

1 **3.4.2.2 CM2 Yolo Bypass Fishery Enhancement**

2 The purpose of this conservation measure is to improve upstream and downstream fish passage,  
3 reduce straying and stranding of native fish, increase availability of floodplain fish rearing and  
4 spawning habitat, and stimulate the food web in the Yolo Bypass and to investigate the potential  
5 for food web export from the Yolo Bypass to the Delta. The conservation measure requires the  
6 preparation and implementation of a Yolo Bypass Fishery Enhancement Plan (YBFEP) that  
7 details the specific actions to be implemented to achieve the biological objectives of this  
8 measure. Key benefits to covered fish species include reduced migratory delays and loss of  
9 salmon, steelhead, and sturgeon at Fremont Weir and other structures; enhanced rearing habitat  
10 for Sacramento River Basin salmonids; enhanced spawning and rearing habitat for splittail; and  
11 potential improvement of food sources of Delta smelt in habitat downstream of the Bypass. The  
12 YBFEP will:

- 13 • evaluate alternative actions to restore passage and reduce stranding, including, but not  
14 limited to, physical modifications to the Fremont Weir and Yolo Bypass to manage the  
15 timing, frequency, and duration of inundation of the Yolo Bypass (Figure 3.4) with  
16 gravity flow from the Sacramento River, and to improve upstream fish passage past  
17 barriers including Fremont and Lisbon Weirs;
- 18 • based on the evaluation, identify the actions, including, but not limited to, the physical  
19 modifications to the Fremont Weir and the Yolo Bypass, that will be implemented;
- 20 • describe the YBFEP's biological objectives, performance goals, and monitoring metrics  
21 in detail;
- 22 • ensure compatibility with the flood control functions of the Yolo Bypass;
- 23 • identify specific funding sources from the BDCP funding commitments;
- 24 • discuss regulatory and legal constraints and how the constraints will be addressed; and
- 25 • provide an implementation schedule with milestones for key actions.

26 The BDCP Implementing Entity will consult with the U.S. Army Corps of Engineers, DWR,  
27 DFG, NMFS, and USFWS in development of the YBFEP and will coordinate with Yolo and  
28 Solano counties, affected reclamation districts, other flood control entities, and the Yolo Bypass  
29 Working Group on a wide range of issues during preparation of the YBFEP. During  
30 implementation of this conservation measure, the BDCP Implementing Entity will coordinate  
31 with the U.S. Army Corps of Engineers, DWR, reclamation districts, and other flood control  
32 entities, as appropriate, to ensure that fish passage improvements, bypass improvements, and  
33 Fremont Weir improvements and operations are constructed in accordance with the YBFEP and  
34 particularly the compatibility with the flood control functions of the Yolo Bypass.

35 The YBFEP analysis of alternative actions will focus on the construction of physical  
36 improvements and modifications from Fremont Weir downstream to the Lisbon Weir to (1)  
37 reduce migratory delays and loss of salmonids and sturgeon at Fremont Weir; and (2) enhance  
38 seasonal floodplain habitats for salmonids, splittail, and other covered aquatic species. The  
39 YBFEP will also evaluate the need for actions that may be necessary to optimize the number of  
40 juvenile salmonids entering the bypass when the water is being diverted through the modified

1 Fremont Weir. In addition, a gated channel that could provide flows from the Sacramento River,  
2 Colusa Basin Drain, Knights Landing Ridge Cut, or other sources into the Yolo Bypass along the  
3 west side will be evaluated.

4 All of the actions identified below will be evaluated in the YBFEP. If supported by the  
5 evaluation (i.e., would achieve the biological objectives of this conservation measure), all of  
6 these actions will be further developed in the YBFEP and implemented. If the YBFEP evaluation  
7 does not support implementation of one or more of the actions--because the action would not be  
8 effective, is not needed because of the effectiveness of other actions, would have unacceptable  
9 effects on flood control, or for other reasons--the action will not be implemented. However, the  
10 YBFEP will identify for implementation specific actions that together are sufficient to achieve  
11 the biological objectives identified in the YBFEP.

12 **Actions to Reduce Migratory Delays and Loss of Salmonids and Sturgeon at**  
13 **Fremont Weir**

14 1. Fremont Weir Fish Ladder Replacement. The existing Fremont Weir Denil fish  
15 ladder will be removed and replaced with new salmonid passage facilities designed to  
16 allow for the effective passage of adult salmonids and sturgeon from the Yolo Bypass  
17 past the Fremont Weir and into the Sacramento River when the river overtops the  
18 weir. Specific design criteria of the ladder have not yet been determined. This facility  
19 will incorporate monitoring technologies to allow for collection of information to  
20 evaluate its efficacy at passing adult fishes.

21 2. Experimental Sturgeon Ramps. An experimental ramp(s) will be constructed at the  
22 Fremont Weir to allow for the effective passage of adult sturgeon and lamprey from  
23 the Yolo Bypass over the Fremont Weir and into the Sacramento River at flows when  
24 the new Fremont Weir Fish Ladder will also be operated when the river overtops the  
25 weir by approximately 3 feet (Figure 3.█). Specific design criteria of ramps have not  
26 yet been determined. This facility will incorporate monitoring technologies to allow  
27 for collection of information to evaluate its efficacy at passing adult fishes.

28 3. Deep Fish Passage Gates and Channel. To enhance adult fish passage through the  
29 Fremont Weir, as part of modifications to the Fremont Weir (see action #8, below), a  
30 deep fish passage notch will be cut through a much smaller section of the Fremont  
31 Weir to an elevation of 11.5 feet (NAVD88) (Figure 3.█). This notch will be fitted  
32 with operable "fish passage gates" that will allow controlled flow into the Yolo  
33 Bypass when the Sacramento River stage is between 11.5 and 17.5 feet (NAVD88).  
34 A "fish passage channel" will be excavated to convey water from the Sacramento  
35 River to the new fish passage gates, and from the fish passage gates to the Tule Canal  
36 to convey water from the Sacramento River, through the gates, and to the Tule Canal  
37 and Toe Drain.

38 4. Stilling Basin Modification. Modifications will be made to the existing Fremont  
39 Weir stilling basin to ensure that the basin drains sufficiently into the deep fish  
40 passage channel. Effective drainage of the stilling basin will prevent stranding of  
41 juvenile and adult fish that are attracted to pooled water in the stilling basin during  
42 drainage of the floodplain.

- 1           5. Sacramento Weir Improvements. Modifications will be made to reduce leakage at the  
2 Sacramento Weir and therefore reduce attraction of fish from the Yolo Bypass to the  
3 weir where they are blocked and could become stranded. For comparative analysis  
4 purposes, the plan will review the benefits and necessity of constructing fish passage  
5 facilities at the Sacramento Weir to reduce juvenile fish stranding and improve  
6 upstream adult fish passage. This action may require excavation of a channel to  
7 convey water from the Sacramento River to the Sacramento Weir and from the  
8 Sacramento Weir to the Toe Drain, construction of new gates at a portion of the weir,  
9 and minor modifications to the stilling basin of the weir to ensure proper basin  
10 drainage. Specific design criteria of ramps would need to be determined.
- 11           6. Tule Canal/Toe Drain and Lisbon Weir Improvements. The YBFEP will include  
12 physical modifications to passage impediments, including road crossings and  
13 agricultural impoundments in the Tule Canal/Toe Drain to improve fish passage and  
14 survival. The plan will evaluate the benefits of replacing three existing structures at  
15 the northern end of the Tule Canal with bridges or other structures to allow adult fish  
16 passage. Lisbon Weir will be redesigned to improve fish passage while maintaining  
17 or improving water capture efficiency for irrigation.
- 18           7. Lower Putah Creek Improvements. The YBFEP will include a realignment of Lower  
19 Putah Creek. The YBFEP will include a realignment sufficient to improve upstream  
20 and downstream passage of Chinook salmon and steelhead in Putah Creek and  
21 floodplain habitat restoration to provide benefits for multiple species on existing  
22 public lands. This action will be designed so that it will not create stranding or  
23 migration barriers for juvenile salmon.

24           **Actions to Increase Seasonal Floodplain Habitats for Salmonids, Splittail, and other**  
25           **Covered Aquatic Species**

- 26           8. Fremont Weir Modification. The YBFEP will include engineering designs to  
27 physically modify the Fremont Weir to manage the timing, frequency, and duration of  
28 inundation of the Yolo Bypass (Figure 3.4) with Sacramento River flows. The plan  
29 will support the physical and biological attributes described in Section 3.4.2.1,  
30 *Physical Habitat Conservation Concepts*. In the BDCP Effects Analysis, it was  
31 assumed a section of the Fremont Weir will be lowered to 17.5 feet (NAVD88)  
32 (lower elevations may be considered if necessary to satisfy inundation targets or fish  
33 passage needs) and fitted with operable gates that will allow for controlled flow into  
34 the Yolo Bypass when the Sacramento River stage at the weir exceeds 17.5 feet.  
35 Separate operable gates will be designed and operated to provide for the efficient  
36 upstream and downstream passage of sturgeon and salmonids to and from the Yolo  
37 Bypass into the Sacramento River (as described in action #3 above). The YBFEP will  
38 explain how this modification will provide significantly increased acreage of seasonal  
39 floodplain rearing habitat with biologically appropriate durations and magnitudes on a  
40 return rate of one to three years, depending on water year type.
- 41           9. Yolo Bypass Modification. Grading, removal of existing berms, levees, and water  
42 control structures, construction of berms or levees, re-working of agricultural delivery  
43 channels, and earthwork or construction of structures to reduce Tule Canal/Toe Drain  
44 channel capacities will be conducted to the extent necessary to improve the  
45 distribution (e.g., wetted area) and hydrodynamic characteristics (e.g., residence

1 times, flow ramping, and recession) of water moving through the Yolo Bypass. The  
2 YBFEP will include modifications that will allow water to inundate in certain areas of  
3 the bypass to maximize biological benefits and keep water away from other areas to  
4 reduce stranding of covered fish species in isolated ponds, minimize impacts to  
5 terrestrial covered species, including giant garter snake, and accommodate other  
6 existing land uses (e.g., wildlife, public, and agricultural use areas). If necessary,  
7 lands will be acquired, in fee-title and through conservation or flood easements.

8 10. Westside Channel. The YBFEP will include a feasibility study and evaluation of a  
9 gated channel to provide flows into Yolo Bypass along the west side. Potential flow  
10 sources are the Sacramento River, Colusa Basin Drain or Sacramento River flows  
11 through Knights Landing Ridge Cut, or augmentation of other western tributaries.  
12 Some modification of the existing configuration of the discontinuous channels along  
13 the western edge of the Yolo Bypass may also be required. If effective at meeting  
14 biological objectives, this option could be included in the implementation of the  
15 conservation measure.

## 16 ***Operational Criteria and Adaptive Limits***

17 The YBFEP will include operational criteria as well as a strategy for adaptive management. The  
18 YBFEP will describe how a modified Fremont Weir will be operated to manage the timing and  
19 increase the frequency and duration of inundation of a portion of the Yolo Bypass with  
20 Sacramento River flows via the Fremont Weir to achieve the biological goals and objectives.  
21 The YBFEP will take into account both Weir and tributary inflows.

22 In the Effects Analysis, inundation timing, frequency, and duration in the Yolo Bypass within  
23 the period of December 1 through March 31 (with occasional extension to May 15, depending on  
24 hydrologic conditions and measures to minimize land use and ecological conflicts) at the reduced  
25 weir elevation of 17.5 feet was considered. In evaluating this scenario, target flows into the  
26 bypass were between 3,000 and 6,000 cfs. In the Effects Analysis, flow through modified  
27 Fremont Weir gates was limited to maximum spills of 6,000 cfs when the Sacramento River was  
28 not spilling over the 33 foot crest of the weir. For the Effects Analysis, no management of the  
29 gates was assumed to limit lower flows (e.g., <3,000 cfs). The YBFEP will further refine these  
30 operational criteria to provide the specific biological objectives, restoration actions, and locations  
31 necessary to meet performance goals including habitat attributes, juvenile and adult metrics, and  
32 inundation depth and duration criteria. The YBFEP will include criteria for rare situations to  
33 limit flooding when, as determined by the BDCP Implementing Entity, inundation could cause  
34 more harm than benefit to covered species. Gates will remain closed in such situations

35 Under existing conditions the Fremont Weir is overtopped and spills into the Yolo Bypass in  
36 about 70 percent of years. The proposed notch and gates could increase that frequency to about  
37 75-95 percent of years with a modified weir height of 17.5 feet (NAVD88) compared to the  
38 existing weir height of 33 feet (NAVD88). The frequency of Fremont Weir spills of at least 30  
39 days at 3,000 cfs between 1984 and 2007 would double with a modified weir height of 17.5 feet  
40 compared to the existing weir height of 33 feet (Table 3.###). Once the targeted duration of  
41 inundation is achieved and the river is below the top of the Fremont Weir, the weir gates could  
42 be operated to reduce diversion of flow from the Sacramento River to allow for drainage of the  
43 Bypass while still allowing for fish passage. The basic flood control functions of the Fremont  
44 Weir will not be changed; at flood stage, the weir will overtop as it does currently.

1

**Table 3.##. Number of events (number of water years<sup>1</sup> in which events took place in parentheses) with consecutive spills producing<sup>2</sup> at least 3,000 cfs over the Fremont Weir under current (elevation = 33 ft NAVD88) and weir with proposed elevational change (elevation 17.5 ft NAVD88) conditions.**

	<i>Events during Water Years 1984-2008<sup>3</sup></i>		<i>Events during Water Years 1929-2008<sup>3</sup></i>	
	<b>Current Weir</b>	<b>Proposed Notch</b>	<b>Current Weir</b>	<b>Proposed Notch</b>
Less than 30 days	17 (10)	42 (20)	48 (29)	137 (62)
At least 30 days	9 (9)	18 (14)	11 (10)	70 (52)
At least 45 days	4 (4)	11 (11)	5 (5)	46 (41)
<i>Notes:</i>				
1. Water Year is defined as August 1 of the previous year through July 31 of the current year. For example, Water Year 2005 is August 1, 2004 to July 31, 2005.				
2. Assumes no more than a 7 day gap in flooding to count as the same event				
3. Flows between October 1, 1929 and December 31, 1983 have been reconstructed from the hydrologic record				

2

3 **Problem Statement**

4 The majority of historical floodplain in the Sacramento and San Joaquin River systems have  
5 been lost, particularly floodplains that flow directly into the Delta. This loss of floodplains has  
6 resulted in a reduction of highly productive rearing habitat for juvenile salmon and spawning and  
7 rearing habitat for other native species such as splittail. Loss of floodplain habitat has reduced  
8 the seasonal input of organic and inorganic material and food resources into adjoining riverine  
9 habitat and the downstream bay and estuary. Inundation of the Yolo Bypass from the  
10 Sacramento River is currently limited to times when the Fremont Weir is overtopped, limiting  
11 the availability of habitat for covered fish species and inputs to the food web from the Yolo  
12 Bypass.

13 The current configuration of the Yolo Bypass and Fremont Weir creates passage impediments  
14 and potential stranding for adult Chinook salmon, steelhead, green and white sturgeon, and river  
15 and Pacific lamprey and stranding hazards for juvenile Sacramento splittail, sturgeon, Chinook  
16 salmon, and steelhead. First, the Denil fish ladder at the Fremont Weir, designed for adult  
17 salmonid passage, is not effective at passing salmon, adult sturgeon and lamprey. Second, the  
18 stilling basins immediately downstream of the Sacramento and Fremont weirs have higher  
19 stranding rates of juvenile Chinook salmon than do earthen ponds as floodwater recedes  
20 (Sommer et al. 2005). Third, there are road crossings and agricultural impoundments in the Tule  
21 Canal/Toe Drain that block hydrologic connectivity, and therefore, fish passage. Fourth, the  
22 Lisbon Weir, which was built to impound agricultural water in the Toe Drain upstream of the  
23 weir, creates a passage impediment for fish at low stage when riprap is exposed or shallowly  
24 submerged.

25 Putah Creek is used for spawning habitat by a small population of Chinook salmon and  
26 steelhead. The Los Rios Check Dam, an irrigation impoundment structure, is seasonally  
27 removed but remains in place for several months while adult salmon and steelhead are  
28 attempting to migrate upstream. The reach of channel downstream of the check dam runs  
29 through a straight ditch to the Toe Drain. Putah Creek often breaks through its bank a short  
30 distance upstream of the Los Rios Check Dam, requiring periodic road maintenance at the Yolo  
31 Bypass Wildlife Area.

## 1 **Hypothesized Benefits**

2 Modifying the Fremont Weir and its operations and improving fish passage will reduce the  
3 adverse effects of stressors related to food availability, habitat availability, passage, harvest,  
4 stranding, predation, and entrainment for some of the covered fish species. Specifically, this  
5 conservation measure will:

- 6 • create additional spawning habitat for Sacramento splittail (Sommer et al. 2001a, 2002,  
7 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006). Because splittail are  
8 primarily floodplain spawners, successful spawning is predicted to increase with  
9 increased floodplain inundation;
- 10 • create additional juvenile rearing habitat for Chinook salmon, Sacramento splittail, and  
11 possibly steelhead (Sommer et al. 2001a,b, 2002, 2007b, 2008, Moyle 2002, Moyle et al.  
12 2004, Feyrer et al. 2006). Growth and survival of larval and juvenile fish is higher in the  
13 floodplain compared to those rearing in the mainstem Sacramento River (Sommer et al.  
14 2001b);
- 15 • increase downstream juvenile passage of Chinook salmon, Sacramento splittail, river and  
16 Pacific lamprey, and possibly steelhead. An inundated Yolo Bypass is used as an  
17 alternative to the mainstem Sacramento River for downstream migration of salmonids,  
18 splittail, river lamprey, and sturgeon. Sommer et al. (2003, 2004a) found that, other than  
19 steelhead and Pacific lamprey, juveniles from all of these species inhabit the Yolo Bypass  
20 during periods of inundation. Based on the timing and life history traits of steelhead  
21 relative to Chinook salmon, steelhead likely also benefit from inhabiting the Yolo  
22 Bypass. Similarly, based on the timing and life history traits of Pacific lamprey relative  
23 to river lamprey, Pacific lamprey likely also benefit from inhabiting the Yolo Bypass
- 24 • increase adult upstream passage of fall-, late fall-, winter-, and spring-run Chinook  
25 salmon, steelhead, green and white sturgeon, and river and Pacific lamprey. It is thought  
26 that an inundated Yolo Bypass is used as an alternative route by upstream migrating  
27 adults of these species when Fremont Weir is spilling ;
- 28 • increase food production for rearing salmonids, splittail, and other covered species on the  
29 floodplain (Sommer et al. 2001a,b, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004,  
30 Feyrer et al. 2006). During periods when the bypass is flooded, there is relatively high  
31 production of zooplankton and macroinvertebrates that serve, in part, as the forage base  
32 for many of the covered fish species (Benigno and Sommer 2008);
- 33 • increase the availability and production of food in the Delta, Suisun Marsh, and bays  
34 downstream of the bypass, including restored habitat in Cache Slough, for delta smelt,  
35 longfin smelt, and other covered species by exporting organic material and  
36 phytoplankton, zooplankton, and other organisms produced from the inundated  
37 floodplain into the Delta (Schemel et al 1996, Jassby and Cloern 2000, Mitsch and  
38 Gosselink 2000, Moss 2007, Lehman et al. 2008). The co-occurrence of suitable food  
39 supplies (zooplankton) and various life stages of delta smelt (e.g., larval and juvenile life  
40 stages) has been assumed to be an important factor affecting delta smelt survival and  
41 abundance (Feyrer et al. 2007b, Miller 2007b). The relationship between longfin smelt

1 abundance and Delta outflow has experienced two step-declines: one after the invasion of  
2 *Corbula* and one during the POD years, although the slope of the relationship has not  
3 changed, suggesting that longfin smelt are food-limited (Baxter et al. 2008). Hobbs et al.  
4 (2006) found evidence of food limitation in early-stage juvenile longfin smelt, although  
5 spatially and temporally variable;

6 • increase the duration that the floodplain is inundated during periods that the Yolo Bypass  
7 is receiving water from both the Fremont Weir and the westside tributaries (e.g., Cache  
8 and Putah Creeks);

9 • reduce losses of adult Chinook salmon, sturgeon, and other fish species to stranding and  
10 illegal harvest by improving upstream passage at the Fremont Weir. When flows in the  
11 Sacramento River recede, the Fremont Weir stops spilling, trapping fish downstream of  
12 the weir. Many of these fish remain in the shallow water near the weir, providing easy  
13 access to illegal harvesters. Under this conservation measure, the Fremont Weir will be  
14 modified to reduce stranding when Sacramento River flows recede;

15 • reduce the exposure and risk of outmigrating juvenile fish migrating from the Sacramento  
16 River into the interior Delta through the Delta Cross Channel and Georgiana Slough, thus  
17 decreasing the risk for predation losses (Brandes and McLain 2001);

18 • reduce the exposure of outmigrating juvenile fish to entrainment or other adverse effects  
19 associated with the intakes of the proposed north Delta water diversion facilities by  
20 passing juvenile fish into the Yolo Bypass upstream of the proposed intake locations; and

21 • improve fish passage, and possibly increase and improve seasonal floodplain habitat  
22 availability, by retrofitting Los Rios Check Dam with a fish ladder, or creating another,  
23 fish-passable route for water from Putah Creek to reach the Toe Drain.

24 Increasing the frequency and duration of inundation within the Yolo Bypass is the largest  
25 opportunity for enhancing seasonally inundated floodplain habitat in the Central Valley . The  
26 Yolo Bypass provides the only opportunity for increasing the frequency and duration of  
27 inundation of a floodplain in the Planning Area without restoration of historical floodplain  
28 surfaces presently in more highly developed, year-round land uses.

### 29 ***Adaptive Management Considerations***

30 Implementation of this conservation measure by the Management Entity will be informed  
31 through effectiveness monitoring that will be conducted as described in Section 3.6, *Monitoring*  
32 *and Research Program*, and the adaptive management process described in Section 3.7, *Adaptive*  
33 *Management Program*. Results of both biological and operational monitoring in the Yolo  
34 Bypass and the mainstem Sacramento River will be used within the BDCP adaptive management  
35 framework to refine and modify project structures and operations and fish passage  
36 improvements.

### 37 ***Timeline for Implementation***

1 The Yolo Bypass Fishery Enhancement Plan will be completed within 6 months of approval of  
2 BDCP. The Plan shall include: (1) specific biological objectives, restoration actions, and locations;  
3 (2) specific operational criteria; (3) a timeline with key milestones, (4) performance goals and  
4 associated monitoring, including habitat attributes, juvenile and adult metrics, and inundation depth  
5 and duration criteria; (5) specific actions to minimize stranding or migration barriers for juvenile  
6 salmon; and (6) identification of regulatory and legal constraints that may delay implementation, and  
7 a strategy to address those constraints. Construction of capital improvements identified in the Plan  
8 will be completed within five years of completion of the Plan.