles
Lisbon Weir
Existing Railcar Bridge
Los Rios Check Dam
Main Lift
Rice Corner
The "Y"
Sacramento Deep Water Ship Channel
Toe Drain Canal
Jefferson Blvd
County Road 106
County Road 106A
County Road 32A
County Road 32B
Southport Pkwy
Oakland Bay Dr
Topaz Rd
Enterprise Blvd

Recommended Project 9 (RP-9):

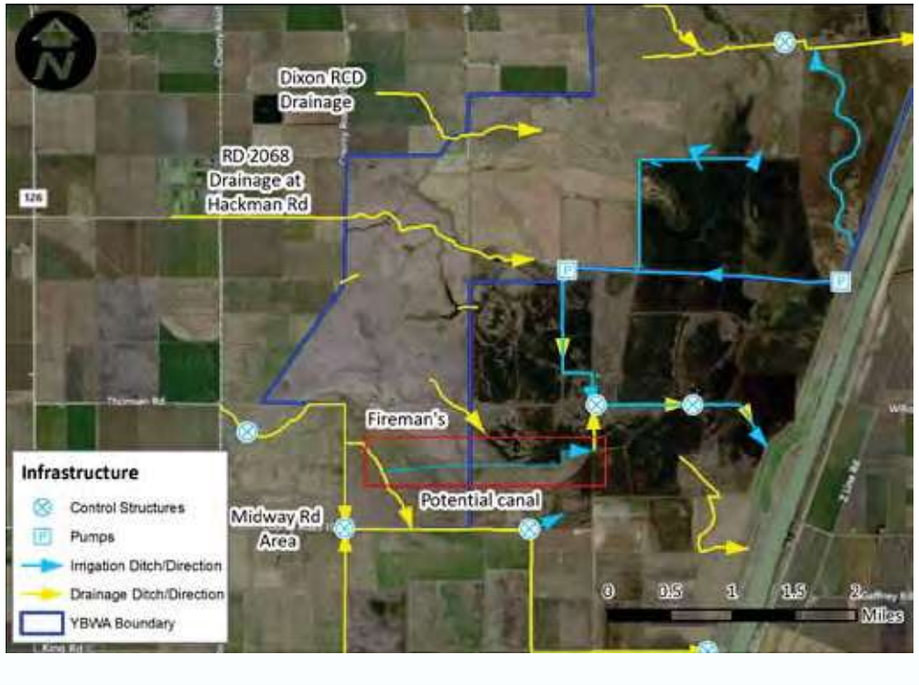
Stormwater and Summer Tailwater Re-Use and Supply

Location:

Near the RD 2068 delivery point at the east end of Midway Road.

Recommendations:

Re-use or divert excess winter runoff and/or agricultural tailwater near the Midway Road Area.



Description of Improvements and Potential Benefit:

Improvements include several control structure installations or upgrades, one pump station installation and one upgrade, as well as canal creation and improvements. Benefits include Improved summer and/or winter supply to potential contracted users, and potential habitat and water quality improvements.

Description of Problem:

Existing configuration of canals and pumps does not

RECOMMENDED PROJECT #9	RD 2068 Stormwater and Summer Ta					
Project Metric	No	Yes			Un-known	
		Low	Med	High		
Agricultural benefit			X			Improved summer and
Migratory waterfowl or shorebird habitat benefit			X			Improved summer and
"Shovel readiness"		X				Relatively simple desig
Ease of permitting				X		This project would req Alterations to Land Ca would also likely requi Department of Fish an U.S. Army Corps of Eng Valley Flood Protectio
Potential for local matching funding					X	To be determined.
Eligibility for grants					X	To be determined.
Estimated benefit acreage					X	Varies depending on l
Cost estimate			X			$1,340,000
Listed species benefit	X					
Public benefit (hunting, education, access, etc)			X			Improved water level and winter waterfowl/ private lands
Water quality benefit	X					Could have a WQ bene
Other environmental benefit	X					

Recommended Project 10 (RP-10):

Local Agricultural Crossing Improvements

Location:

Throughout the Yolo Bypass at localized crossings with and without water control structures as initially identified by management area or property. (See Figures A-10a and A-10b).

Recommendations:

Replace 28 agricultural crossings that do not require a control structure with railcar bridges with concrete abutments or similar upgrades. Upgrade priority water control structures to improve water supply function and drainage.

Railcar crossing without concrete abutments at the Island, YBWA. This crossing is recommended for replacement with concrete abutment railcar crossing. **(See Figures A-10a and A-10b).**

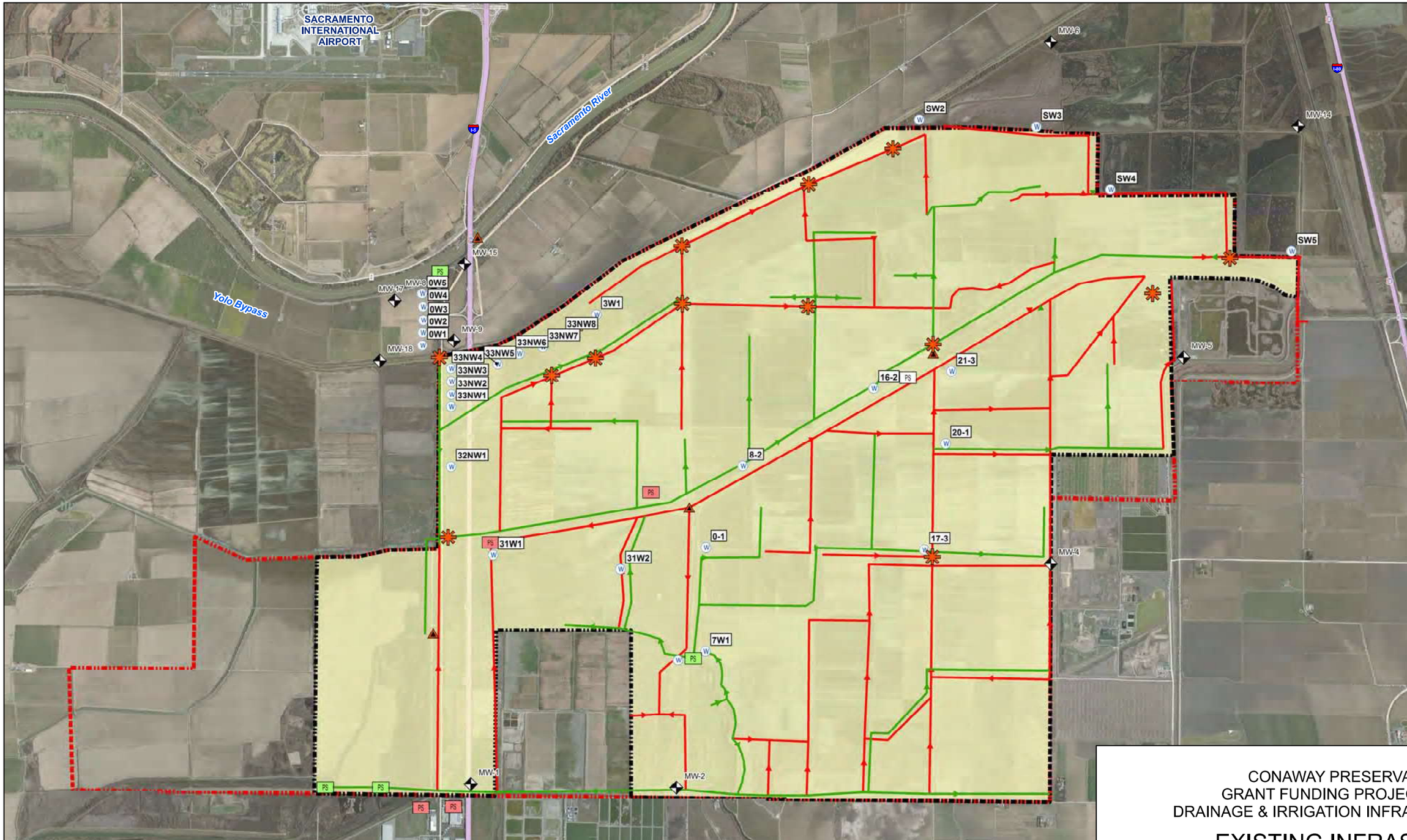
Description of Improvements and Potential Benefit:

Improvements to culvert crossings include replacing existing crossings with clear span decks consisting of either rail car bridges or other structural techniques. Benefits include reduced maintenance costs, improved water delivery, drainage for agriculture and managed wetlands, and improved conveyance during flooding and low water operations. Control of mosquito populations may also improve. Landowners and wetland managers indicated that rail car bridges generally are less likely to be blocked by beaver dams than culverts. Improvements to water control structures may consist of similar clear span decks with concrete abutments with the addition of sluice gates or flashboard riser combination gates. Those gates can be removed in the winter for improved drainage by creating a larger flow conveyance area.

Description of Problem:

RECOMMENDED PROJECT #10	Local Agricultural Crossing					
Project Metric	No	Yes			Un-known	
		Low	Med	High		
Agricultural benefit				X		Reduced maintenance operations.
Migratory waterfowl or shorebird habitat benefit				X		Improved conveyance
"Shovel readiness"			X			Relatively simple desig
Ease of permitting				X		These crossings would for the Existing Facilitie Exemptions (Class 1 or within the water cours from the California De Nationwide Permit fro Permit from the Centra
Potential for local matching funding			X			Landowners may be in improve operations. N may be available for in
Eligibility for grants				X		Multi-benefit aspects c
Estimated benefit acreage				X		Varies depending on l
Cost estimate			X			Up to $70,000 per cros
Flood benefit			X			Improved conveyance
Listed species benefit					X	
Public benefit (hunting, education, access, etc)				X		Improved reliability of
Water quality benefit	X					
Other environmental benefit	X					

Figure A-10a


SACRAMENTO INTERNATIONAL AIRPORT
Sacramento River
Yolo Bypass
MW-6
MW-14
MW-5
MW-4
MW-1
MW-2
MW-15
MW-17
MW-8
MW-9
MW-18
SW2
SW3
SW4
SW5
0W5
0W4
0W3
0W2
0W1
3W1
33NW8
33NW7
33NW6
33NW5
33NW4
33NW3
33NW2
33NW1
32NW1
31W1
31W2
7W1
0-1
8-2
16-2
17-3
21-3
20-1
CONAWAY PRESERVA
GRANT FUNDING PROJE
DRAINAGE & IRRIGATION INFRA
EXISTING INFRAS


Project 6
Projects 7 and 8
(YBWA Wide)
Los Rios
Main Lift
Los Rios
Check Dam
Existing Railcar Bridge
Putah Creek
Levee Terminus
Los Rios
Yolo Bypass
Wildlife Area
Lisbon Weir
Project 3
Trestles
Tule Ranch
Senator
Glide In
0 0.4 0.8 1.2 1.6
Miles
Infrastructure
Culvert Crossings
Gravity Drain/Supply
Control Structures

Figure A-10b

Recommended Project 11 (RP-11):

Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency

Location:

Throughout the Yolo Bypass.

Recommendations:

Develop a special district, possibly through an existing Resource Conservation District, to maintain irrigation and drainage canals and implement other system improvements.

Description of Problem:

Existing agricultural operations and wetland managers control vegetation and siltation in irrigation and drainage canals at landowners' expense even though the Yolo Bypass provides system wide benefits as part of the Sacramento River Flood Control Project. Existing agriculture and managed wetland canals, crossings, fields and pumps require frequent maintenance, including removal of silt, invasive aquatic vegetation, and beaver blockages. Removal of flood debris on bridges, crossings, streambanks, and fields is also necessary after large flood events. Future increased inundation and frequency of flooding could increase maintenance needs and costs incurred to landowners and managers.

Description of Improvements and Potential Benefit:

Landowners could participate in the maintenance and improvement program through a state funded reimbursement process or the state or special district could hire a dedicated labor force and purchasing equipment through grants or other funding sources. The program would need to be managed by one or two full time staff, probably a general manager, and a labor/engineering supervisor. If the program includes a dedicated labor force, operating costs could significantly increase. Alternatively, a Yolo Bypass "Keeper" approach could be adopted, similar to the Putah Creek Streamkeeper, a position created by the Putah Creek Accord in 2000. System wide benefits would include improved conveyance during flooding, improved water supply operations for proposed fish habitat management, improved drainage of lands on the receding limb of the hydrograph, and improved access during and after flood events. Public and private landowners in the Bypass would benefit from reduced maintenance costs and improved access.

RECOMMENDED PROJECT #11	Bypass Wide: Creation of Coordinated Mainter					
Project Metric	No	Yes			Un-known	
		Low	Med	High		
Agricultural benefit				X		Improved supply and d and silt removal.
Migratory waterfowl or shorebird habitat benefit				X		Improved supply and d and silt removal.
"Shovel readiness"	X					Not applicable.
Ease of permitting						The establishment of a reimbursement progra would not require any
Potential for local matching funding		X		X		Local landowners and funds on an annual ba funding is currently ins
Eligibility for grants		X				Given the costs are on be difficult to identify must be identified.
Estimated benefit acreage				X		Varies depending on ju
Cost estimate			X			Costs could vary consi staff, accommodation considerably dependin
Flood benefit				X		Improved drainage an silt removal.
Listed species benefit					X	
Public benefit (hunting, education, access, etc)				X		Improved reliability of
Water quality benefit					X	
Other environmental benefit		X				Environmental benefit watercourses.

Recommended Project 12 (RP-12):
Westside Tributaries Monitoring

Location:

Knights Landing Ridge Cut, Cache Creek, Willow Slough Bypass, Putah Creek tributary inputs to Bypass.

Recommendations:

Various measures to improve, or introduce, flow gauging on tributary flow inputs to the Yolo Bypass.

Description of Problem:

Since westside tributary inflows play an important role in Bypass inundation, understanding the timing and magnitude of inflows is needed to determine their relative influence compared to larger inflows from the Fremont and Sacramento Weirs. Better data is needed to synthesize past and future hydrology datasets for the purposes of modeling existing conditions and future management scenarios. For example, discussion on future management scenarios has included the consideration of modifying the inundation regime for the Yolo Bypass during flood events. In terms of balancing habitat and agricultural objectives, the magnitude, frequency, duration, timing, depth, area, and rate of change of floodplain inundation are all critical parameters to understand thoroughly. The westside tributary inflows affect these parameters significantly. A brief summary of available data for each tributary is provided below:

- Flow estimates entering the Yolo Bypass at Knights Landing Ridge Cut (KLRC), were approximated prior to 2009 based on Colusa Drain flows at Highway 20, rough rainfall runoff estimates for the un-gauged portion of Colusa Basin, and flows to the Sacramento River via the Knights Landing Outfall Gates (Outfall Gates). This resulted in flow estimates with large uncertainty. In 2009, flow gauging on KLRC downstream of the Outfall Gates (CDEC ID RCS) was initiated by DWR North Central Region Office (NCRO).
- Flow estimates entering the Yolo Bypass at the Cache Creek Settling Basin have been based on USGS gauged flows on Cache Creek just downstream of I-5 since 1903 without any routing and attenuation (i.e. compensating for changes to the hydrograph shape due to channel geometry or storage in the Cache Creek Settling Basin).

criteria when Monticello Dam is spilling. Only low flows (i.e., less than 100 cfs) are gauged on Putah Creek by Solano County Water Agency (SCWA) downstream of PDD at several locations.

Further details of this recommended project are provided in the accompanying report, Appendix B.

Description of Improvements and Potential Benefit:

- **Knights Landing Ridge Cut:** DWR NCRO should continue the RCS monitoring program, continue to refine the low flow rating curve, and extend the rating curve for flows above 1,600 cfs. Future funding for continued monitoring at this location needs to be confirmed with DWR. In addition, a more reliable and accurate method for approximating inflows into the Yolo Bypass prior to 2009 needs to be performed via desktop analysis.
- **Cache Creek:** In addition to operating the USGS gauging station just downstream of I5, the USGS should continue monitoring the total outflow from the Cache Creek Settling Basin. Future funding for continued monitoring at this location should be confirmed with the USGS. In addition, a more reliable and accurate method for approximating inflows into the Yolo Bypass prior to 2009 needs to be performed via desktop analysis.
- **Willow Slough Bypass:** The main recommendation here is to install flow and stage monitoring stations along the Willow Slough Bypass. Once data has been collected for several years, the assumptions from the Management Strategy using scaled Interdam Runoff can be validated and potentially modified.
- **Putah Creek:** The US Bureau of Reclamation and Solano Irrigation District (SID) Putah Diversion Office (PDO) have been monitoring and recording flows on Putah Creek between Monticello Dam and Lake Solano. More recently, SCWA has been monitoring low flows (i.e., less than 100 cfs) and stages at eight stations along Putah Creek from the PDD to Los Rios Check Dam primarily during the growing season to verify fish pulse flows. Locations within the Yolo Bypass are not suitable for flow rating above 100 cfs due to backwater conditions from the Toe

RECOMMENDED PROJECT #12	Bypass Wide: West Side Tribu					
Project Metric	No	Yes			Un-known	
		Low	Med	High		
Agricultural benefit		X				Improved understandi
Migratory waterfowl or shorebird habitat benefit		X				Improved understandi
"Shovel readiness"			X			Relatively simple desig
Ease of permitting				X		The proposed monitor likely qualify for the In Exemption). No other
Potential for local matching funding		X				
Eligibility for grants				X		DWR.
Estimated benefit acreage				X		Whole Bypass.
Cost estimate			X			$160,000 to $500,000 of monitoring.
Flood benefit					X	Improved understandi
Listed species benefit					X	
Public benefit (hunting, education, access, etc)					X	
Water quality benefit					X	Water quality, particula regime.
Other environmental benefit					X	

APPENDIX B

WESTSIDE TRIBUTARY INFLOWS

1 WESTSIDE TRIBUTARY INFLOWS

The Yolo Bypass receives rainfall runoff, agricultural tailwater drainage, bypass flood flows, stormwater and wastewater effluent from several locations, primarily originating from the west. Four main tributaries, hereafter referred to as the Westside tributaries, convey variable amounts of runoff, stormwater and flood flows: the Knights Landing Ridge Cut Canal, Cache Creek, Willow Slough via the Willow Slough Bypass, and Putah Creek. The following sections summarize existing knowledge about the Westside tributaries, describe the low flow hydrology as estimated or described by the Yolo Bypass Management Strategy (herein, Management Strategy) (Jones & Stokes, 2001), and provide recommendations for validating these estimation equations or for future data collection.

Previous Yolo Bypass modeling efforts (e.g. cbec MIKE21 modeling) used the Management Strategy estimations as these represented the best available data at that time. cbec and others have previously noted potential improvements to modeling input data with more detailed information regarding Westside tributary flow characteristics and inflow locations (cbec, 2012; Northwest Hydraulics et al., 2012). A major recommendation from the present study is to implement a focused data collection and validation effort of hydrologic data for the Westside tributaries. The main recommendations include:

- **Knights Landing Ridge Cut:** Refine the rainfall trigger value at Colusa, or the value of rainfall in inches per day that must be exceeded to justify a "significant" amount of precipitation for a calculation of flow in the Knights Landing Ridge Cut. The Management Strategy cites 0.3 inches per day at Colusa as the condition determining KLRC inflow to the Yolo Bypass.
- **Cache Creek:** In addition to continuing Cache Creek data collection at the USGS gauges immediately entering the western edge of the Bypass near the Overflow Weir, historical gauged flows near Interstate 5 can be transformed with basic routing to account for storage and attenuation in the Settling Basin, especially during low flows.
- **Willow Slough Bypass:** The main recommendation here is to install flow and stage monitoring stations in the Willow Slough Bypass. Once data has been collected for several years, the assumptions from the Management Strategy can be validated and potentially modified.
- **Putah Creek:** SCWA has been monitoring low flows (i.e. less than approximately 100 cfs) at eight stations along Putah Creek from the Putah Diversion Dam to Los Rios Check Dam (available online at http://www.grabdata.com/solano_putahcreek.htm). It is recommended that these stations be rated for higher flows for historical verification and for use in future modeling efforts. Validation of the Interdam Reach (between Monticello Dam and Putah Diversion Dam) is also recommended.

The historical daily inflow hydrology to the Yolo Bypass was developed as part of the Yolo Bypass Management Strategy, Chapter 2 – Existing Conditions in the Yolo Bypass, (Jones & Stokes, 2001) for these four tributaries for the period of 1968 to 1998. cbec recently updated this hydrologic dataset through 2011 for a DWR modeling effort (cbec, 2012). During the period from 1968 to 2011, or 44 years, Fremont Weir spilled 29 of those years or 2 out of 3 years (66% of years) according to the updated hydrology dataset. The "Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals" Final Report evaluated a shorter timeframe of 26 years (1984 and 2009), during which the Fremont Weir

spilled 15 of those years or 58% of years. In years when Fremont Weir did not spill, Cache Creek and the Knights Landing Ridge Cut generally supplied the majority of peak flows into the Yolo Bypass, followed by Willow Slough Bypass and Putah Creek (Figure B-1). These datasets are based primarily on estimation assumptions discussed in the following subsections.

1.1.1 KNIGHTS LANDING RIDGE CUT CANAL

1.1.1.1 Existing Configuration

The Knights Landing Ridge Cut Canal (herein, KLRC) originates at the Colusa Basin Drain near Knights Landing. It was designed to convey Colusa Basin flood flows as an alternative to discharging to the Sacramento River. The KLRC, completed in 1915, is approximately 400 feet wide with two channels excavated by dredger and borrowed to construct the bounding levees. A mid channel island also runs the midline of the KLRC due to dredger arm constraints (H.T. Harvey, 2008). The original design capacity was 15,000 to 20,000 cfs, with a 1983 preliminary current meter measurement and calculation estimating the maximum capacity at 15,700 cfs (DWR, 1990).

Upstream inflows originate from the Glenn-Colusa Irrigation District (GCID) in the form of winter runoff and summer agricultural tailwater runoff. The GCID replaced Davis Weir along the Colusa Drain near Williams with an Obermeyer bladder dam in 2010 (GCID, 2010). A set of flap gates, the Knights Landing Outfall Gates (KLOG), at the Sacramento River control winter flood flow conveyance down the KLRC, such that when river stage exceeds 25 feet USED (United States Engineering Datum, formerly United States Army Corps of Engineers Datum) or 24.2 feet NAVD88 (North American Vertical Datum of 1988) the flap gates close and all GCID runoff is conveyed into the Yolo Bypass (H.T. Harvey, 2008). The Wallace Weir, owned and operated by Knaggs Ranch, located on the KLRC at the western side of the Yolo Bypass (Figure B-2), is an earthen berm approximately 450 feet long with a permanent box culvert 28 feet wide at the northeastern end. The earthen berm is required to be removed on December 1 of each year to facilitate the flood conveyance function, and replaced in April or May. The maintainers sometimes leave the berm in place longer when it appears there is a low probability of early high flows from the Colusa Basin Drain. Depending on water year, timing of spring runoff event conditions and upstream users, runoff is impounded at Wallace Weir for use within and across the Yolo Bypass in Reclamation District 1600 (RD 1600). During the August to September drain period largely associate with rice production, a majority of tailwater runoff proceeds to the Sacramento River and in the winter and spring months when the river exceed 24.2 ft NAVD88, all water enters the Yolo Bypass.

1.1.1.2 Historical Hydrology and Recommendations

The main recommendation here is to refine the rainfall trigger value at Colusa, or the value of rainfall in inches per day that must be exceeded to justify a “significant” amount of precipitation for a calculation of flow in the KLRC. The Management Strategy cites 0.3 inches per day at Colusa as the condition determining KLRC inflow to the Yolo Bypass. Additionally, continued long term monitoring of flow and stage data at CDEC station ID RCS (Figure B-2) is highly encouraged to further verify the estimation

assumptions or for future modeling efforts. Reviewed flow data for RCS at Knights Landing is available with DWR starting December 7, 2006.

To summarize Chapter 2 of the Management Strategy, daily inflow hydrology to the Yolo Bypass from KLRC was estimated by subtracting gauged outflows to the Sacramento River past the Knights Landing Outfall Gates (KLOG) from gauged flow at DWR's Colusa Basin Drain at Highway 20 station (CDEC ID: CDR) extrapolated to the entire watershed area (see Figure B-2 for gauging station locations and Jones & Stokes (2001) for detailed assumptions). This daily calculation is only performed if rainfall rates at Colusa exceed 0.3 inches per day, otherwise the estimated inflow value falls to zero (Jones & Stokes, 2001). To validate this estimation, it was compared to gauged flow in the Ridge Cut (CDEC ID: RCS) for one week in January 2010. In January 2010, a relatively minor storm event passed through the region, causing four non-consecutive days of Fremont Weir overtopping (Jan. 23, Jan. 24, Jan. 28 and Jan. 29), with flow in the Toe Drain near Interstate 5 (CDEC ID: YBY) ranging from 5,290 cfs and 7,170 cfs (Table 1). Rainfall at Colusa equaled or exceeded 0.3 inches per day on 2 of 7 days while flow at Highway 20 was relatively high exceeding 11,000 cfs. Because Sacramento River stage at Knights Landing exceeded 24.2 feet NAVD88, no outflow was conveyed from the Drain to the river. These conditions led to only two of seven days being included in the calculation. See the last two columns of Table B-1 comparing the Management Strategy estimate versus observed flow at CDEC station ID RCS (Figure B-2) in the KLRC and note the rainfall trigger and that the inflow estimate as compared to gauged flow.

A comparison of the January 2010 event to the March 2011 event shows large variation in the gauged data as well. While the January 2010 event gauged flow at CDEC Station ID CDR (Figure B-2) near Highway 20 reported higher magnitude than in the KLRC, the opposite occurred in March 2011 event likely due to ungauged overflows over the KLOG from the river to the Drain as stage in the Sacramento River exceeded the flood stage (37 feet USED or 36.2 feet NAVD88) (Figure B-3). A comparison of the two small spikes before and after the March 2011 event, in January and June 2011 respectively, show a closer match between CDR near Highway 20 and the Ridge Cut, as well as a better estimation of KLRC inflows.

Table B-1. Validation of Knights Landing Ridge Cut inflow hydrology estimate for a small flood event[1]

Location	Fremont Weir Spill	Toe Drain at I-5	Precipitation at Colusa	Colusa Basin Drain at Highway 20	Colusa Drain Outflow to Sacramento River	Sacramento River at Knights Landing	*KLRC*	Ridge Cut Slough at Co Hwy E8
Date	**FRE (cfs)**	**YBY (cfs)**	**CIMIS (in)**	**CDR (cfs)**	**A02945 (cfs)**	**KNL (ft, NAVD88)**	***KLRC Inflow Estimate (cfs)***	**RCS (cfs)**
1/23/2010	5,465	5,390	0.19	8,661	0	35.2	*0*	2,225
1/24/2010	3,317	5810	0.3	8,209	0	35.4	*9940*	2,457
1/25/2010	--[2]	5,290	1.4	7,633	0	34.4	*9242*	2,754
1/26/2010	--[2]	5,600	0.06	9,354	0	33.7	*0*	3,105

1/27/2010	--[2]	7,170	0	11,319	0	34.2	*0*	3,555
1/28/2010	3,707	6,300	0	10,847	0	35.0	*0*	3,909
1/29/2010	2,129	5,950	0.06	8,788	0	35.0	*0*	4,144

[1]All data is observed gauge data except the KLRC inflow estimate.

[2]No spill over Fremont Weir.

Since historical diversions and overflow at the KLOG are not gauged, updating the equation to account for these year to year variations is infeasible. Thus, the main recommendation here is to refine the rainfall trigger value of 0.3 inches per day. Additionally, continued long term monitoring of flow and stage data at RCS is highly encouraged to further verify the estimation assumptions or for subsequent modeling efforts.

1.1.2 Cache Creek

1.1.2.1 Existing Configuration

Cache Creek inflows to the Bypass proceed from the Cache Creek Settling Basin either over the Cache Creek Overflow Weir, with a design capacity of 30,000 cfs or through a low flow outlet at the southern extent of the settling basin. FloodSAFE Yolo identified the Cache Creek Settling Basin for modification to improve flooding conditions in the region in a 2009 presentation (FloodSAFE Yolo, 2009). Potential changes in the region should be considered for Yolo Bypass management as well (CVFPP, 2011). Additionally, the Central Valley Flood Protection Board recently requested approval of a letter to United States Army Corps of Engineers requesting a reconnaissance study to determine federal interest in the modification project (CVFPB, 2013).

1.1.2.2 Historical Hydrology and Recommendations

In addition to continuing Cache Creek data collection at the USGS gauges immediately entering the western edge of the Bypass, the key recommendation here is to consider transforming CCY historical gauged flows with basic routing to account for storage and attenuation in the Settling Basin, especially during low flows.

As described in the Yolo Bypass Management Strategy (Jones & Stokes, 2001), inflows to the Yolo Bypass from Cache Creek are gauged by the United States Geological Service (USGS), with a long term gauging record (USGS ID: 11452500; CDEC ID: CCY on Figure B-2). While the Management Strategy notes that no significant tributaries or diversions exist downstream of this gauge, the timing and magnitude of inflows at the inlet to the Yolo Bypass are likely affected by storage in the Cache Creek Settling Basin located adjacent to the western edge of the Yolo Bypass. A comparison between CCY and recent total flow (overflow weir plus outflow) data collection as part of a Cache Creek Settling Basin Study at USGS station 11452901 (location shown in B- 2) for the 2010 and 2011 storm events shows that small peaks events at CCY are attenuated in the Settling Basin (Figure B-4). Additionally, for larger events, as in March 2011, the timing and magnitude of total peak inflow to the Bypass may be delayed.

1.1.3 Willow Slough Bypass

1.1.3.1 Existing Configuration

Willow Slough originates from a small unregulated watershed between Cache Creek and Putah Creek with historically intermittent swales and sloughs draining to the Yolo Basin (CDFW, 2008). The Willow Slough Bypass has a design capacity of 6,000 cfs and is maintained by DWR (CVFMP, 2010). The Davis Wastewater Treatment Plant discharge location releases effluent to the Willow Slough Bypass (see Figure B-2). In addition, the Davis Wetlands border the Willow Slough Bypass and discharge treated water into the Yolo Bypass. As part of the State Plan for Flood Control, Willow Slough was rerouted from its historic northward route toward the Yolo Bypass to its current configuration within the Willow Slough Bypass with a diversion weir (Merritt Diversion Dam) at the bifurcation point just downstream of a railroad bridge near the County Road 29 and 101A (F Street) intersection (CVFMP, 2010).

1.1.3.2 Historical Hydrology and Recommendations

The main recommendation here is to install flow and stage monitoring stations in the Willow Slough Bypass, preferably upstream and downstream of the diversion dam that sits at the upstream end of the Willow Slough Bypass floodway. Once data has been collected for several years, the assumptions from the Management Strategy can be validated and potentially modified.

As described in the Management Strategy (Jones & Stokes, 2001), Willow Slough has not been gauged during the historical record. Instead historical hydrology was estimated by inferring Willow Slough flow from gauged runoff in the Interdam Reach (between Lake Berryessa and Lake Solano) of Putah Creek adjusted by drainage area for the Interdam Reach compared to Willow Slough. See the Management Strategy for more details on these assumptions. As Willow Slough is unregulated, small peak runoff events are common (CDFW, 2008). Compared to Putah Creek from recent water years 2005 to 2011, Willow Slough flows are similar in pattern with slightly higher magnitude peaks due to estimation assumptions scaling up drainage area, except when Berryessa spills as in 2006 (Figure B-5).

1.1.4 Putah Creek

1.1.4.1 Existing Configuration

Putah Creek is regulated by Monticello Dam at Lake Berryessa, and the Putah Diversion Dam near Winters and the Los Rios Check Dam in the YBWA. Putah Creek below the Diversion Dam serves as a diversion point for irrigation and discharge along its length and also as a flood control channel maintained by DWR in the leveed portion from 1 mile upstream of Interstate 80 to the Yolo Bypass (CVFPB, 2010). The Los Rios Check Dam is a 12 foot high, by 25 foot wide concrete structure with removable timber stop logs, which are in place from April/May through December 1st to impound water for agriculture and wetland management. During the remaining months, the stop logs are removed to assist fall-run Chinook migration in Putah Creek when Solano County Water Agency (SCWA) is releasing water from Putah Diversion Dam to fulfill the requirements of the Putah Creek Accord (CDFW, 2008).

The Putah Creek Accord was signed in May 2000 to provide minimum flows and pulse flows for the benefit of fish and wildlife.

Lower Putah Creek is also undergoing a study funded through an Ecosystem Restoration Program Grant to consider realignment of the channel within the YBWA, improve fish passage and meet other Ecosystem Restoration Project Goals (Yolo Basin Foundation, 2010b). As part of that, stage and flow monitoring (at locations noted in Figure B-2) was conducted between November 2012 and June 2013, which confirmed that the conveyance capacity of the creek within the YBWA before it begins to spill onto its floodplain is approximately 1,000 cfs.

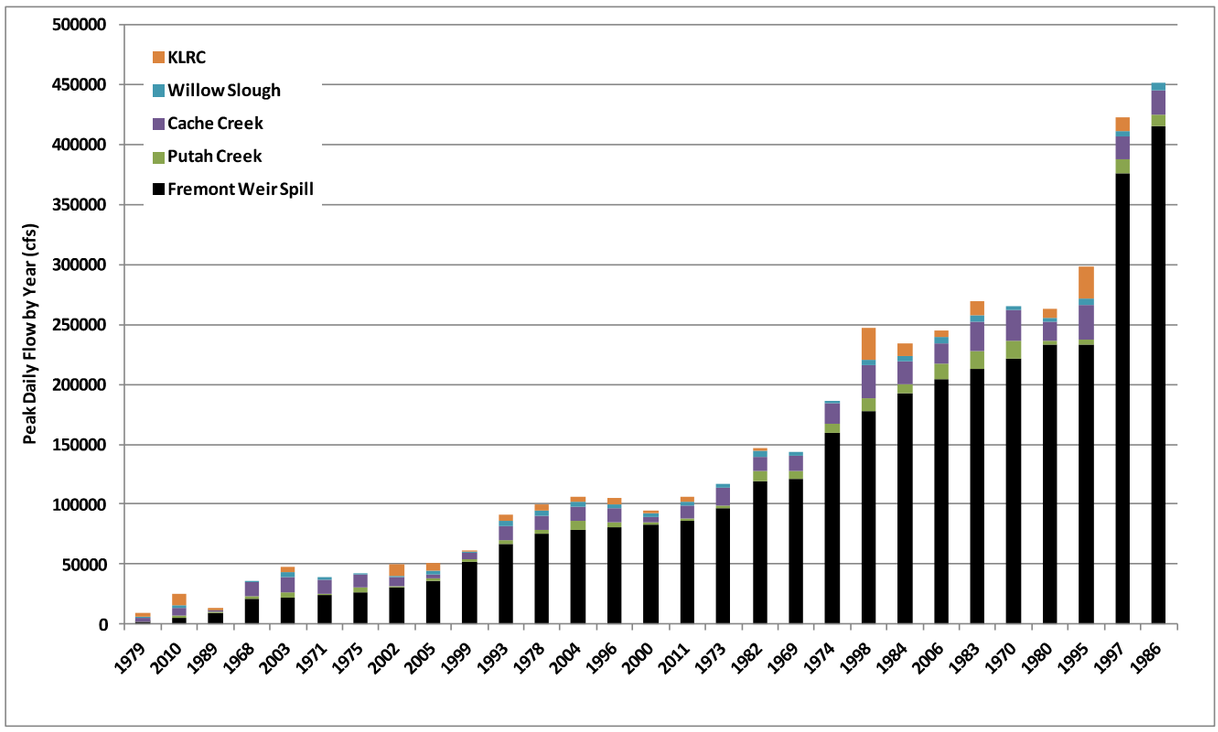
In addition, the UC Davis Wastewater Treatment Plant discharges into Putah Creek at Old Davis Road (see Figure B-2).

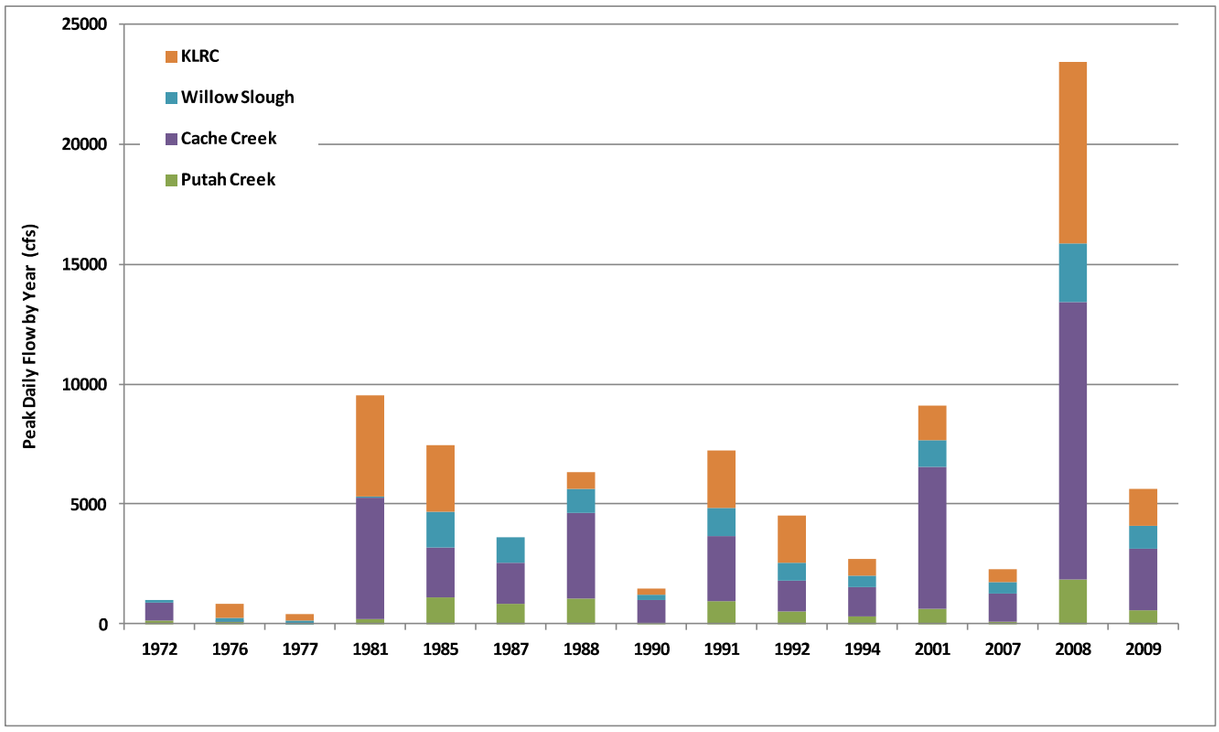
1.1.4.2 Historical Hydrology and Recommendations

SCWA has been monitoring low flows (i.e. less than approximately 100 cfs) data collection at eight stations along Putah Creek from the Putah Diversion Dam to Los Rios Check Dam (available online at http://www.grabdata.com/solano_putahcreek.htm). We recommend that these stations be rated for higher flows for historical verification and for use in future modeling efforts.

The Management Strategy estimated inflows to the Yolo Bypass from Putah Creek based on release and spill at Monticello Dam and Putah Diversion Dam. During times with no active rainfall-runoff (Condition 1) or if Monticello Dam is spilling (Condition 3), inflow to the Yolo Bypass equals Putah Diversion Dam releases minus 30 cfs seepage and evapotranspiration losses. If there is active rainfall runoff (Condition 2), defined as Interdam Runoff in excess of 100 cfs, then inflow to the Yolo Bypass equals two times the Putah Diversion Dam releases minus 30 cfs for losses. See the Management Strategy (Jones & Stokes, 2001) for more detail regarding these assumptions.

Interdam Runoff is defined as the difference between (a) Berryessa release plus spill and (b) Putah Diversion Dam release after diversion to the Putah South Canal. To better estimate Interdam runoff, total flow through the Putah Diversion Dam (i.e., release plus spill) including diversions to the Putah South Canal could be added to part (b) in this equation.





Notes: Years with Fremont Spill (top) and without (bottom)	cbec eco engineering	*Yolo Bypass Drainage and Water Infrastructure Improvement Study* **Relative tributary yearly maximum flow**	
		Project No. 12-1039	Created By: AMS
			Figure B-1

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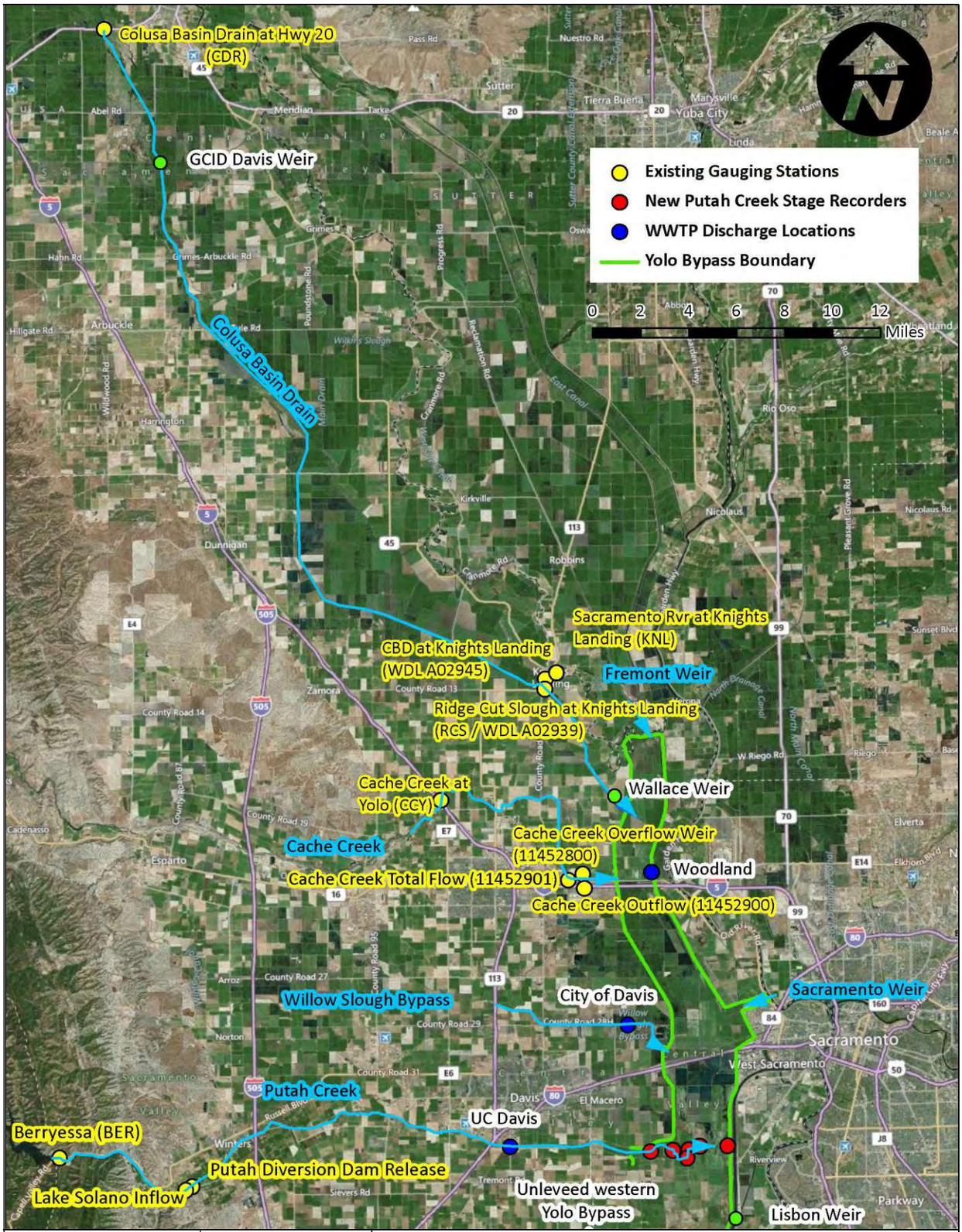
1/3/2014



Notes: Image courtesy of BingMaps (2009).	cbec eco engineering	*Yolo Bypass Drainage and Water Infrastructure Improvement Study* **Tributary gauging stations**	
		Project No. 12-1039	Created By: AMS	**Figure B-2**

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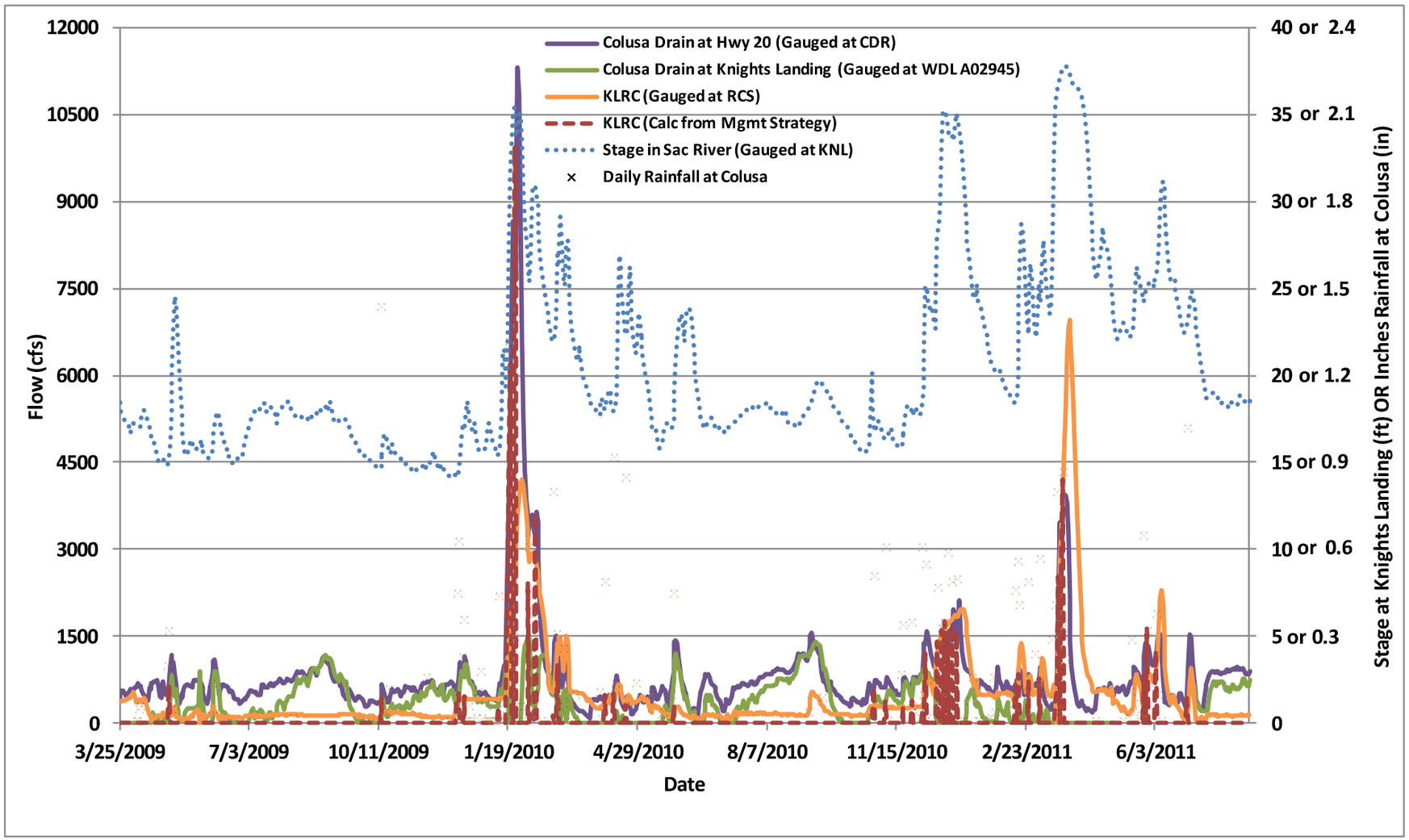
1/4/2014



Notes: Daily flow and stage data.

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Yolo Bypass Drainage and Water Infrastructure Improvement Study

KLRC estimation validation

Project No. 12-1039	Created By: AMS	**Figure B-3**

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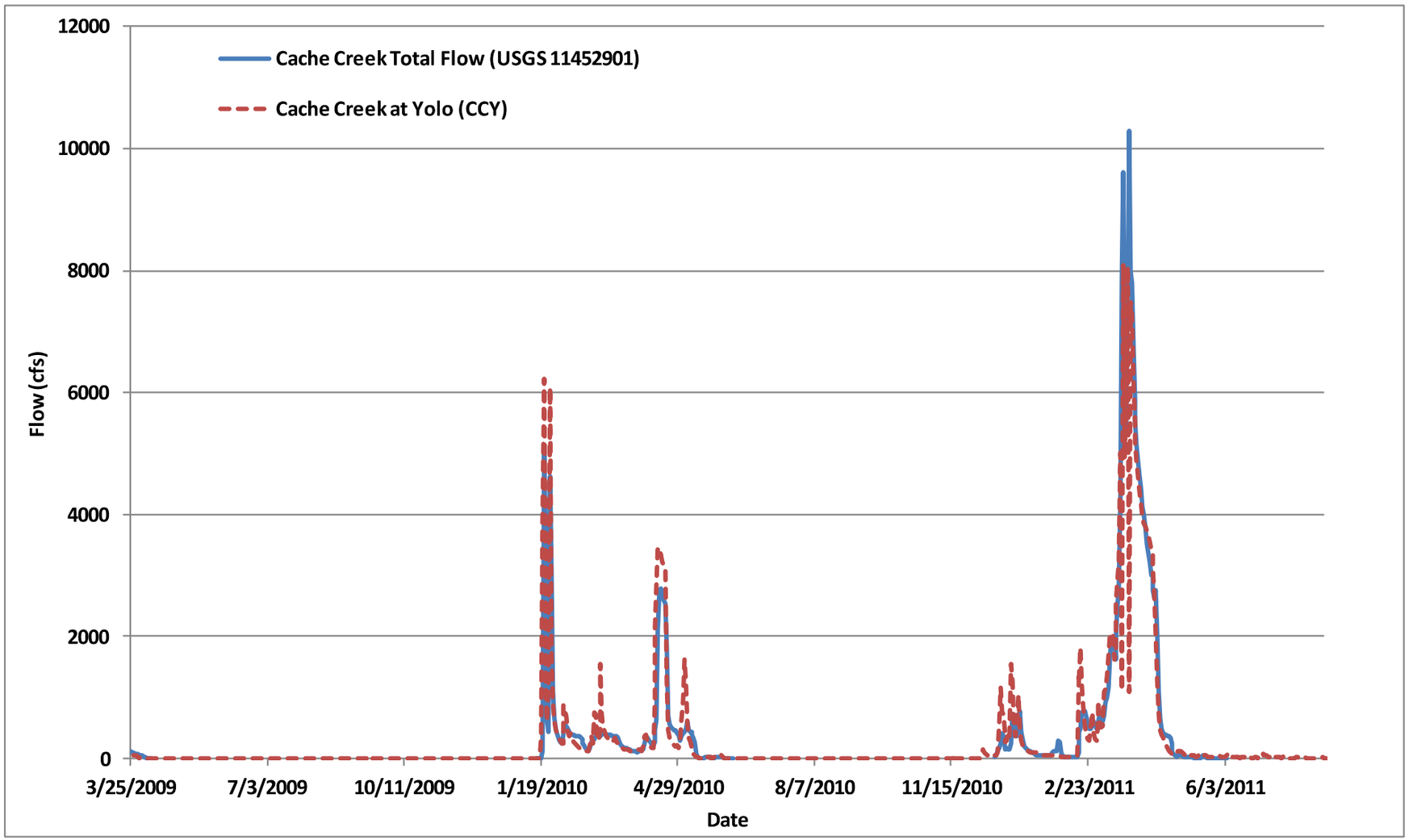

Notes: CCY is gauged daily flow at I-5 upstream of the Settling Basin, Cache Creek Total Flow is the composite of the overflow weir and low flow channel gauged data at 11452800 and 11452900 respectively. Note small peak attenuation and differences in event peak magnitude.

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Yolo Bypass Drainage and Water Infrastructure Improvement Study

Cache Creek inflow to Yolo Bypass

Project No. 12-1039	Created By: AMS	**Figure B-4**

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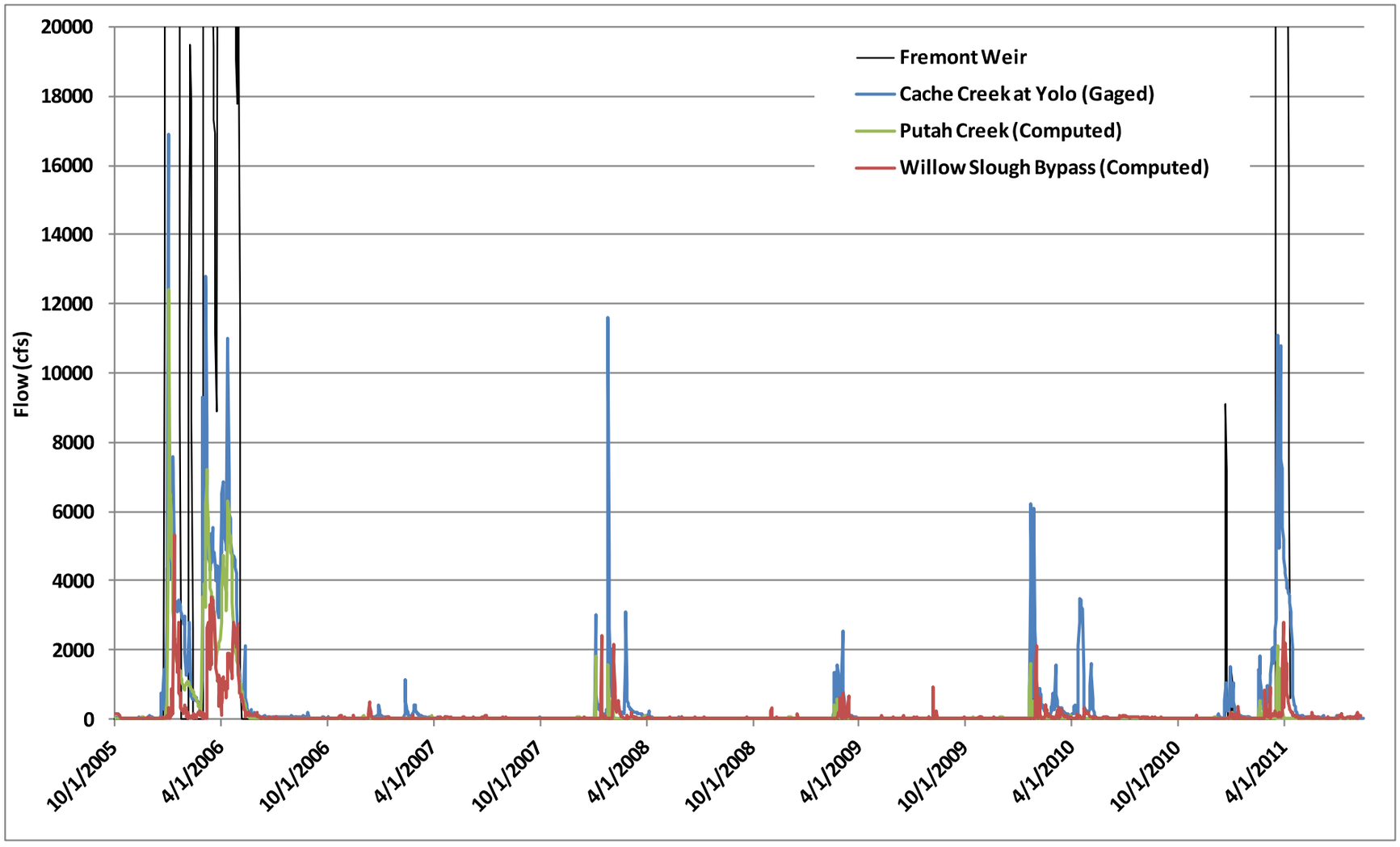

Notes: Recent hydrologic datasets for tributaries by Yolo Bypass Management Strategy (Yolo Basin Foundation, 2001) rationale. Note relative increase in Putah Creek relative to Willow Slough when Berryessa spills.

Yolo Bypass Drainage and Water Infrastructure Improvement Study

Recent Cache, Putah and Willow Slough comparison

Project No. 12-1039	Created By: AMS	**Figure B-5**

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