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Conaway Ranch Floodway Corridor and Habitat Enhancement Project

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Prepared for

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INTRODUCTION

The Conaway Ranch property covers over 17,300 acres on the west side of the Sacramento River between the cities of Davis and Woodland. Roughly 40 percent of the ranch is located within the Yolo Bypass, which is a seasonal floodplain that could provide important habitat to a number of aquatic organisms within the Sacramento-San Joaquin Delta system. (See Figure 1). The ranch owners are in the process of preparing a resource management plan for the ranch and a project that provides regional flood protection as well as habitat enhancement could be an integral element of the plan. The size of the ranch and its location relative to the Yolo Bypass and the Sacramento River make it uniquely positioned to be part of a regional flood control and habitat enhancement plan for the region. This report describes a conceptual flood control and habitat enhancement project that has been developed for the ranch.

FLOODWAY CORRIDOR COMPONENT

Background – Need for Floodway Corridor Project

The Cities of Sacramento and West Sacramento are located near the confluence of two major rivers – the Sacramento and the American. Large portions of the cities lie within low lying areas that are protected from flooding by a system of levees. Recent studies have shown that some of the levees protecting Sacramento and West Sacramento do not provide even 100-year flood protection. A levee failure and the resulting flooding would have catastrophic results. According to a study by the California Department of Water Resources, a major flood in Sacramento would damage over 60,000 homes, schools, hospitals and businesses and could cause more than $11 billion in damage. The Sacramento region has the lowest flood protection of any major urban area in the United States; even lower than the flood protection for New Orleans prior to Hurricane Katrina.

The Conaway Ranch Floodway Corridor Project offers an opportunity to increase the level of flood protection for Sacramento metropolitan area by lowering the water surface elevations in portions of the Sacramento River, American River, Natomas Cross Canal, Natomas East Main Drainage Canal, and the Yolo Bypass.

Description of the Flood Control Project

This section provides a description of the facilities included with the project. A discussion of the hydraulic benefits of the project is provided in the next section.

The flood control portion of the project consists of three major components. Each component is described below and depicted on Figure 2.

Flood Control Component 1 – New Sacramento River Bypass

This component would consist of a new bypass facility that would divert flood flows from the Sacramento River to the Yolo Bypass. A new weir structure would be constructed along the west side of the Sacramento River, just north of Interstate 5. During large storm events flood flows in the Sacramento River would be diverted over the weir to a new bypass channel that would deliver flows to the Yolo Bypass. The bypass channel would consist of levees on each side that would tie into the Sacramento River and Yolo Bypass levees. This new bypass facility would reduce flood flows in the Sacramento River and would provide a corresponding reduction in water surface elevations against some of the levees protecting Sacramento and West Sacramento.

Flood Control Component 2 – Conaway Ranch Flood Storage

Diverting additional flood flows into the Yolo Bypass would increase flows and stages in the bypass downstream of the new bypass. To mitigate for potential flow increases, the southwestern portion of Conaway Ranch, which currently lies outside the Yolo Bypass, would be used to convey and store flood waters during large storm events. Over 6,800 acres of the ranch property lie west of the Yolo Bypass and south of the historic Willow Slough channel and are currently protected by a Sacramento Flood Control Project levee (See Figure 2). This area could be used to provide over 66,000 acre-feet of storage volume during a 200-year storm event. At the northeast corner of this storage area, the existing west levee of the Yolo Bypass could be modified to allow flood flows from the Yolo Bypass to enter the storage area during large storm events. The flow into the ranch could be controlled with an overflow weir in the existing levee or perhaps by a "soft" levee section that could be breached when necessary. Flows passing into the storage area would be stored until the peak flow in the Yolo Bypass began to recede, then would be conveyed back into the bypass through an outlet facility at the southeast corner of the storage area.

New containment levees would be required along the south and east sides of the storage area. There is an existing levee along the north side of the storage area although surveying and geotechnical testing would be required to determine if this levee would meet freeboard, stability, and under-seepage criteria without modification.

Flood Control Component 3 – Remove Yolo Bypass Restrictions

Diverting flows into the Yolo Bypass could also increase water surface elevations in the bypass upstream of the new bypass facility due to an existing railroad trestle. The Sacramento Northern Railroad crosses the Yolo Bypass just north of Interstate 5. The railroad trestle is a restriction to flows in the Yolo Bypass and diverting additional flow into the bypass would cause an increase in water surface upstream of the railroad trestle. The increases in water surface elevation, although not large, could extend several miles upstream of the trestle, in the Yolo Bypass.

Component 3 of the Conway Ranch Flood Control Project would include relocation of the railroad so it travels to the south through Conaway Ranch, west of the Yolo Bypass (see Figure 2). The relocated railroad would join the Southern Pacific Railroad just north of Interstate 80 and cross the Yolo Bypass at this location. The relocated railroad would rejoin its original alignment in West Sacramento. If relocation of the railroad is not feasible, the existing trestle could be rebuilt with a more efficient design that would reduce the associated flow restriction, or levee improvements could be constructed upstream to mitigate for potential increases in water surface elevations.

To complete this component, the water supply canal that currently provides the main water supply to Conaway Ranch could also be replaced with an underground pipeline to eliminate the flow restriction currently created by the low levees forming the sides of the canal, and further reduce the impacts of additional flows on the Yolo Bypass.

Benefits of the Floodway Corridor Project

Flood Control Benefits

The potential hydraulic benefits of the Conaway Ranch Floodway Corridor Project were evaluated using the Sacramento River UNET hydraulic model that was originally developed by the U.S. Army Corps of Engineers for the Sacramento and San Joaquin River Basins Comprehensive Study, and subsequently modified by MBK Engineers. The model was used to calculate 100-year and 200-year water surface elevations in the Sacramento River system for both pre-project and post-project conditions.

Model Configuration and Key Modeling Assumptions

The configuration of the model and the key modeling assumptions used in this analysis are described below.

- The input hydrographs into the hydraulic model were based on the 100-year and 200-year hydrology from the Corp's Comprehensive Study with a storm centering for the latitude of Sacramento (Sac Centering).
- The hydraulic model was configured to allow upstream levees to overtop without failing. If a levee is overtopped, flows are allowed to spill over the levee, but the levee is not breached.
- The new diversion structure on the west levee of the Sacramento River was configured as a 2000-foot weir with a crest elevation of 25.0 (NGVD29). It is anticipated that this diversion structure would be a gated weir that is operated based on the water surface elevations at key locations in the system. The gates would remain closed during normal floods and would only be opened during large storm events. However, the ungated configuration used for this study is considered adequate for estimating the potential hydraulic benefits of the project during a major storm event.
- The new bypass was modeled as a storage area with a low weir at the downstream end rather than a new channel reach with cross sections. This simplifying assumption is considered reasonable because the length of the bypass is relatively short (approximately 3000 feet) and the travel time of flow through the bypass will also be relatively short.

- The Conaway Ranch floodway area was modeled as a storage area connected to the bypass by two weirs. An inlet weir with a length of 2,000 feet and a crest elevation of 28.5 feet (NGVD29) was modeled just south of the historic Willow Slough. An outlet weir with a length of 500 feet and a crest elevation of 27.0 feet (NGVD29) was modeled at the south end of the ranch, just north of the City of Davis wetlands area. Model tests showed that these weir elevations provided good performance for both the 100-year and 200-year storms. Additional analyses will be necessary to determine the optimum inlet and outlet configurations in conjunction with the operating procedures selected for the bypass structure on the Sacramento River. The elevation-storage relationship for the floodway area is provided on Table 1.
- In the Yolo Bypass, there is a small increase in water surface elevations (0.0 to 0.15 feet) between the new bypass and the inlet to the Conaway Ranch storage area. It is assumed that this increase is insignificant and does not trigger the need for levee improvements.

Table 1. Conaway Ranch Floodway Storage Data (a)

Elevation, ft, NGVD29	Depth, ft	Area, ac	Cumulative Volume, ac-ft
15	0	440	0
20	5	2,920	8,400
25	10	5,360	29,100
30	15	6,520	58,800
35	20	6,820	92,150

(a) The calculated 100-year and 200-year water surface elevations in the proposed floodway area are 29.0 and 31.2, respectively.

Hydraulic Modeling Results

The results of the hydraulic modeling indicate that the project could provide significant flood protection benefits to the Sacramento region. Figure 3 presents a summary of the potential water surface elevation reductions in the Sacramento Region for a 200-year storm event. As shown on Figure 3, the 200-year water surface elevation reductions in the Sacramento area waterways range from 0.4 to 2.5 feet. The largest reductions would occur in the areas closest to the upstream side of the new bypass and the reductions would generally decrease as the distance from the new bypass increases. The water surface reductions for the 100-year storm are similar.

In the Sacramento River, the reduction in peak water surface elevations would range from 0.4 to 2.5 feet. The peak flows would actually increase in the Sacramento River between the Verona gage and the new bypass. However, the water surface elevations would decrease due to the drawdown effect from the new bypass. Due to the increase in flow, the peak velocities in the river would also increase between Verona and the new bypass. Protection measures may be required at potential erosion sites in this reach. Downstream of the new bypass, peak flows in the river would be decreased and would result in a corresponding reduction in the water surface elevation. A summary of the results in the Sacramento River are provided on Figures 4 through 9.

In the Yolo Bypass, water surface elevations would generally be reduced between 0.1 and 0.3 feet. One exception is for the reach between the new bypass, just north of Interstate 5, and the inlet into the Conaway Ranch flood storage area. In this 2.4 mile reach, the water surface elevation would increase between 0.0 to 0.15 feet due to an increase in peak flows from the new diversion. In this reach, the peak flow would increase by approximately 28,400 cfs and 37,600 cfs for the 100-year and 200-year storms, respectively. The Conaway Ranch flood storage area would mitigate these flow increases through the southern portion of the ranch and downstream. The removal or reconstruction of the railroad trestle would prevent increases in water surface elevations upstream of the railroad that would otherwise be caused from the additional flows passing though this restrictive structure. A summary of the results in the Yolo Bypass are provided on Figures 10 through 17.

For the 100-year storm, the Conaway Ranch storage area would store a maximum of approximately 35,000 acre-feet at a peak stage of 29.0 feet (NGVD29). For the 200-year storm, the flood storage area of the ranch would store a maximum of approximately 66,800 acre-feet at a peak stage of 31.2 feet (NGVD29). The area inundated during the 100-year and 200-years storm would be approximately 6,300 acres and 6,600 acres, respectively.

Other waterways in the region such as the Natomas Cross Canal, the Natomas East Main Drainage Canal, and the lower end of the American River would also benefit from the project. Water surface reductions in these waterways could range from 0.4 to 0.7 feet. Figures 18 and 19 provide results for the Natomas Cross Canal. Figures 20 and 21 provide results in the Natomas East Main Drainage Canal. The results in the American River are essentially the same as those in the adjacent portions of the Natomas East Main Drainage Canal; therefore, separate figures for the American River are not provided.

Evaluation of January 1997 Storm Event

The flood control project was also modeled using the flows from the 1997 storm event, which was a major storm that severely stressed the flood control system in the Sacramento region and caused significant flooding in parts of the state. For their Sacramento and San Joaquin River Basins Comprehensive Study, the U.S. Army Corps of Engineers calibrated their UNET hydraulic model using the 1997 storm event. This model was subsequently updated by MBK Engineers and MBK's updated model was used for this study.

Figure 22 provides a comparison of the total system inflows for the 1997 storm and the Corps of Engineers 100-year and 200-year storms. The figure presents the sum of the inflows into the Sacramento Flood Control Project from the major flow sources including: the Sacramento River, Sutter Bypass, Feather River, Natomas Cross Canal, Natomas East Main Drainage Canal, and the American River. The flows entering the Yolo Bypass from the west (i.e., Cache Creek, Willow Slough Bypass, and Putah Creek) are not included because they represent a small percentage of the total inflow. As Figure 22 shows, the total peak flow and multi-day average flows from the 100-year and 200-year storms are significantly higher than those for the 1997 storm event. This is at least partly due to the fact that an upstream levee failure on the Feather River during the 1997 storm event resulted in less flow reaching the Sacramento area during the peak of the storm.

Results from the 1997 storm modeling indicate that the flood control project could provide significant benefits during a storm of that magnitude. As shown on Figure 23, the potential water surface elevation reductions in the Sacramento River for the 1997 storm are similar to those for the 100-year and 200-year storm events. However, for this study, the inlet weir into the Conaway Ranch floodway area was configured for a larger storm event. As a result, for the 1997 storm, the additional flow into the Yolo Bypass is not fully mitigated by the project because the water surface elevations in the bypass are too low to allow full utilization of the storage volume within the ranch. For the 1997 storm event, full mitigation of flows into the bypass would require lowering the inlet weir into the proposed floodway area from elevation 28.5 feet to 27.3 feet (NGVD29). With the lowered inlet weir, the Conaway Ranch storage area would store a maximum of approximately 16,300 acre-feet at a peak stage of 22.9 feet (NGVD29) during the 1997 storm event. This is significantly less than the available storage within the floodway area. The 100-year storm would also function well with the lowered weir configuration, but the much larger 200-year event would fill the storage area too quickly, resulting in peak water surface elevation increases of about 0.04 feet in the Yolo Bypass downstream of Conaway Ranch.

The results from the analysis of the 1997 storm event indicate that the project could be configured to provide significant benefits for a storm of similar magnitude. However, the results also demonstrate the need to perform additional studies to better define the configuration and operation of the flood control system.

Other Potential Project Benefits of the Flood Control Project

There are ancillary benefits of the project other than those discussed above:

- Creation of a floodway on the ranch would assist with the protection of the property's agricultural, ecological, open space, and scenic values.
- Removing the possibility of urbanization in the proposed floodway area will prevent an increase in the number of people, property, and infrastructure that would be subject to catastrophic flooding in the event of a levee failure.
- The flood control project is compatible with any larger effort to increase the conveyance capacity of the Yolo Bypass should that become part of an expanded flood control solution for the region.

HABITAT ENHANCEMENT COMPONENT

Background – Need for Habitat Enhancement Project

Seasonally inundated floodplain habitats within the San Francisco Bay and Sacramento-San Joaquin Delta support a variety of habitat functions for fish, aquatic macroinvertebrates, riparian vegetation, and wildlife. Seasonally inundated floodplain habitat provides an important source of nutrients and organic carbon which are key to the production of phytoplankton and zooplankton that serve as the basis of the aquatic food chain within the estuary. Floodplain habitat is also used by a variety of fish species, such as Sacramento splittail (Figure 24), as spawning and larval rearing habitat. Juvenile Chinook salmon (Figure 25), steelhead, and other fish species seasonally inhabit floodplains as a juvenile foraging area. Studies conducted within the Yolo Bypass and other floodplain habitats (Sommer *et al., 2001*; Sommer *et al., 2002*; and others) have demonstrated that seasonally inundated

floodplain habitat is extremely important as spawning and juvenile rearing area supporting a diverse community of aquatic organisms within the Bay-Delta system. For example, Sommer *et al.* (2001) documented 42 species of fish inhabiting the Yolo Bypass including species listed for protection under the California and/or federal Endangered Species Acts (winter-run and spring-run Chinook salmon, steelhead, and delta smelt), as well as recreationally valuable species such as fall-run Chinook salmon, white sturgeon, and striped bass.

Over the past 150 years there has been a significant loss of seasonally inundated shallow-water floodplain habitat within the Sacramento River watershed and throughout the Delta as a result of levee construction and reclamation of tidal marshes. Opportunities to protect and enhance floodplain habitat continue to be lost by levee construction and urban development. Re-creation of floodplain habitat by levee setback is extremely expensive and difficult to accomplish. In contrast, modifications to existing flood control bypasses that increase the frequency and duration of seasonal inundation over a wider range of flows, can improve fish passage, improve local drainage, and provide high-value fish and wildlife habitat at a substantially reduced cost. A key element in the long-term restoration of the Bay-Delta estuary is the identification of opportunities to reconnect floodplain habitat with the Sacramento and San Joaquin rivers. Currently, potentially valuable floodplain habitat to support fish and wildlife values has been operated and managed for the sole purposes of flood control protection and agricultural production. Floodplain habitat benefiting fish and wildlife can be designed and managed to be compatible with and reduce impacts to these and other land uses.

Habitat Enhancement Benefits

The Conaway Ranch (Figure 1) offers a unique opportunity for integrated land-use management that would support continued agricultural and flood control operations, while also increasing the frequency and duration of seasonally inundated floodplain habitat to benefit fish and wildlife. The ability to protect and enhance floodplain habitat conditions for fish and wildlife as part of the Conaway Ranch integrated management project would require: (1) securing an environmental easement that would protect valuable floodplain habitat and adjacent lands from other uses; (2) construction of operational facilities for water control and fish passage; (3) re-grading portions of the floodplain habitat to increase the quality of the seasonal inundation based on managed flows diverted from the Sacramento River; (4) Constructing a fish screen on the existing Conaway Ranch diversion and a new pumping station to ensure that fish moving through the area are not entrapped by this agricultural diversion.

One of the significant advantages of the Conaway Ranch floodplain habitat is its connectivity with both the Sacramento River to the north and the portion of the Yolo Bypass located south of Interstate 80 (Figure 1). By increasing the frequency and duration of shallow water floodplain habitat inundation within the Conaway Ranch, the production of organic carbon, phytoplankton, zooplankton, and nutrients, would be increased and conveyed downstream through the improved Yolo Bypass channels, ultimately entering the Sacramento River via Cache Slough (Figure 1). Cache Slough is an important area for spawning and larval rearing by species such as delta smelt that would benefit by the addition of nutrients and zooplankton that serve as the vital food resource during the early larval rearing period. Organic material, in addition to larval and juvenile fish, produced within the seasonally inundated floodplain habitat would also flow downstream within the lower Sacramento River entering Suisun Bay and the Suisun Marsh area where they would further benefit the abundance and diversity of the aquatic community.

Another potential benefit of enhancing the seasonally inundated floodplain on Conaway Ranch would be that juvenile Chinook salmon, steelhead, and other fish species that were spawned and reared in the upper Sacramento River and its tributaries could enter the floodplain near Elkhorn where they would have a greater opportunity to forage on abundant zooplankton, grow to a larger size (Sommer *et al.,* 2001) and hence have increased survival. In addition, downstream migrating juvenile fish, such as Chinook salmon, that enter the bypass would circumvent a majority of the interconnections within the central Delta, such as the Delta Cross Channel and Georgiana Slough where mortality has been shown to be consistently higher when compared to those juveniles that do not enter the central Delta.

Providing connectivity between the Sacramento River and seasonally inundated floodplain habitat within Conaway Ranch offers a variety of benefits to fish and other aquatic resources including, but not limited to: increasing the availability of nutrients, organic carbon, phytoplankton, and zooplankton that form the basis of the food chain within the estuary; increasing growth rates and subsequent survival; reducing the exposure of juvenile fish to high mortality areas within the central and southern Delta.

Protection and enhancement of floodplain habitat on Conaway Ranch is consistent with high-priority management actions identified to benefit salmonids and other native Delta fish through Endangered Species Act recovery plans, the Bay-Delta Conservation Plan Actions, the 2005 California Water Plan Floodplain Management recommendation, and other state and federal fish and wildlife management programs. The proposed Conaway Ranch floodplain habitat project would also address one of the major stressors identified in the Pelagic Organism Decline (POD) with respect to insufficient food supplies to support healthy populations of pelagic fish species such as delta smelt, longfin smelt, and others. For example, studies conducted by Bennett (1996) have shown that a high proportion of the delta smelt sampled from the estuary show physiological signs of malnutrition. Increased production of zooplankton and other nutrients within the Conaway Ranch floodplain would directly increase food availability for delta smelt and other fish within the Yolo Bypass, Cache Slough, Suisun Bay, and Suisun Marsh areas.

In addition to providing substantial benefits to the Bay-Delta aquatic community, seasonally inundated floodplain habitat on Conaway Ranch would also provide benefits to riparian vegetation and wildlife. As part of the project, riparian corridors along the floodplain corridor would provide additional organic material to the system as well as providing important habitat for a variety of wildlife species. Because of the connectivity between Conaway Ranch and the Yolo Bypass south of Interstate 80, the value of habitat for wildlife along the corridor would be further enhanced with other wildlife management areas such as Vic Fazio wetland habitat. The seasonally inundated floodplain habitat that would be created on the Conaway ranch provides connectivity that together would substantially expand fish and wildlife habitat within the Bay-Delta estuary.

In addition to providing direct benefits of seasonally inundated floodplain habitat to the Bay-Delta aquatic community the Conaway Ranch project provides a foundation for collaboration, funding, and support by state and federal resource agencies, academia, and non-governmental environmental groups implementing additional habitat enhancement and mitigation projects. Habitat enhancement within the Conaway Ranch floodplain would also augment environmental projects identified for implementation elsewhere within the Delta as part of the Bay-Delta Conservation Plan. Since the Conaway Ranch is located in the northern region of the Delta (Figure 1) habitat enhancement would be compatible with operation of the existing SWP and CVP export facilities or with all other water conveyance facilities currently being evaluated within the Delta.

Habitat Enhancement Features

The habitat enhancement component of the Conaway Ranch project contains two main features: 1) the creation and enhancement of seasonally inundated floodplain area within the ranch along Tule Canal, and; 2) creation of a flow and fish passage facility between the Sacramento River and the Yolo Bypass. These two features are described below.

Seasonally Inundated Floodplain Habitat

Floodplain habitat would be enhanced on Conaway Ranch by grading and channel modifications to promote seasonally inundated floodplain along the Tule Canal within the Yolo Bypass. Tule Canal is a perennial riparian channel located along the east side of the Yolo Bypass that conveys flow from the Knights Landing Ridge Cut, local runoff from within the bypass, and flows that spill from the Sacramento River over the Fremont Weir. Within Conaway Ranch, normal flows in Tule Canal are prevented from reaching the adjacent floodplain to the west by a small embankment. By modifying or removing portions of this embankment, seasonal flows can enter the floodplain adjacent to Tule Creek more frequently.

The Natural Heritage Institute *et al., 2002,* previously evaluated the possibility of creating additional seasonal floodplain within the Yolo Bypass, including the Conaway Ranch. The study classified the potential inundation area within Conaway Ranch as Site H and described this site as follows:

> *The floodplain width above Site H is relatively narrow, but it includes a strip of land along the west side of the Tule Canal that is particularly promising because it is not farmed and its elevation is not much higher than the low-flow water surface in the Tule Canal. The site is an approximately 1,200-foot-wide strip of land about 2 miles long, beginning about 0.5 mile downstream of the Interstate 5 (I-5) causeway and ending 2 miles upstream of the Sacramento Bypass. The site is separated from the agricultural fields to the west by a large berm constructed in October 1962 in an attempt to protect crops during an exceptionally early-season flood. Accordingly, it is referred to in this report as the "1962 flood strip". The strip is separated from the Tule Canal by a small berm).*

The project proposed in this study is essentially the same as that proposed in the National Heritage Institute study. The shallow berm between the "1962 flood strip" and the Tule Canal would be removed at the upstream and downstream ends of the site, creating a shallow channel parallel to the Tule Canal that would be inundated by seasonal storm flows. The frequency of flows into the seasonal floodplain area can be increased by construction of an adjustable weir in Tule Canal. The weir would restrict flows into the canal downstream and promote flow into the habitat area along the overbank.

A HEC-RAS hydraulic model of the seasonal floodplain concept was created to evaluate the potential benefits of the project. The geometry for the model was based on the cross section data from a UNET model of the Yolo Bypass created by the U.S. Army Corps of Engineers for their Comprehensive Study and assumed trapezoidal cross sections for Tule Canal. The invert elevations within the canal were based on data developed for the National Heritage Institute report. Using the HEC-RAS model, it was determined that the proposed project could provide a seasonal floodplain covering approximately 700 acres at a total flow rate of 1,500 cfs (See Figure 26). The depth of the floodplain would range between 0 to 3.6 feet, with an average depth of almost 2 feet. Velocities would be less than 1 foot per second. These results are based on an assumed weir configuration that would divert approximately 940 cfs into the floodplain area with the remaining flow conveyed in the canal. The actual weir configuration and flow split are subject to further detailed study.

The flow rate of 1,500 cfs was selected based on the capacities of the Tule Canal and Toe Drain, as estimated by others. According to staff at the California Department of Water Resources, the capacity of the Tule Canal and Toe Drain system is approximately 1,800 cfs. This capacity will need to be verified prior to implementation of the project.

Additional grading and channel/floodplain modifications may be identified during the design process for the project to increase the cross-sectional area that would be seasonally flooded to enhance habitat quality and availability for various fish species, as well as increase the production of phytoplankton and zooplankton, while continuing to maintain a deeper central channel that would provide a corridor for upstream and downstream fish migration. As part of the grading and management of the seasonally inundated floodplain, habitat specific attention would be given to developing appropriate ground surface elevations and contours to promote drainage of water, organics, and larval and juvenile fish from the shallow floodplain areas into the main channel traversing the Conaway Ranch during the flow recession stage each year to help minimize and avoid potential stranding. An example of the cross-section of the proposed floodplain habitat is shown on Figure 26. A typical inundated floodplain habitat is shown in Figure 27. The proposed floodplain habitat would provide a variety of micro-habitats for fish and macro-invertebrates but would also include riparian vegetation along the channel margins to serve as habitat and a migration corridor for wildlife. Allowing the seasonally inundated floodplain to be colonized by grasses and other vegetation, including potentially agricultural crops, during the non-flooded period provides additional substrate and organic material that would be available for nutrient cycling, as a source of organic carbon, as habitat for insects and other organisms, and would serve as a substrate for fish spawning during the period of seasonal inundation.

Flow Diversions from the Sacramento River

Predictable increased and prolonged inundation of the floodplain strip could be achieved by increasing the flow in the Tule Canal from a new facility that would divert flows from the Sacramento River. Water diversions from the Sacramento River to support the seasonal floodplain habitat would occur during the months from January through May. The diversion flow rate would vary depending on conditions in the Sacramento River, but a flow rate of approximately 1,500 cfs would provide a significant inundation area as described above.

The flow diversion is proposed to occur at the north boundary of Conaway Ranch, just north of Interstate 5. This is the location of the proposed flood control weir and bypass between the Sacramento River and the Yolo Bypass as described earlier in this report. Construction of a new flood bypass facility at this location would provide an opportunity to include flow diversion and fish passage facilities at the same location.

For this study it was assumed that the gravity flows would be conveyed through large concrete boxes through the levee with sluice gates to provide control of the flow. The openings would need to be designed for fish passage considerations and, ultimately, the configuration of the facility could be different from the one considered in this study. The facility would be designed and managed to promote the movement of downstream migrating juvenile Chinook salmon, steelhead, and other fish from the Sacramento River into the floodplain habitat while also allowing the upstream migration of adult fish such as Sacramento splittail and sturgeon to pass through the floodplain and subsequently successfully migrate upstream into the Sacramento River.

The availability of gravity flow from the Sacramento River to the Tule Canal will vary from year to year depending on the conditions in the Sacramento River Basin. An analysis of historic stages in the Sacramento River was performed to estimate the potential frequency that gravity flow diversions would be available during the target months of January through May. Hourly stage data in the Sacramento River was available from May 1, 1990 through May 31, 2007 at I Street and at the Fremont Weir. This data was converted to average daily stage and was used to estimate the average daily stage at the proposed point of diversion. River stage-frequency data at the proposed diversion point were estimated for January through May as shown on Figures 28 through 32.

To achieve a flow of 1,500 cfs, the river stage will need to be approximately 15.6 feet (NGVD29). Significant habitat benefits could be achieved with a total flow rate as low as 500 cfs. To achieve a flow of 500 cfs, the river stage will need to be approximately 14.0 feet (NGVD29). As indicated by the Figures 28 through 32, during the months of January through March, the stage in the river will be above elevation 14 feet (NGVD29) approximately 42 percent of the time and above 15.6 (NGVD29) approximately 45 percent of the time. Stages in the river are typically lower during the months of April and May and gravity flow will be available less often. For these two months, the stage in the river will be above elevations 14 feet and 15.6 feet (NGVD29) approximately 29 percent and 25 percent of the time, respectively. Table 2 summarizes the stage-frequency analysis.

Table 2. Sacramento River Stage-Frequency Data

Month	Percent of Time Above Elev. 14.0 Feet, NGVD29	Percent of Time Above Elev. 15.6 Feet, NGVD29
January	47%	43%
February	58%	50%
March	51%	43%
April	31%	25%
May	27%	26%
All Five Months	43%	37%

In addition to the daily stage-frequency analysis described above, daily stage graphs were prepared for five water years with each year representing a different hydrologic classification type for the Sacramento Valley (i.e., Wet, Above Normal, Below Normal, Dry, and Critical). These graphs are presented on Figures 34 through 38. As seen on Figure 34, during a wet year, gravity flow could be available for almost the entire January through May target period. However, the availability of supplemental gravity flow is less important during wet years because flood flows will be introduced to the system as spill over the Fremont Weir and into the Yolo Bypass. For above normal and below normal water years, significant gravity flows are likely to be available for extended periods, but not for the entire five months. This is illustrated on Figures 35 and 36. For water year 2003, which had above normal runoff, a gravity flow rate of 500 cfs could have been achieved for most of January and February, unavailable in March and April, and available again in May. During dry and critical years, gravity flows are expected to be available only for short periods of time, if at all, as demonstrated in Figures 37 and 38. The total number and percentage of days that a gravity flow rate of 500 cfs would have been available for each of the five sample years is summarized in Table 3.

Table 3. Gravity Flow Availability in January through May

Water Year	Hydrologic Classification	Number of Days of Available Gravity Flow (> 500 cfs)	Percent of Days When Gravity Flow is Available (> 500 cfs)
2006	Wet	144	95%
2003	Above Normal	81	54%
2004	Below Normal	69	46%
2001	Dry	17	11%
1990	Critical	3	2%

During periods of low river stage, it may be desirable to supplement the flows in Tule Canal through pumping. This could be accomplished through the use of large screw pumps, which could provide a supplemental source of water in the Tule Canal while minimizing the potential harm to aquatic species in the Sacramento River. A screw pump provides the potential to pass downstream migrating juvenile Chinook salmon, steelhead, and other fish from the Sacramento River to the Yolo Bypass without harm. Pumped flows may attract migrating fish upstream to the flow diversion structure. It will be necessary to provide a fish passage facility between the diversion structure and the Sacramento River to give migrating fish a path to the river. For this study, it was assumed that a pumping capacity of 500 cfs would be provided during dry years and a fish passage facility would be constructed.

Diversion of water from the Sacramento River through the seasonally inundated floodplain habitat would result in minimal water loss from the system because it would occur during the winter and early spring when evaporation and evapotranspiration rates are low and most of the water would flow downstream through the Yolo Bypass in the Tule Canal and the Toe Drain, subsequently reentering the Delta in the vicinity of Cache Slough. Water rights issues will need to be explored in detail prior to implementation of the project.

Screening of Conaway Ranch Agricultural Diversion

Reclamation District 2035 (RD 2035) operates the water supply system used to provide water for irrigation of crops on Conaway Ranch in the spring and summer months, and for flooding fields for rice decomposition and/or to create waterfowl habitat in the fall and winter. The current system includes a pumping station on the western side of the Sacramento River just north of the Vietnam Veterans Bridge on Interstate 5. This diversion is one of the largest unscreened diversions remaining on the Sacramento River.

For many years, RD 2035 has diverted water from this existing pumping station, which has a capacity of 400 cubic feet per second (cfs), and discharges under County Road 16 (River Road), into a channel that ultimately feeds into the Conaway Ranch water supply system. Water is diverted through this facility to serve the agricultural users on Conaway Ranch, under appropriative and riparian water rights held by Conaway Ranch, and a settlement agreement between the U.S. Bureau of Reclamation and Conaway Ranch.

A new diversion structure and pumping station have been designed by RD 2035 to replace the existing facility, using funding provided through the CALFED Ecosystem Restoration Program. The new diversion facility has also been designed with a capacity of 400 cfs, and meets the latest criteria for fish screen design as defined by the NOAA Fisheries and the California Department of Fish and Game. This new facility will comply with federal and state fish screening criteria, and will help ensure a reliable supply of water to the agricultural users on Conaway Ranch.

There are also plans under consideration that would increase the capacity of the siphon under Highway 16, and convert the open channel that parallels Highway 16 across the Yolo Bypass into a piped transmission system. The primary reason for converting this open channel into a piped system is to eliminate the obstruction it creates to flow when the Yolo Bypass is flooded. These supply system improvements are not part of the project facilities that have been designed under the CALFED funding.

The in-river diversion structure would be equipped with stainless-steel state-of-the-art fish screens. The screens would be oriented so that the screen faces would be parallel to the river flow to minimize the formation of eddies. A uniform approach velocity of less than 0.33 foot per second would be provided across the face of the screen. This velocity is consistent with regulatory requirements for the protection of fish.

The fish screen would be automatically cleaned on a recurring basis. The fish screens would be cleaned via an airburst system or mechanical brush. The cleaning cycle would be initiated by either a high water level differential across the screens, elapsed time period, or manual actuation. Each screen would be cleaned, consistent with CDFG requirements.

Funding for construction of this new facility has not been secured. Because of changing priorities for state and federal programs that have historically funded this type of facility in the past, the fish screen/pumping facility received funding for planning and design, but not for construction. Because RD 2035 diversions for agricultural uses on the ranch will continue from a location on the river very near to the area where fish will move into and out of the proposed habitat enhancement project, it will be necessary to construct the new fish screen and pumping facility to ensure they are not entrapped at the diversion facility.

ESTIMATED ORDER-OF-MAGNITUDE IMPLEMENTATION COST

An order-of-magnitude implementation cost was estimated for the Conaway Ranch Floodway Corridor and Habitat Enhancement Project. The following assumptions were made for the cost estimate.

- Unit costs are based on current construction costs. (June 2007 ENR 20 Cities CCI of 7939)
- Unit costs were determined from recent construction projects, manufacturer's quotes, and estimating guides such as RSMeans.
- New levees for flood protection purposes were assumed to have a top width of 12 feet and side slopes of 3:1. A 4-inch aggregate base patrol road was included on the top of the levee.
- The existing levee along the south side of the historic Willow Slough was assumed to be adequate for flood protection in its current condition.
- The required earthwork for habitat enhancement was roughly estimated using cross sections from the Corps of Engineers UNET model. More detailed topographic data will be required to better define the earthwork quantity.
- It was assumed that native revegatation would be required over one third of the seasonal floodplain area.
- A construction contingency of 25% was included to account for the planning level uncertainties and construction cost uncertainties associated with the estimates.
- The following mark-ups were added to the total construction cost to obtain an estimate of the total project capital or implementation cost.

  - Design Studies & Final Design @ 10%
  - Construction Management @ 10%
  - Environmental Permits and Mitigation @ 5%
  - Program Management @ 5%
- The estimate does not include the cost for easement acquisition.
- No costs are included for bond financing or other similar costs for funding the project.

As shown on Table 4, the order-of-magnitude implementation cost for the project is estimated to be approximately $214 million.

FUTURE STEPS

More detailed studies should be conducted to better define the proposed facilities and the project cost. Below is a list of some of the additional studies.

- Hydraulic studies to better define the operation and configuration of the flood control system and the habitat flow diversion facility.
- Geotechnical analyses to better define the design requirements for the new structures and levees.
- Surveying and mapping to define the topographic features in the project area.
- An investigation of the water rights issues of the habitat flow diversion.
- A study to define the potential geomorphic effects of the introduced habitat flows.
- An economic analysis to fully define the costs and benefits of the project.
- Environmental studies will be required to meet CEQA and NEPA requirements and to define potential constraints and mitigation measures.
- Because of the regional nature of the project, close coordination will be required between proponents of the project and other regional stakeholders to insure that project maximizes the benefits to the region.

REFERENCES

Bennett, W. A. and P. B. Moyle. 1996. Where have all the fishes gone? Interactive factors producing fish declines in the Sacramento-San Joaquin Estuary. J. T. Hollibaugh (Editor). San Francisco Bay: The Ecosystem. Pacific Division of the American Association for the Advancement of Science, San Francisco, CA.

National Heritage Institute, California Department of Water Resources, California Department of Fish and Game, Yolo Basin Foundation, Northwest Hydraulic Consultants, Gus Yates, Peter Kiel, and Jones & Stokes, 2002. Habitat Improvement for Native Fish in the Yolo Bypass.

Sommer, T., L. Conrad, G. O'Leary, F. Feyrer, and W. Harrell. 2002. Spawning and rearing of splittail in a model floodplain wetland. Transactions of the American Fisheries Society.

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham and W. J. Kimmerer. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences.

Table 4. Estimated Planning Level Costs

Item No.	Item Description	Estimated Quantity	Unit of Measure	Unit Cost, dollars	Total Cost [a], dollars
1	New Sacramento River Bypass				
	Concrete	14,300	CY	850	12,155,000
	Gates	1	LS	27,000,000	27,000,000
	Rock Protection	12,000	SY	80	960,000
	Excavation & Embankment Placement	23,9000	CY	15.0	3,585,000
	Inspection Trench Excavation	21,500	CY	5.0	107,500
2	Conaway Floodway				
	Concrete	12,500	CY	850	10,625,000
	Rock Protection	15,300	SY	80	1,224,000
	Excavation & Embankment Placement	662,000	CY	15.0	9,930,000
	Inspection Trench Excavation	96,600	CY	5.0	483,000
	Interior Drainage Facilities	1	LS	9,000,000	9,000,000
	Maintenance Road	78,500	LF	7.4	580,900
3	Remove Yolo Bypass Restrictions				
	72-inch Raw Water Pipeline (Canal Replacement)	16,000	LF	720	11,520,000
	Relocate Railroad	1	LS	20,000,000	20,000,000
4	Floodplain Habitat Enhancement				
	Earthwork	100,000	CY	6	600,000
	Revegetation	1	LS	100,000	100,000
5	Flow Diversion & Fish Passage Facilities				
	Earthwork	70,000	CY	15	1,050,000
	Concrete Structures	720	CY	900	648,000
	Gates & Metalwork	1	LS	500,000	500,000
	Screw Pumps & Controls	1	LS	6,000,000	6,000,000
Subtotal (rounded)					116,100,000
Contingency (25%) [b]					29,025,000
Subtotal, Preliminary Estimated Construction Cost - (rounded)					145,125,000
Design Studies (2%)					2,902,500
Final Design (9%)					13,061,250
Construction Management (10%)					14,512,500
Environmental Mitigation (4%)					5,805,000
Program Implementation (5%)					7,256,250
Floodway Easement Acquisition					TBD
Screened Conaway Diversion Facility					25,000,000
Total, Estimated Project Cost (rounded)					213,660,000

(a) All costs are in current dollars (June 2007 ENR 20-Cities Construction Cost Index = 7939).
(b) Includes construction contingency and level-of-planning contingency.

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