

Second Draft Habitat Restoration Conservation Measures

Note to Steering Committee: This handout presents the second draft of habitat restoration conservation measures. This draft incorporates comments received from Steering Committee members on the first draft conservation measures presented to the Steering Committee on September 19, 2008. All new text added to this draft from the first draft is displayed in underlined red text; text in black is the same as delivered in the first draft. These draft conservation measures will be discussed at the October 17, 2008 Steering Committee meeting and written comments must be received prior to October 21, 2008.

The extent of habitat restoration is not identified in this draft of the conservation measures. The Habitat Restoration Technical Team has developed criteria for identifying the extent of physical habitat (floodplain, intertidal marsh, channel margin, and riparian) that feasibly could be restored in each of the Restoration Opportunity Areas (ROAs) and for prioritizing each of the restoration opportunities associated with each ROA (Figure 1). The SAIC team is in the process of applying these criteria, the results of which will be reviewed and addressed by the Habitat Restoration Technical Team on October 29, 2008.

These second draft conservation measures will be discussed at the October 17, 2008 Steering Committee meeting. **Written comments are requested prior to October 22, 2008** such that we may incorporate those comments into the next draft of these measures.

Introduction

The habitat restoration conservation measures are organized into five categories— floodplain, freshwater intertidal marsh, brackish intertidal marsh, channel margin, and riparian habitat restoration conservation measures. Restored freshwater intertidal marsh as used in this handout corresponds to the tule and cattail dominated elements of the BDCP tidal freshwater emergent wetland natural community; restored riparian forest and scrub is an element of the BDCP valley riparian natural community. Shallow subtidal aquatic habitats¹ are anticipated to be restored incidentally with restoration of intertidal marshes and correspond to elements of the BDCP tidal perennial aquatic natural community.

The following information is provided with each conservation measure following the conservation measure description.

¹ Elevations considered suitable for shallow subtidal aquatic habitat include lands with elevations extending >0-6 feet below the intertidal zone. Lands within the shallow subtidal aquatic habitat zone may be elevated to elevations suitable for restoration of intertidal marsh habitat.

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Rationale. This section describes the justification for proposing the conservation measure. Rationale statements are primarily directed at identifying the covered species and ecosystem benefits that would be expected with implementing the conservation measure. The identified benefits are based on scientific literature and expert opinion as expressed by HRPTT members, as provided by experts requested to present information to the HRPTT on selected topics, and relevant expert opinion expressed in other BDCP venues (e.g., working groups and other technical teams).

Implementation timeframe. This section describes the BDCP implementation period (i.e., near-term or long-term) that is likely the most appropriate period for implementing the measure. The BDCP near-term implementation period refers to the period from issuance of BDCP permits to completion of the around-Delta conveyance facilities and the BDCP long-term implementation period includes the period from when dual-conveyance operations are initiated over the remainder of the term of the BDCP.

Implementation considerations. This section describes restoration design, management, and other relevant items that may need to be addressed by the BDCP Implementing Entity when planning implementation of the conservation measure.

Resiliency to future change. This section provides a qualitative assessment of the likely ability of the habitat restored under the conservation measure to continue to provide the desired level of covered species and ecosystem benefits into the future with anticipated changes in environmental conditions with climate change and sea level rise.

Uncertainties/risks. This section describes important uncertainties associated with ability of the conservation measure to achieve the desired covered species and ecosystem benefits and the ecological risks that may be associated with implementing the proposed conservation measure. Important uncertainties and risks are those identified in the course of HRPTT deliberations, including results of coarse-level DRERIP evaluations of proposed restoration actions.

Monitoring and adaptive management considerations. This section describes monitoring and adaptive management-related elements of the conservation measure, including elements of implementation that may be subject to adaptive management and the types of monitoring that may be appropriate for assessing the effectiveness of the restoration in achieving desired ecological benefits and for informing the adaptive management process. [Note to reviewers: The content of this section will be expanded for each conservation measure to provide more specificity regarding monitoring actions and metrics and adaptive management triggers and actions, as appropriate, through future iterations of these materials.]

1 **Reversibility.** This section qualitatively assesses the likely ability to reverse the
2 environmental outcomes of the conservation measure, if necessary.

3
4 Attachment A, *Restoration Concept Definitions*, provides additional information
5 regarding restoration design requirements and expected ecological outcomes associated
6 with each of the habitat restoration categories.

7
8 The information described above for each of the draft conservation measures will be
9 expanded upon and incorporated into appropriate sections of the BDCP Conservation
10 Strategy chapter.

11 12 13 **Floodplain Habitat Restoration Conservation Measures**

14
15 **Conservation Measure FLOO1.1: Modify the Fremont Weir and the Yolo Bypass to**
16 **provide for a higher frequency and duration of inundation.** Within the Yolo
17 Bypass/Cache Slough Complex ROA (see Figure 1), floodplain habitat in the Yolo
18 Bypass would be designed and operated to support the physical and biological attributes
19 described in Attachment A. To increase the frequency and duration of inundation of
20 floodplain habitat in the Yolo Bypass, the Fremont Weir would be notched to an
21 elevation of 17.5 feet (NAVD88) and fitted with an operable gate(s) that, when operated,
22 would allow Sacramento River water to flow into the Yolo Bypass when Sacramento
23 River stage at the weir exceeds 17.5 feet. The operable gate(s) would be designed and
24 operated to provide for the efficient upstream and downstream fish passage to and from
25 the Yolo Bypass into the Sacramento River. Other design elements of this measure would
26 include:

- 27 ▪ excavation of a canal to convey water past the higher elevation natural levee of
28 the Sacramento River upstream of the new gate at Fremont Weir and past
29 accumulated sediment below the new gate at Fremont Weir to the Tule Canal;
- 30 ▪ acquisition of lands, in fee-title and through conservation or flood easements,
31 necessary for restoration of seasonally inundated aquatic habitats and for
32 accommodating future sea level rise;
- 33 ▪ removal and replacement of the existing Fremont Weir fish ladder with a new
34 fish passage facility designed to effectively allow for the passage of adult
35 salmonids and sturgeon from the Yolo Bypass past the Fremont Weir into the
36 Sacramento River.
- 37 ▪ grading, removal of existing berms or levees, and construction of berms or
38 levees to the extent necessary to improve the distribution (e.g., wetted area) and
39 hydrodynamic characteristics (e.g., residence times, flow ramping and recession)
40 of water moving through the Yolo Bypass, prevent stranding of covered fish
41 species, and to protect property; and
- 42 ▪ construction of a structure in the Sacramento River, if needed, in the vicinity of
43 the new weir gate to encourage the passage of juvenile salmonids migrating

1 down the Sacramento River into the Bypass.

2 The range of frequencies, durations, and periods that the operable gate(s) would be
3 operated to inundate the Yolo Bypass are described in Conveyance Action Parameter 1.

4
5 **Rationale:** All BDCP covered fish species are believed to directly or indirectly
6 benefit from seasonally inundated floodplain habitat within the Sacramento River
7 and Delta. Sommer et al. (2003, 2004) found that larval and/or juvenile Chinook
8 salmon, delta smelt, longfin smelt, river lamprey, and splittail seasonally inhabit
9 the Yolo Bypass during periods when the floodplain is inundated. Harrell et al.
10 (2003) found that adult fall-, winter-, and spring-run Chinook salmon, splittail,
11 delta smelt, and white sturgeon inhabit the Yolo Bypass when inundated. The
12 floodplain supports spawning habitat for splittail and juvenile rearing habitat for
13 juvenile Chinook salmon, steelhead, and sturgeon. Analyses of the annual trends
14 in juvenile splittail abundance have shown substantially increased juvenile
15 abundance in wet years. Increased splittail production in wet years is hypothesized
16 to be the result of favorable habitat conditions for successful spawning and early
17 development of larval and juvenile splittail within inundated floodplain habitat
18 (Sommer et al. 2001a). Results of investigations have shown that growth and
19 survival of juvenile fish is improved for those fish rearing in the floodplain
20 compared to those that migrate downstream and rear in the mainstem Sacramento
21 River (Sommer et al. 2001b). Flooding of the bypass also provides surface water
22 connectivity that supports upstream and downstream migration of covered species,
23 as well as production and downstream transport of nutrients, phytoplankton, and
24 zooplankton. During periods when the bypass is flooded, studies have shown
25 relatively high production of zooplankton and macroinvertebrates that serve, in
26 part, as the forage base for many of the covered fish species (Benigno and Sommer
27 2008). Furthermore, is believed that organic carbon and food production within
28 the flooded bypass is transported downstream into the Cache Slough region of the
29 Delta, and subsequently into the western Delta and Suisun Bay (Schemel et al.
30 1996, Jassby and Cloern 2000).

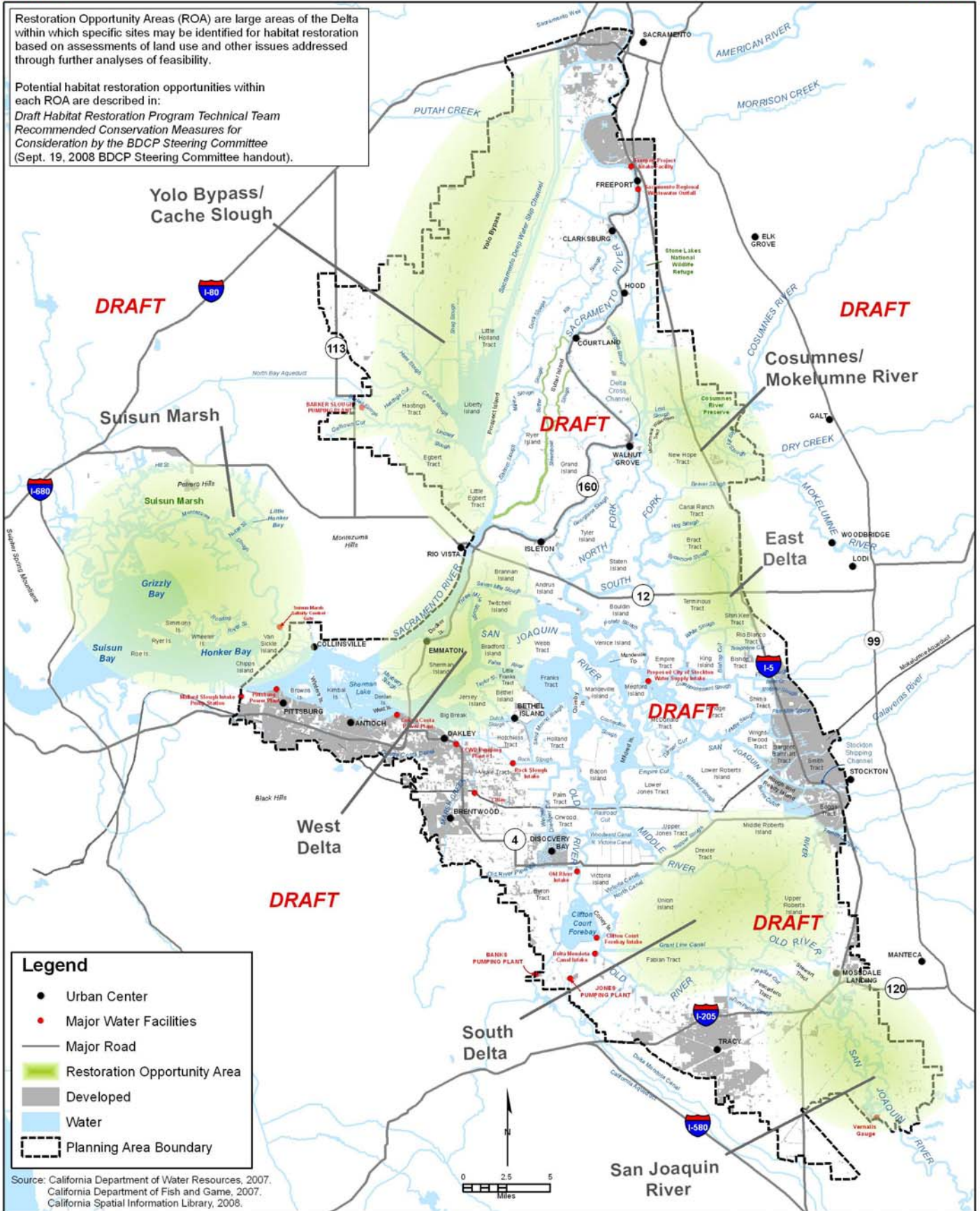
31
32 Increasing the frequency and duration of floodplain inundation in the Yolo Bypass
33 is expected to reduce the adverse effects of stressors related to food availability,
34 habitat availability, passage, harvest, stranding, predation, and entrainment for the
35 covered fish species by:

- 36 ■ creating additional spawning habitat for Sacramento splittail (Sommer et
37 al.2001a,2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006);
- 38 ■ creating additional juvenile rearing habitat for Chinook salmon, Sacramento
39 splittail, and possibly steelhead (Sommer et al.2001a,b, 2002, 2007, 2008,
40 Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006);
- 41 ■ increasing the production of food for rearing salmonids, splittail, and other
42 covered species (Sommer et al. 2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle
43 et al. 2004, Feyrer et al. 2006);

44

Restoration Opportunity Areas (ROA) are large areas of the Delta within which specific sites may be identified for habitat restoration based on assessments of land use and other issues addressed through further analyses of feasibility.

Potential habitat restoration opportunities within each ROA are described in:
 Draft Habitat Restoration Program Technical Team
 Recommended Conservation Measures for
 Consideration by the BDCP Steering Committee
 (Sept. 19, 2008 BDCP Steering Committee handout).



Source: California Department of Water Resources, 2007.
 California Department of Fish and Game, 2007.
 California Spatial Information Library, 2008.

Figure 1. BDCP Restoration Opportunity Areas

- 1 ▪ increasing the availability and production of food in the Delta downstream of the
2 bypass for delta smelt, longfin smelt, and other covered species by exporting
3 organic material and phytoplankton, zooplankton, and other organisms produced
4 from the inundated floodplain into the Delta (Mitsch and Gosselink 2000, Moss
5 2007, [Lehman et al. 2008](#))²;
- 6 ▪ increasing the frequency that floodplain flows transport organic carbon and
7 organisms from existing and future restored intertidal marsh at the downstream
8 end of the bypass into the Delta in support of in-Delta food production for delta
9 smelt, longfin smelt, and other covered species (Mitsch and Gosselink 2000,
10 Moss 2007, [Lehman et al. 2008](#))²;
- 11 ▪ increasing the duration that the floodplain is inundated during periods that the
12 Yolo Bypass is receiving water from both the Fremont Weir and the westside
13 tributaries (e.g., Cache and Putah Creeks);
- 14 ▪ reducing losses of Chinook salmon, sturgeon, and other fish species to stranding
15 and illegal harvest by improving passage at the Fremont Weir;
- 16 ▪ [reducing the exposure and risk of outmigrating juvenile fish migrating from the
17 Sacramento River into the interior Delta through the Delta Cross Channel and
18 Georgiana Slough, thus decreasing the risk for predation losses \(Brandes and
19 McLean 2001\); and](#)
- 20 ▪ [reducing the exposure of outmigrating juvenile fish to entrainment at intakes of
21 the proposed North Delta water diversion facilities by passing juvenile fish into
22 the Yolo Bypass upstream of the proposed intake locations.](#)

23 Increasing the frequency and duration of inundation within the Yolo Bypass is the
24 largest opportunity for increasing inundated floodplain habitat in the North Delta.
25 The Yolo Bypass provides the only opportunity for increasing the frequency and
26 duration of inundation of a floodplain in the Planning Area without restoration of
27 historical floodplain surfaces presently in other land uses. Land use in the Yolo
28 Bypass has developed to be compatible with [the existing Yolo Bypass flood
29 regime.](#)

30
31 [Modification of the Yolo Bypass seasonal floodplain is also compatible with and
32 would provide benefits under proposed water supply operations in both the BDCP
33 near-term implementation period and long-term implementation period with
34 operation of a North Delta diversion facility on the Sacramento River.](#)

35
36 **Recommended Implementation Timeframe:** It is anticipated that
37 implementation of this conservation measure could be initiated in the BDCP near-
38 term implementation period.

39
40 **Implementation Considerations:** There are numerous challenges to

² Generally wetland principles support this rationale (Mitsch and Gosselink. 2000, Moss 2007, [Lehman et al. 2008](#)), but there may be indirect effects that create complex responses as illustrated in Jassby's analysis of Bay/Delta phytoplankton production (Jassby 2008).

1 implementing this measure to improve the Yolo Bypass floodplain habitat.

2 Implementation considerations include:

- 3 ▪ coordination with the U.S. Army Corps of Engineers and other flood control
4 agencies to allow notching, construction of an operable gate, excavation of a
5 channel, operation of the Fremont Weir, and modifications to Bypass
6 topography and flow patterns;
- 7 ▪ coordination with the Department of Fish and Game on water management
8 affecting the Yolo Wildlife Area;
- 9 ▪ coordination with the Yolo Basin Natural Heritage Program to ensure effective
10 implementation of conservation measures under both programs;
- 11 ▪ coordination with the Yolo Basin Foundation, Yolo Bypass Working Group, and
12 the Lower Yolo Bypass Planning Forum;
- 13 ▪ securing conservation easements, fee title, or other agreements necessary to
14 accommodate changes in patterns of inundation frequency and duration on
15 current land uses;
- 16 ▪ the need to construct levees to protect private landholdings that have not been
17 secured through conservation easements;
- 18 ▪ ensuring that the design and management of Yolo Bypass floodplain habitats
19 would be compatible and provide synergistic species and ecosystem benefits
20 with restoration of freshwater intertidal marsh habitats in the Cache Slough
21 Complex ROA (see Figure 1 and Conservation Measure FIMA1.1);
- 22 ▪ potential for increasing mercury methylation and resuspension and downstream
23 transport of other contaminants;
- 24 ▪ opportunities for improving passage through the Yolo Bypass downstream of
25 Fremont Weir, Toe Drain, and Tule Canal;
- 26 ▪ opportunities for reducing the potential adverse effects of pesticides/herbicides
27 on agricultural lands by promoting organic farming practices within the Bypass;
- 28 ▪ potential effects on existing biological resources; and
- 29 ▪ opportunities for providing localized floodplain inundation benefits during
30 periods when Sacramento River stage is below 17.5 feet by forcing water from
31 the Toe Drain onto adjacent lands.

32
33 **Resiliency to future changes:** This conservation measure is expected to be
34 resilient to future changes in hydrology and sea levels. With changes in
35 hydrology, the period of inundation is expected to occur earlier in the year than
36 under current conditions (Cayan et al. 2006). The Fremont Weir and Yolo Bypass
37 would continue to accommodate flood flows. Although the frequency, duration,
38 or magnitude of seasonal inundation of the floodplain may vary in the future, the
39 basic functional processes and biological benefits associated with the action
40 would continue into the future over the entire range of anticipated changes in
41 future hydrologic conditions. Sea level rise would be expected to reduce the

1 extent of inundated floodplain at the south end of the bypass and result in tidal
2 emergent wetlands extending into these areas. This tidal emergent wetland would
3 produce organic carbon and organisms in support of food production for covered
4 fish species.

5
6 **Uncertainties/risks:** Methylation of mercury may occur in seasonally inundated
7 floodplains and intertidal zones, making methylmercury bioavailable to plants,
8 fish, and wildlife in and downstream of the floodplain (Alpers et al. 2006).
9 Mercury loading from Cache and Putah Creeks and exposure to agricultural
10 pesticides and herbicides may adversely affect habitat productivity. Requirements
11 and the effectiveness of reducing the risk of stranding juvenile fish during
12 floodplain recession require further analysis.

13
14 There is some uncertainty regarding the relative biological effects that may occur
15 as a result of increasing seasonal flows through the bypass on habitat conditions,
16 migration rates, and the downstream transport of fish egg and larvae as well as
17 phytoplankton, zooplankton, and organic matter within the Sacramento River
18 within the reach of the mainstem river between the Fremont Weir and Rio Vista.
19 Reduced flows within the mainstem river during the late winter and early spring
20 (i.e., when the bypass would be flooding) have the potential to reduce survival of
21 those organisms that continue to inhabit the mainstem river.

22
23 Although the available data supports the biological benefits of increasing the
24 frequency and duration of floodplain inundation, there is uncertainty in the
25 relationship between the seasonal timing and duration of inundation and the
26 benefits for various species.

27
28 **Monitoring and adaptive management considerations:** [Note to reviewers:
29 this section is a general summary; more detail will be provided in future
30 iterations.] Implementation of this conservation measure would provide
31 opportunities to adaptively manage flows in the Bypass using the new operable
32 gate(s) in the weir to improve food production and habitat conditions for covered
33 fish species over time based on monitoring results. Basic operational monitoring
34 would include variables such as Sacramento River stage, flow into the Yolo
35 Bypass, water velocities and residence times, water quality, and overall conditions
36 of aquatic habitat within the seasonal floodplain. Physical habitat parameters that
37 would be useful to monitor include the extent of wetted area and water depths,
38 dissolved oxygen concentrations, water temperatures, water velocities and
39 residence times, and other features of the floodplain habitat. In addition to
40 providing information necessary to adaptively manage inundated floodplain
41 habitat conditions, results of monitoring (e.g., monitoring of phytoplankton and
42 zooplankton production relative to residence time and water depth) would help
43 identify ways to improve the design and management of floodplain habitats
44 restored in future years. Additionally, monitoring of covered fish species benefits
45 provided by both the Yolo Bypass and a new Deep Water Ship Channel Bypass
46 (see Conservation Measure FLOO2.1) under various operations would help

1 inform how to co-manage inundation of the bypasses to spatially and temporally
2 optimize benefits for covered fish species. Some additional monitoring
3 considerations under various bypass operations to inform adaptive
4 implementation include:

- 5 ▪ extent of phytoplankton, zooplankton, and macroinvertebrate production under
6 various bypass operations;
- 7 ▪ load of organic carbon, phytoplankton, zooplankton, and macroinvertebrates
8 exported into aquatic habitats in the Delta;
- 9 ▪ effects of floodplain inundation on food production downstream of the bypass;
- 10 ▪ effects of floodplain inundation on Delta turbidity;
- 11 ▪ effectiveness of the new fish passage facility in providing passage past and
12 reducing stranding at the Fremont Weir;
- 13 ▪ incidence of and magnitude of stranding of all life stages of covered fish
14 species;
- 15 ▪ shifts in topography over time (e.g., floodplain scouring that create surfaces
16 that pond deep water) that could create stranding risks for covered fish species;
- 17 ▪ effects of floodplain inundation on habitat conditions for delta smelt in Cache
18 Slough, the Toe Drain, and other habitat use areas affected by the discharge of
19 water from the bypass;
- 20 ▪ effects of various bypass inundation conditions and non-inundation periods on
21 fish abundance, food production and export, organic carbon production and
22 export, toxic concentrations, and other relevant parameters in restored
23 intertidal marshes and adjacent subtidal habitats restored in the Cache Slough
24 area;
- 25 ▪ effects on the relative survival, migration, and transport of covered fish species
26 within the mainstem Sacramento River as a function of flows diverted into the
27 Yolo Bypass;
- 28 ▪ levels of mercury methylation and biological uptake;
- 29 ▪ habitat use by green and white sturgeon and other covered fish species; and
- 30 ▪ growth and survival of rearing Sacramento splittail and Chinook salmon.

31 Additionally, experiments could be conducted to determine if inundating small
32 areas of the bypass floodplain during drier years by placing barriers in the Toe
33 Drain would yield tangible food and habitat benefits for covered fish species.

34
35 **Reversibility:** Flow-related effects of this conservation measure are considered
36 to be easily reversible because the BDCP Implementing Entity could choose not
37 to operate the Fremont Weir gate(s), thus maintaining the existing inundation
38 patterns of the Yolo Bypass. Costs related to modification of the existing weir to
39 install an operable gate(s) and re-grading within the bypass, however, could not
40 be recovered. New levees and berms could permanently remove farm land within

1 the footprint of these structures if they are too costly to remove.

2
3 **Conservation Measure FLOO2.1: Create and operate a new flood bypass in the**
4 **Yolo Bypass/Cache Slough Complex ROA to restore seasonally inundated**
5 **floodplain habitat.** The BDCP Implementing Entity would coordinate flood control
6 planning with the Central Valley Flood Protection Board, California Department of
7 Water Resources (DWR), and U.S. Army Corps of Engineers to assess the desirability
8 and feasibility for creating a new flood bypass located in the Yolo Bypass/Cache Slough
9 **Complex ROA (see Figure 1) adjacent to** the east levee of the Sacramento River Deep
10 Water Ship Channel. **This new flood bypass (hereafter referred to as the Deep Water Ship**
11 **Channel Bypass) would restore seasonally inundated floodplain habitats for covered fish**
12 **species and provide flood control benefits. If results of planning studies indicate that**
13 **construction of a Deep Water Ship Channel Bypass is desirable and feasible, the BDCP**
14 **Implementing Entity would enter into a cost sharing agreement with the U.S. Army**
15 **Corps of Engineers for project planning and construction and would assist with securing**
16 **Congressional authorization and funding for the project. If authorized and funded, the**
17 **BDCP Implementing Entity would enter into subsequent agreements with the U.S. Army**
18 **Corps of Engineers and other appropriate agencies governing bypass operations for**
19 **providing joint flood control and ecosystem benefits and maintenance responsibilities.**
20

21 The Deep Water Ship Channel Bypass would be designed to reduce flood risks to
22 Clarksburg and the Pocket Area of Sacramento and reduce flood pressures along
23 downstream levees to Rio Vista. If implemented, the bypass would be designed and
24 operated to provide seasonally inundated floodplain habitat for periods of at least 45 days
25 from late-winter through spring during years when sufficient water is available in the
26 Sacramento River for this purpose. Restored floodplain habitat within the bypass would
27 be designed and operated to support the physical and biological attributes described in
28 Attachment A.
29

30 Design elements of this measure could include:

- 31 ▪ acquisition of lands in fee-title or through conservation easements suitable for
32 restoration of seasonally inundated floodplain habitats and for accommodating
33 future sea level rise;
- 34 ▪ construction of a new levee east of the Sacramento Deep Water Ship Channel to
35 contain bypass flows between the new levee and the existing east levee of the
36 Deep Water Ship Channel (the bypass width would be relatively narrow [an
37 estimated 1,000-2,000 feet] to minimize impacts on existing land uses and still
38 provide substantial benefits to covered species);
- 39 ▪ construction of an operable gate(s) along the west levee Sacramento River
40 upstream of Freeport designed to pass flows into the bypass and to provide for
41 passage of fish upstream and downstream of the gate(s);
- 42 ▪ modify the landform within the bypass to prevent stranding of covered fish
43 species.

- 1 ▪ removing levees at the south end of the bypass to provide flow connectivity with
2 the Delta; and
- 3 ▪ potentially discontinuing farming within the bypass if the bypass is designed with
4 sufficient flood capacity to provide for the natural establishment and growth of
5 riparian vegetation on the floodplain surface to provide structural and
6 hydrodynamic complexity (the bypass width likely would be too narrow to
7 provide for both farming and the desired level of riparian habitat-associated
8 benefits).

9 Preliminary assessments of this concept indicate that, based on flows recorded at Freeport
10 from 1984-2007, a gate invert elevation of 6 feet in the vicinity of Freeport would allow
11 at least 3,000 cfs to inundate the floodplain for at least 45 consecutive days in 48 percent
12 of the years . The extent of inundated floodplain would be determined by the width of
13 the bypass, but would be expected to range between 2,000 and 5,000 acres. The range of
14 frequencies, durations, and periods that the operable gate(s) would be operated to
15 inundate the new bypass are described in Conveyance Action Parameter 2.

16
17 If construction of the Deep Water Ship Channel Bypass is not deemed desirable and
18 feasible or if funding or authorizations necessary to construct the bypass are not obtained,
19 the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate
20 this conservation measure. If terminated, remaining funding would be deobligated from
21 this conservation measure and reallocated to augment funding for other effective
22 conservation measures identified in coordination with the Fishery Agencies through the
23 BDCP adaptive management process.

24
25
26 **Rationale:** Flood control agencies are currently planning modifications to the
27 existing Central Valley flood control system, which provides an opportunity for
28 the BDCP Implementing Entity to coordinate with these agencies to explore the
29 desirability and feasibility for constructing and operating a Deep Water Ship
30 Channel Bypass.

31
32 Historically seasonally inundated floodplains are believed to have played an
33 important role as spawning and juvenile rearing habitat for salmonids, splittail,
34 sturgeon, and other Central Valley fish. As a result of channelization, levee
35 construction, and reclamation for agriculture and other uses, many of the
36 seasonally inundated floodplains on the Sacramento River (and most other Central
37 Valley rivers) and the Delta are no longer accessible to fish and other aquatic
38 species. As discussed for Conservation Measure FLOO1.1, results of recent
39 studies conducted by Sommer et al. (2003, 2004) and others have shown the
40 biological value of seasonal floodplain habitat. These studies have shown that
41 seasonal floodplains provide important spawning and egg incubation habitat for
42 Sacramento splittail, juvenile rearing habitat for Chinook salmon, steelhead,
43 sturgeon, and others, and increase the availability of nutrients as well as
44 production of phytoplankton, zooplankton, and macroinvertebrates that serve as
45 the basis for the trophic web and important food resources for the covered species.

1 Increasing seasonal floodplain habitat along the Sacramento River also provides
2 increased connectivity among habitats, an alternative migration route for juvenile
3 and adult fish, and a corridor for the downstream transport of fish and nutrients
4 into the lower Sacramento River and Delta.
5

6 Increasing the extent of floodplain habitat within the Delta by creating a Deep
7 Water Ship Channel Bypass is expected to reduce the adverse effects of stressors
8 related to food availability, habitat availability, predation, and entrainment for the
9 covered fish species by:

- 10 ■ creating additional spawning habitat for Sacramento splittail by expanding
11 access to floodplain habitat area and providing in-channel spawning habitat by
12 creating backwaters (Sommer et al.2001a, 2002, 2007, 2008, Moyle 2002,
13 Moyle et al. 2004, Feyrer et al. 2006);
- 14 ■ creating additional rearing habitat for Sacramento Basin runs of Chinook
15 salmon, Sacramento splittail, and possibly steelhead (Sommer et al.2001a,b,
16 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006);
- 17 ■ increasing the production of food for rearing salmonids, splittail, and other
18 covered species (Sommer et al. 2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle
19 et al. 2004, Feyrer et al. 2006);
- 20 ■ naturally establishing freshwater intertidal marsh at suitable elevations within
21 the bypass as a result of restoring tidal connectivity that will produce organic
22 carbon and food in support of aquatic food web processes;
- 23 ■ increasing the availability and production of food in Delta channels downstream
24 of restored floodplain habitat for delta smelt, longfin smelt, and other covered
25 species by exporting organic material and phytoplankton, zooplankton, and
26 other organisms produced from the inundated floodplain into the Delta (Mitsch
27 and Gosselink 2000, Moss 2007)²;
- 28 ■ reducing the exposure and risk of outmigrating juvenile fish migrating from the
29 Sacramento River into the interior Delta through the Delta Cross Channel and
30 Georgiana Slough, thus decreasing the risk for predation losses (Brandes and
31 McLain 2001, USFWS unpubl. data, Bureau pers. com.); and
- 32 ■ reducing the exposure of outmigrating juvenile fish to entrainment at intakes of
33 the proposed North Delta water diversion facilities by passing juvenile fish into
34 the new bypass upstream of the proposed intake locations.

35 In addition to providing benefits for the covered fish species, riparian habitats if
36 allowed to establish within the new floodplain would substantially increase valley
37 elderberry longhorn beetle habitat and Swainson's hawk nesting habitat.
38

39 **Recommended Implementation Timeframe:** This conservation measure would
40 be implemented in the BDCP long-term implementation period to accommodate
41 the time necessary to coordinate planning with responsible agencies and local land
42 owners and to fund, plan, authorize, and permit construction of the Deep Water

1 Ship Channel Bypass. Planning and coordination efforts with responsible agencies
2 and local landowners, however, could be initiated in the near-term implementation
3 period.
4

5 **Implementation Considerations:** Implementation considerations include:

- 6 ■ coordination with the U.S. Army Corps of Engineers and other flood control
7 agencies to obtain permits to allow for 1) use of the east Sacramento River Deep
8 Water Ship Channel levee to serve as the west levee of the new bypass, 2)
9 construction of a new levee that would serve as the east levee of the new bypass,
10 and 3) levee modifications along the Sacramento River at the upstream end of
11 the new bypass to accommodate the construction and operation of a new
12 operable gate(s).
- 13 ■ coordination with local landowners;
- 14 ■ securing conservation easements, fee title, or other agreements necessary to
15 address the effects of seasonal inundation on current land uses;
- 16 ■ designing the flood capacity of new floodplains to allow for the natural
17 establishment and growth of native woody riparian vegetation;
- 18 ■ potential for increasing mercury methylation and resuspension and downstream
19 transport of other contaminants; and
- 20 ■ potential for short-term mobilization of toxic compounds from newly inundated
21 agricultural lands.

22 **Resiliency to future changes:** This conservation measure is expected to be
23 resilient to future changes in hydrology and sea levels. With changes in
24 hydrology, the period of inundation is expected to occur earlier in the year than
25 under current conditions (Cayan et al. 2006). Although the frequency, duration,
26 or magnitude of seasonal inundation of the floodplain may vary in the future, the
27 basic functional processes and biological benefits associated with the action
28 would continue into the future over the entire range of anticipated changes in
29 future hydrologic conditions. The the operable gate(s) could be used to regulate
30 seasonal flows and floodplain inundation in response to future changes in
31 Sacramento River hydrology. Sea level rise would be expected to reduce the
32 extent of inundated floodplain at the south end of the bypass and result in tidal
33 emergent wetlands extending into these areas. This tidal emergent wetland would
34 produce organic carbon and organisms in support of food production for covered
35 fish species.

36
37 **Uncertainties/risks:** Methylation of mercury may occur in seasonally inundated
38 floodplains and intertidal zones, making methylmercury bioavailable to plants,
39 fish, and wildlife in and downstream of the floodplain (Alpers et al. 2006).
40 Exposure to agricultural pesticides and herbicides may impact habitat productivity
41 in the first few periods that the restored floodplain is inundated. Requirements
42 and the effectiveness of reducing the risk of stranding juvenile fish during
43 floodplain recession require further analysis.

1
2 Uncertainty also exists regarding the relative biological effects that may occur as
3 a result of providing seasonal flows through a new flood bypass on habitat
4 conditions, migration rates, and the downstream transport of fish eggs and larvae
5 as well as phytoplankton, zooplankton, and organic matter within the mainstem
6 Sacramento River. Reduced flows within the mainstem of the Sacramento River
7 during the late winter and early spring when the bypass would be flooding have
8 the potential to reduce survival of those organisms that continue to inhabit the
9 mainstem river.

10
11 Although the available data supports the biological benefits of increasing the
12 frequency and duration of floodplain inundation along the Sacramento River,
13 there is uncertainty in the relationship between the seasonal timing, duration of
14 inundation, and the benefits for various species.

15
16 **Monitoring and adaptive management considerations:** *[Note to reviewers:*
17 *this section is a general summary; more detail will be provided in future*
18 *iterations.]* Implementation of this conservation measure would provide
19 opportunities to adaptively manage flows in the new bypass using the operable
20 gate(s) to improve food production and habitat conditions for covered fish species
21 over time based on monitoring results. Basic operational monitoring would
22 include variables such as Sacramento River stage, flow into the Yolo Bypass,
23 water velocities and residence times, water quality, and overall conditions of
24 aquatic habitat within the seasonal floodplain. Physical habitat parameters that
25 would be useful to monitor include the extent of wetted area and water depths,
26 dissolved oxygen concentrations, water temperatures, water velocities and
27 residence times, and other features of the floodplain habitat. Opportunities for
28 adaptive management include assessing the effectiveness of seasonal floodplain
29 habitat restoration designs and the ability of native riparian vegetation to
30 successfully establish on the new floodplain surface. Monitoring the
31 establishment of riparian vegetation would provide information necessary for
32 determining the need to control the establishment of non-native vegetation or
33 plant native vegetation to promote development of native riparian forest and scrub
34 habitats. Additionally, monitoring of covered fish species benefits provided by
35 inundation of the Deep Water Ship Channel Bypass and the Yolo Bypass (see
36 Conservation Measure FLOO1.1) under various operations would help inform
37 how to co-manage inundation of the bypasses to spatially and temporally optimize
38 benefits for covered fish species. Some additional monitoring considerations to
39 inform adaptive implementation include:

- 40 ▪ phytoplankton and zooplankton production on the inundated floodplain;
41 ▪ load of organic carbon, phytoplankton, zooplankton, and macroinvertebrates
42 exported into aquatic habitat in the Delta;
43 ▪ effects of floodplain inundation on food production and water quality in
44 downstream areas;

- 1 ▪ incidence of and magnitude of stranding of all life stages of covered fish
- 2 species;
- 3 ▪ shifts in topography over time (e.g., floodplain scouring that create surfaces
- 4 that pond deep water) that could create stranding risks for covered fish species;
- 5 ▪ effects on the relative survival, migration, and transport of covered fish species
- 6 within the mainstem Sacramento River as a function of flows diverted into the
- 7 new bypass;
- 8 ▪ effects of floodplain inundation on Delta turbidity;
- 9 ▪ habitat use by green and white sturgeon, salmon, steelhead, and other covered
- 10 fish;
- 11 ▪ levels of mercury methylation and resuspension of contaminants, and
- 12 biological uptake; and
- 13 ▪ growth and survival of rearing Sacramento splittail and Chinook salmon.

14
15 **Reversibility:** Construction of the new bypass would be very difficult to reverse
16 because of the high capital costs associated with construction of new levees and
17 construction of an operable gate(s) and associated levee modifications.

18
19 Flow-related effects of this conservation measure are considered to be easily
20 reversible because the BDCP Implementing Entity could choose not to operate the
21 gate(s). Costs related to modification of the existing levee to install an operable
22 gate(s), construction of the east bypass levee, modifications to the west Deep
23 Water Ship Channel levee (if needed), and re-grading within the new bypass,
24 however, could not be recovered. The new levee could permanently remove farm
25 land within the levee footprint if it is too costly to remove.

26
27 **Conservation Measure FLOO2.2: Restore floodplain habitat along [redacted] miles of the**
28 **San Joaquin River from Vernalis to Mossdale.** The BDCP Implementing Entity would
29 coordinate flood control planning with the Central Valley Flood Protection Board,
30 California Department of Water Resources (DWR), and U.S. Army Corps of Engineers to
31 assess the desirability and feasibility for setting back levees along the San Joaquin River
32 from Vernalis to Mossdale to restore seasonally inundated floodplain habitats for covered
33 fish species and provide flood control benefits. If results of planning studies indicate that
34 setting back levees along this reach of the San Joaquin River is desirable and feasible, the
35 BDCP Implementing Entity would enter into a cost sharing agreement with the U.S.
36 Army Corps of Engineers for project planning and construction and would assist with
37 securing Congressional authorization and funding for the project. If authorized and
38 funded, the BDCP Implementing Entity would enter into subsequent agreements with the
39 U.S. Army Corps of Engineers and other appropriate agencies governing levee and
40 floodway maintenance responsibilities.

41
42 Located within the South Delta ROA (see Figure 1), this conservation measure would
43 expand the flood capacity of the existing constricted flood control channel downstream of

1 Vernalis to Mossdale by setting back levees along the San Joaquin River to expand the
2 floodplain to allow flood waters to attenuate, improving access of juvenile fish, such as
3 Chinook salmon and steelhead, to seasonally inundated floodplain habitat, and reducing
4 flood risk to properties upstream and downstream. If implemented, restored floodplain
5 habitat along the San Joaquin River would be designed and operated to support the
6 physical and biological attributes described in Attachment A. Implementation would
7 require acquisition of lands in fee-title or through conservation easements within the
8 footprint of the expanded floodway and levees.

9
10 Floodplain habitat would be restored by setting back levees along the San Joaquin River
11 and removing all or large sections of the existing levees. The extent that levees would be
12 set back and the extent of floodplain restored would primarily be dependent on the extent
13 of restored floodplain that could be inundated under [redacted] year flood events as modeled for
14 hydrological conditions expected with climate change. Initial hydrodynamic modeling
15 under existing hydrologic conditions suggests that, on average, new floodplain habitat
16 areas could be inundated for at least 30 consecutive days from late winter to early spring
17 on average once every 5.5 years (i.e., 18% of years). The new floodplain area would be
18 contoured, if needed, to reduce and avoid the potential for stranding of juvenile and adult
19 fish following inundation events.

20 The channel within the restored floodplain reach would be modified where practicable to
21 create low velocity habitat areas designed to provide spawning habitat for splittail and
22 rearing habitat for splittail and salmonids. Within the restored floodplain, farming
23 potentially would be discontinued and riparian vegetation would be allowed to naturally
24 establish and the channel would be allowed to meander between the new levees through
25 the natural processes of erosion and sedimentation (the width of setback levees likely
26 would be too narrow to provide for both farming and the desired level of riparian habitat-
27 associated benefits).

28 If setting back levees along this reach of the San Joaquin River is not deemed desirable
29 and feasible or if funding or authorizations necessary to construct the bypass are not
30 obtained, the BDCP Implementing Entity, in coordination with Fishery Agencies, may
31 terminate this conservation measure. If terminated, remaining funding would be
32 deobligated from this conservation measure and reallocated to augment funding for other
33 effective conservation measures identified in coordination with the Fishery Agencies
34 through the BDCP adaptive management process.

35
36 **Rationale:** Flood control agencies are currently planning modifications to the
37 existing Central Valley flood control system, which provides an opportunity for
38 the BDCP Implementing Entity to coordinate with these agencies to to explore the
39 desirability and feasibility for setting back levees along this reach of the San
40 Joaquin River.

41
42 Increasing the extent of floodplain habitat by setting back levees along the San
43 Joaquin River from Vernalis to Mossdale is expected to reduce the adverse effects
44 of stressors related to food and habitat availability for the covered fish species by:

- 45 ▪ creating additional spawning habitat for Sacramento splittail by expanding

1 floodplain habitat area and providing in-channel spawning habitat by creating
2 backwaters (Sommer et al. 2001a, 2002, 2007, 2008, Moyle 2002, Moyle et al.
3 2004, Feyrer et al. 2006)

- 4 ▪ creating additional rearing habitat for San Joaquin Basin runs of Chinook
5 salmon, Sacramento splittail, and possibly steelhead (Sommer et al.2001a,b,
6 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006);
- 7 ▪ increasing the production of food for rearing salmonids, splittail, and other
8 covered species (Sommer et al. 2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle
9 et al. 2004, Feyrer et al. 2006);
- 10 ▪ increasing the availability and production of food in Delta channels downstream
11 of restored floodplain habitat for delta smelt, longfin smelt, and other covered
12 species by exporting organic material and phytoplankton, zooplankton, and
13 other organisms produced from the inundated floodplain into Delta channels
14 (Mitsch and Gosselink 2000, Moss 2007)²; and
- 15 ▪ increasing habitat complexity by allowing the natural establishment and growth
16 of woody riparian vegetation that will provide inputs of large woody debris into
17 the river channel and provide overhead cover.

18
19 In addition to providing benefits for the covered fish species, riparian habitats
20 established within the new floodplain habitat would be expected substantially
21 increase habitat for Swainson’s hawk, riparian brush rabbit, valley elderberry
22 longhorn beetle, delta button celery, and delta tule pea.

23
24 **Recommended Implementation Timeframe:** This conservation measure would
25 be implemented in the BDCP long-term implementation period to accommodate
26 the time necessary to coordinate planning with responsible agencies and local land
27 owners and to fund, plan, authorize, and permit construction of the set back levees
28 and demolition of existing levees. Planning and coordination efforts with
29 responsible agencies and local landowners, however, could be initiated in the near-
30 term implementation period. Furthermore, it would not be desirable to restore
31 floodplain in the south Delta until after completion of the around-Delta
32 conveyance facilities to minimize adverse effects of South Delta SWP and CVP
33 pumping operations on the functions of the restored habitat.

34
35 **Implementation Considerations:** Implementation considerations include:

- 36 ▪ coordination with the U.S. Army Corps of Engineers and other flood control
37 agencies to allow for 1) the removal of flood control levees and the construction
38 of new flood control levees setback from San Joaquin River;
- 39 ▪ coordination with local landowners;
- 40 ▪ designing the flood capacity of setback levees to allow for the natural
41 establishment and growth of native woody riparian vegetation;
- 42 ▪ ensuring that designs would be compatible and provide synergistic species and

1 ecosystem benefits with restoration of floodplain habitats along Old River or
2 Middle River (see Conservation Measure FLOO2.4) and freshwater tidal marsh
3 habitats in the South Delta ROA (see [Figure 1 and](#) Conservation Measure
4 FIMA1.4);

- 5 ■ potential for increasing mercury methylation and resuspension and downstream
6 transport of other contaminants;
- 7 ■ potential for short-term mobilization of toxic compounds from newly inundated
8 agricultural lands;
- 9 ■ potential for aggravating low DO in the Stockton Deep Water Ship Channel if
10 late floods produce large amounts of algae or decaying organic material that are
11 transported into the Ship Channel;
- 12 ■ opportunities for increasing the frequency of inundation of the restored
13 floodplain in future years if changes in upstream operations increase San
14 Joaquin River flows entering the Delta; and
- 15 ■ potential for increased inundation frequency and duration with future changes in
16 hydrology resulting from climate change.

17
18 **Resiliency to future changes:** [Setback levees would be designed to](#)
19 [accommodate future changes in hydrology and sea level rise and, thus, would be](#)
20 expected to be fairly resilient to future changes in [these conditions](#). With changes
21 in hydrology, the frequency of [floodplain](#) inundation would be expected to
22 increase and period of inundation could be expected to occur earlier in winter year
23 than under current conditions (Cayan et al. 2006). Sea level rise could reduce the
24 extent of inundated floodplain in downstream restored habitat area as sea level
25 rises. The lost floodplain habitat, however, would be expected to develop as tidal
26 marsh, which would produce organic carbon and organisms in support of food
27 production for covered fish species.

28
29 **Uncertainties/risks:** Methylation of mercury may occur in seasonally inundated
30 floodplains and intertidal zones, making methylmercury bioavailable to plants,
31 fish, and wildlife in and downstream of the floodplain (Alpers et al. 2006).
32 Exposure to agricultural pesticides and herbicides may impact habitat productivity
33 in the first few periods that the restored floodplain is inundated. Requirements
34 and the effectiveness of reducing the risk of stranding juvenile fish during
35 floodplain recession require further analysis.

36
37 **Monitoring and adaptive management considerations:** [\[Note to reviewers:](#)
38 [this section is a general summary; more detail will be provided in future](#)
39 [iterations.\]](#) Opportunities for adaptive management [include](#) assessing the
40 effectiveness of in-channel backwater and seasonal floodplain habitat restoration
41 designs and the ability of native riparian vegetation to successfully establish on
42 new floodplain surfaces and along the channels. Monitoring the establishment of
43 riparian vegetation would provide information necessary for determining the need
44 to control the establishment of non-native vegetation or plant native vegetation to

1 promote development of native riparian forest and scrub habitats. Monitoring of
2 restored floodplain habitats would also provide information that would be useful
3 in restoring floodplains in other locations. Some of the monitoring considerations
4 include:

- 5 ▪ phytoplankton and zooplankton production on the inundated floodplain and
6 changes in in-channel phytoplankton and zooplankton production associated
7 with increasing the complexity of in-channel habitat;
- 8 ▪ load of organic carbon, phytoplankton, zooplankton, and macroinvertebrates
9 exported into aquatic habitat in the Delta;
- 10 ▪ effects of floodplain inundation on food production and water quality in
11 downstream areas;
- 12 ▪ effects of floodplain inundation on Delta turbidity;
- 13 ▪ habitat use by green and white sturgeon, salmon, steelhead, and other covered
14 fish;
- 15 ▪ levels of mercury methylation and resuspension of contaminants, and
16 biological uptake;
- 17 ▪ covered fish species use of restored backwaters; and
- 18 ▪ growth and survival of rearing Sacramento splittail and Chinook salmon.

19
20 **Reversibility:** The restoration actions described under this conservation measure
21 would be very difficult to reverse because of the high capital costs associated with
22 construction of new levees and the removal of existing levees.
23
24

25 **Conservation Measure FLOO2.3: Restore floodplain habitat along 1.5 miles of the**
26 **San Joaquin River from Mossdale to French Camp Slough.** The BDCP
27 Implementing Entity would coordinate flood control planning with the Central Valley
28 Flood Protection Board, California Department of Water Resources (DWR), and U.S.
29 Army Corps of Engineers to assess the desirability and feasibility for setting back levees
30 along the San Joaquin River from Mossdale to French Camp Slough to restore seasonally
31 inundated floodplain habitats for covered fish species and provide flood control benefits.
32 If results of planning studies indicate that setting back levees along this reach of the San
33 Joaquin River is desirable and feasible, the BDCP Implementing Entity would enter into
34 a cost sharing agreement with the U.S. Army Corps of Engineers for project planning and
35 construction and would assist with securing Congressional authorization and funding for
36 the project. If authorized and funded, the BDCP Implementing Entity would enter into
37 subsequent agreements with the U.S. Army Corps of Engineers and other appropriate
38 agencies governing levee and floodway maintenance responsibilities.
39

40 Located within the South Delta ROA (see Figure 1), this conservation measure would
41 increase seasonally inundated floodplain habitat and expand the flood capacity of the
42 existing flood control channel downstream of Mossdale to French Camp Slough by

1 setting back levees along the San Joaquin River. Restored floodplain habitat would be
2 designed and operated to support the physical and biological attributes described in
3 Attachment A. Implementation would require acquisition of lands in fee-title or through
4 conservation easements within the footprint of the expanded floodway and levees.

5
6 Floodplain habitat would be restored by setting back levees along the San Joaquin River
7 and removing all or large sections of the existing levees. The extent to which levees
8 would be setback and the extent of floodplain habitat restored would primarily be
9 dependent on the extent of restored floodplain that could be inundated under [redacted] year
10 flood events as modeled for hydrological conditions expected with climate change and
11 land surface elevations. The new floodplain area would be contoured, if needed, to
12 reduce and avoid the potential for stranding of juvenile and adult fish following
13 inundation events. Ground surface elevations along tidal reaches may need to be elevated
14 to allow natural establishment of tidal freshwater wetland and riparian habitat.
15 The channel within the restored floodplain reach would be modified where practicable to
16 create lower velocity habitat areas designed to provide spawning habitat for splittail and
17 rearing habitat for splittail and salmonids. Within the restored floodplain, farming
18 potentially would be discontinued and riparian vegetation would be allowed to naturally
19 establish and the channel would be allowed to meander between the new levees through
20 the natural processes of erosion and sedimentation (the width of setback levees likely
21 would be too narrow to provide for both farming and the desired level of riparian habitat-
22 associated benefits).

23
24 If setting back levees along this reach of the San Joaquin River is not deemed desirable
25 and feasible or if funding or authorizations necessary to construct the bypass are not
26 obtained, the BDCP Implementing Entity, in coordination with Fishery Agencies, may
27 terminate this conservation measure. If terminated, remaining funding would be
28 deobligated from this conservation measure and reallocated to augment funding for other
29 effective conservation measures identified in coordination with the Fishery Agencies
30 through the BDCP adaptive management process.

31
32 **Rationale:** Flood control agencies are currently planning modifications to the
33 existing Central Valley flood control system, which provides an opportunity for
34 the BDCP Implementing Entity to coordinate with these agencies to to explore the
35 desirability and feasibility for setting back levees along this reach of the San
36 Joaquin River.

37
38 Increasing the extent of floodplain habitat by setting back levees along the San
39 Joaquin River from Mossdale to French Camp Slough is expected to reduce the
40 adverse effects of stressors related to food and habitat availability for the covered
41 fish species by:

- 42 ▪ creating additional spawning habitat for Sacramento splittail by expanding
43 floodplain habitat area and providing in-channel spawning habitat by creating
44 backwaters (Sommer et al. 2001a, 2002, 2007, 2008, Moyle 2002, Moyle et al.
45 2004, Feyrer et al. 2006)

- 1 ▪ creating additional rearing habitat for San Joaquin Basin runs of Chinook
2 salmon, Sacramento splittail, and possibly steelhead (Sommer et al.2001a,b,
3 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006);
- 4 ▪ increasing the production of food for rearing salmonids, splittail, and other
5 covered species (Sommer et al. 2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle
6 et al. 2004, Feyrer et al. 2006);
- 7 ▪ increasing the availability and production of food in Delta channels downstream
8 of restored floodplain habitat for delta smelt, longfin smelt, and other covered
9 species by exporting organic material and phytoplankton, zooplankton, and
10 other organisms produced from the inundated floodplain into Delta channels
11 (Mitsch and Gosselink 2000, Moss 2007)²; and
- 12 ▪ increasing habitat complexity by allowing the natural establishment and growth
13 of woody riparian vegetation that will provide inputs of large woody debris into
14 the river channel and provide overhead cover.

15
16 In addition to providing benefits for the covered fish species, riparian habitats
17 established within the new floodplain habitat along the San Joaquin River would
18 be expected substantially increase habitat for Swainson's hawk, riparian brush
19 rabbit, valley elderberry longhorn beetle, delta button celery, and delta tule pea.
20

21 **Recommended Implementation Timeframe:** This conservation measure would
22 be implemented in the BDCP long-term implementation period to accommodate
23 the time necessary to coordinate planning with responsible agencies and local land
24 owners and to fund, plan, authorize, and permit construction of the set back levees
25 and demolition of existing levees. Planning and coordination efforts with
26 responsible agencies and local landowners, however, could be initiated in the near-
27 term implementation period. Furthermore, it would not be desirable to restore
28 floodplain in the south Delta until after completion of the around-Delta
29 conveyance facilities to minimize adverse effects of South Delta SWP and CVP
30 pumping operations on the functions of the restored habitat.
31

32 **Implementation Considerations:** Implementation considerations include:

- 33 ▪ coordination with the U.S. Army Corps of Engineers and other flood control
34 agencies to allow for the removal of flood control levees and the construction of
35 new flood control levees setback from San Joaquin River;
- 36 ▪ coordination with local landowners;
- 37 ▪ designing the flood capacity of new floodplains to allow for the natural
38 establishment and growth of native woody riparian vegetation;
- 39 ▪ ensuring that designs would be compatible and provide synergistic species and
40 ecosystem benefits with restoration of floodplain habitats along Old River or
41 Middle River (see Conservation Measure FLOO2.4) and freshwater tidal marsh
42 habitats in the South Delta ROA (see Figure 1 and Conservation Measure
43 FIMA1.4);

- 1 ▪ potential for increasing mercury methylation and resuspension and downstream
2 transport of other contaminants;
- 3 ▪ potential for short-term mobilization of toxic compounds from newly inundated
4 agricultural lands;
- 5 ▪ potential for aggravating low dissolved oxygen in the Stockton Deep Water Ship
6 Channel if late floods produce large amounts of algae or decaying organic
7 material that are transported into the Ship Channel;
- 8 ▪ opportunities for designing the floodway to increase the tidal prism such that
9 tidal velocities and mixing are increased sufficiently to improve dissolved
10 oxygen levels in the Stockton Deep Water Ship Channel;
- 11 ▪ opportunities for increasing the frequency of inundation of the restored
12 floodplain in future years if changes in upstream operations increase San
13 Joaquin River flows entering the Delta; and
- 14 ▪ potential for increased inundation frequency and duration with future changes in
15 hydrology resulting from climate change.

16
17 **Resiliency to future changes:** Setback levees would be designed to
18 accommodate future changes in hydrology and sea level rise and, thus, would be
19 expected to be fairly resilient to future changes in these conditions. With changes
20 in hydrology, the frequency of floodplain inundation would be expected to
21 increase and period of inundation could be expected to occur earlier in winter year
22 than under current conditions (Cayan et al. 2006). Sea level rise could reduce the
23 extent of inundated floodplain in downstream restored habitat area as sea level
24 rises. The lost floodplain habitat, however, would be expected to develop as tidal
25 marsh, which would produce organic carbon and organisms in support of food
26 production for covered fish species. Proposed restored tidal marsh upstream of
27 Stockton would be expected to establish further upstream in the floodplain as sea
28 level rises.

29
30 **Uncertainties/risks:** Methylation of mercury may occur in seasonally inundated
31 floodplains and intertidal zones, making methylmercury bioavailable to plants,
32 fish, and wildlife in and downstream of the floodplain (Alpers et al. 2006).
33 Exposure to agricultural pesticides and herbicides may impact habitat productivity
34 in the first few periods that the restored floodplain is inundated. Requirements
35 and the effectiveness of reducing the risk of stranding juvenile fish during
36 floodplain recession require further analysis.

37
38 **Monitoring and adaptive management considerations:** *[Note to reviewers:*
39 *this section is a general summary; more detail will be provided in future*
40 *iterations.] Opportunities for adaptive management include assessing the*
41 *effectiveness of in-channel backwater and seasonal floodplain habitat restoration*
42 *designs and the ability of native riparian vegetation to successfully establish on*
43 *new floodplain surfaces and along the channels. Monitoring the establishment of*
44 *riparian vegetation would provide information necessary for determining the need*

1 to control the establishment of non-native vegetation or plant native vegetation to
2 promote development of native riparian forest and scrub habitats. Monitoring of
3 restored floodplain habitats would also provide information that would be useful
4 in restoring floodplains in other locations. Some of the monitoring considerations
5 include:

- 6 ■ phytoplankton and zooplankton production on the inundated floodplain and
7 changes in in-channel phytoplankton and zooplankton production associated
8 with increasing the complexity of in-channel habitat;
- 9 ■ load of organic carbon, phytoplankton, zooplankton, and macroinvertebrates
10 exported into aquatic habitat in the Delta;
- 11 ■ effects of floodplain inundation on food production and water quality in
12 downstream areas;
- 13 ■ effects of floodplain inundation on Delta turbidity;
- 14 ■ habitat use by green and white sturgeon, salmon, steelhead, and other covered
15 fish;
- 16 ■ levels of mercury methylation and resuspension of contaminants, and
17 biological uptake;
- 18 ■ covered fish species use of restored backwaters; and
- 19 ■ growth and survival of rearing Sacramento splittail and Chinook salmon.

20
21 **Reversibility:** The restoration actions described under this conservation measure
22 would be very difficult to reverse because of the high capital costs associated with
23 construction of new levees and the removal of existing levees.

24
25 **Conservation Measure FLOO2.4: Restore between [] and [] acres of inundated**
26 **floodplain habitat in the South Delta Restoration Opportunity Area.** Within the
27 South Delta ROA (see Figure 1), inundated floodplain habitat would be restored on
28 Fabian Tract along Old River or on Union Island and Upper Roberts Island along Middle
29 River. The location of restored floodplain habitat would depend on the location and
30 design of the selected conveyance pathway and operations for the through-Delta
31 component of the dual conveyance facility. Floodplain habitat would be restored along
32 the river that would provide the most substantial species and ecosystem benefits with the
33 selected through-Delta conveyance configuration. Restored floodplain habitat would be
34 designed and operated to support the physical and biological attributes described in
35 Attachment A.

36
37 Design elements of this conservation measure could include:

- 38 ■ acquisition of lands in fee-title or through conservation easements suitable for
39 restoration of intertidal and subtidal habitats and for accommodating future sea
40 level rise;

- 1 ▪ setting back levees along the selected river corridor and removing the existing
- 2 levees or large sections of the existing levees;
- 3 ▪ discontinuing farming within the setback levees and allowing riparian vegetation
- 4 to naturally establish on the floodplain; and
- 5 ▪ re-contouring the restored floodplain surface, if needed, to avoid potential for
- 6 stranding of juvenile and adult fish following inundation events.

7
8 **Rationale:** Increasing the extent of floodplain habitat is expected to reduce the
9 adverse effects of stressors related to food and habitat availability for the covered
10 fish species by:

- 11 ▪ creating additional spawning habitat for Sacramento splittail by expanding
- 12 floodplain habitat area (Sommer et al.2001a, 2002, 2007, 2008, Moyle 2002,
- 13 Moyle et al. 2004, Feyrer et al. 2006);
- 14 ▪ creating additional rearing habitat for Sacramento splittail, runs of Chinook
- 15 salmon from the San Joaquin River and other eastside tributaries, and possibly
- 16 steelhead (Sommer et al.2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle et al.
- 17 2004, Feyrer et al. 2006);
- 18 ▪ increasing the production of food for rearing salmonids, splittail, and other
- 19 covered species (Sommer et al. 2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle
- 20 et al. 2004, Feyrer et al. 2006);
- 21 ▪ increasing the availability and production of food in the Delta downstream of
- 22 restored floodplain habitat for delta smelt, longfin smelt, and other covered
- 23 species by exporting organic material and phytoplankton, zooplankton, and
- 24 other organisms produced from the inundated floodplain into the Delta (Mitsch
- 25 and Gosselink 2000, Moss 2007)²; and
- 26 ▪ increasing hydrodynamic and structural complexity within the channel by
- 27 allowing the natural establishment and growth of woody riparian vegetation that
- 28 would provide inputs of large woody debris into the river channel and provide
- 29 overhead cover.

30 Improving in-channel habitat complexity along the Old or Middle River corridors
31 would be expected to reduce the predation risk to covered fish species and improve
32 connectivity between San Joaquin River habitats and Delta habitats for passage of
33 juvenile salmonids outmigrating from the San Joaquin River and eastside
34 tributaries.

35 In addition to providing benefits for the covered fish species, restored riparian
36 habitats associated with creating new floodplain habitat in the South Delta ROA
37 (see Figure 1) would be expected to substantially increase habitat for Swainson's
38 hawk, riparian brush rabbit, valley elderberry longhorn beetle, delta button celery,
39 and delta tule pea.

40
41 **Recommended Implementation Timeframe:** This conservation measure would

1 not be implemented until after completion of the around-Delta conveyance
2 facilities to minimize adverse affects of South Delta SWP/CVP pumping
3 operations on the functions of the restored habitat. Restoration planning and
4 design could be initiated in the near-term implementation period.
5

6 **Implementation Considerations:** Implementation considerations include:

- 7 ■ selecting the location for floodplain restoration (Fabian Tract, Union Island, or
8 Middle Roberts Island) is dependent on the through-Delta corridor (i.e., Old
9 River or Middle River, or both rivers) selected for dual operations and therefore
10 the relative influence of South Delta SWP/CVP pumping operations on the
11 restored habitat;
- 12 ■ coordination with the Department of Water Resources and local reclamation
13 districts to allow for the removal of flood control levees and the construction of
14 new flood control levees setback from the selected river corridor;
- 15 ■ designing the flood capacity of new floodplains to allow for the natural
16 establishment and growth of native woody riparian vegetation;
- 17 ■ ensuring that designs would be compatible and provide synergistic species and
18 ecosystem benefits with restoration of floodplain habitats along the San Joaquin
19 River (see Conservation Measure FLOO2.1) and freshwater intertidal marsh
20 habitats in the South Delta ROA (see Figure 1 and Conservation Measure
21 FIMA1.4);
- 22 ■ potential for increasing mercury methylation;
- 23 ■ potential for short-term mobilization of toxic compounds from newly inundated
24 lands;
- 25 ■ the likelihood that restoration of habitat could increase entrainment risk for
26 covered fish species at the SWP and CVP pumping facilities;
- 27 ■ the likelihood that substantial proportions of food and organic material exported
28 from restored floodplains would be entrained at the SWP and CVP pumping
29 facilities;
- 30 ■ opportunities for increasing the frequency of inundation of the restored
31 floodplain in future years if changes in upstream operations increase San
32 Joaquin River flows entering the Delta; and
- 33 ■ potential for increased inundation frequency with future changes in hydrology
34 resulting from climate change.

35
36 **Resiliency to future changes:** This conservation measure is expected to be
37 somewhat resilient to future changes in the hydrograph and sea level. With
38 changes in the hydrograph, the frequency of inundation would be expected to
39 increase and inundation could occur earlier in the year than under current
40 conditions (Cayan et al. 2006). Sea level rise could reduce the extent of inundated
41 floodplain in downstream restoration areas. The floodplain habitat inundated by

1 sea level rise, however, would be expected to develop into tidal marsh, which
2 would produce organic carbon and organisms in support of food production for
3 covered fish species.

4
5 **Uncertainties/risks:** Methylation of mercury may occur in seasonally inundated
6 floodplains and intertidal zones, making methylmercury bioavailable to plants,
7 fish, and wildlife in and downstream of the floodplain (Alpers et al. 2006).
8 Exposure to residual agricultural pesticides and herbicides may impact habitat
9 productivity in the first few periods that the restored floodplain is inundated. It is
10 uncertain whether or not flows sufficient to inundated restored floodplain habitats
11 would be of sufficient magnitude to provide substantial benefits for covered fish
12 species during periods floodplains are inundated and the SWP and CVP pumping
13 facilities are in operation.

14
15 **Monitoring and adaptive management considerations:** [Note to reviewers:
16 this section is a general summary; more detail will be provided in future
17 iterations.] Opportunities for adaptive management are related to assessing the
18 effectiveness of restored floodplain to develop as functional habitat for covered
19 species and to produce food and organic material in support of food web
20 processes. Adaptive management considerations include assessing the need for
21 further actions to improve species benefits if indicated through monitoring (e.g.,
22 control of non-native fish predators if survival of outmigrating salmonids using
23 the corridor is not improved). Monitoring the establishment of riparian vegetation
24 on the restored floodplains and along the channel would also provide information
25 useful to restoring floodplains in other locations. Some of the monitoring
26 considerations include:

- 27 ■ phytoplankton and zooplankton production on the inundated floodplain and
28 changes in in-channel phytoplankton and zooplankton production associated
29 with increasing the complexity of in-channel habitat;
- 30 ■ load of organic carbon, phytoplankton, zooplankton, and macroinvertebrates
31 exported into aquatic habitat in the Delta;
- 32 ■ natural establishment and growth of riparian vegetation;
- 33 ■ effects of floodplain inundation on food production and water quality in
34 downstream areas;
- 35 ■ effects of floodplain inundation of Delta turbidity;
- 36 ■ habitat use by green and white sturgeon, salmon, and other covered fish
37 species;
- 38 ■ levels of mercury methylation and biological uptake; and
- 39 ■ growth and survival of rearing Sacramento splittail and Chinook salmon.

40
41 **Reversibility:** This conservation measure would be difficult to reverse because

1 of the high capital costs associated with construction of new levees and the
2 removal of existing levees.

3 4 5 **Freshwater Intertidal Marsh Habitat Restoration** 6 **Conservation Measures**

7
8 **Conservation Measure FIMA1.1. Restore a mosaic of [redacted] to [redacted] acres of freshwater**
9 **intertidal marsh, shallow subtidal aquatic, and transitional grassland habitat within**
10 **the Yolo Bypass/Cache Slough Complex Restoration Opportunity Area.** Restored
11 freshwater intertidal marsh and shallow subtidal aquatic habitats would be designed to
12 support the physical and biological attributes described in Attachment A. The mosaic of
13 habitats would include at least [redacted] acres of freshwater intertidal marsh habitat. Areas
14 suitable for restoration include, but are not limited to, Haas Slough, Hastings Cut,
15 Lindsey Slough, Barker Slough, Calhoun Cut, Liberty Island, Little Holland, the
16 Westlands property, Shag Slough, Little Egbert Tract, and Prospect Island. Design
17 elements of this conservation measure could include:

- 18 ▪ acquisition of lands in fee-title or through conservation easements suitable for
19 restoration of intertidal and subtidal habitats and for accommodating future sea
20 level rise;
- 21 ▪ breaching levees to provide for tidal exchange with lands being restored and
22 construction of new levees to provide flood protection for adjacent landowners
23 as appropriate;
- 24 ▪ modifying ditches and cuts to encourage the development of a dendritic system
25 of tidal channels based on local hydrology, sized appropriately for the tidal
26 prism being conveyed;
- 27 ▪ restoring stream functions of erosion and sedimentation (e.g., Ulatis Flood
28 Control channel) to improve spawning conditions for delta smelt and other fish
29 and macroinvertebrates; and
- 30 ▪ planting tules before breaching levees to raise ground surface elevations
31 suitable for tidal marsh restoration on subsided lands (e.g., Little Egbert Tract).

32
33 **Rationale:** Restoring freshwater intertidal marsh and shallow subtidal aquatic
34 habitats within the Cache Slough Complex is expected to reduce the adverse
35 effects of stressors related to food availability and habitat availability for the
36 covered fish species by:

- 37 ▪ increasing rearing habitat area for Chinook salmon, Sacramento splittail, and
38 possibly steelhead (Healey 2001, Brown 2003);
- 39 ▪ increasing the production of food for rearing salmonids, splittail, and other
40 covered species (Kjelson et al. 1982, Siegel 2007);
- 41 ▪ increasing the availability and production of food in the Delta downstream of
42 Rio Vista by exporting organic material from the marsh plain and

1 phytoplankton, zooplankton, and other organisms produced in intertidal
2 channels into the Delta (Siegel 2007);

- 3 ■ locally providing areas of cool water refugia for delta smelt (C. Enright pers.
4 comm.);
- 5 ■ increasing the extent of habitat available for colonization by Mason's lilaeopsis;
6 and
- 7 ■ increasing the extent of habitat for giant garter snake, California black rail, and
8 tricolored blackbird.

9
10 Additionally, the Cache Slough Complex encompasses a substantial area of land
11 with elevations suitable for freshwater tidal marsh restoration that would involve
12 few impacts on infrastructure or permanent crops relative to other areas of the
13 north Delta.

14
15 **Recommended Implementation Timeframe:** It is anticipated that
16 implementation of this conservation measure could be initiated in the BDCP near-
17 term implementation period.

18
19 **Implementation Considerations:** Implementation considerations include:

- 20 ■ the need to coordinate with the Solano County HCP to ensure effective
21 implementation of conservation measures under both programs;
- 22 ■ feasibility for subsidence reversal using tule plantings or other techniques to
23 raise ground surface elevations before breaching levees;
- 24 ■ ensuring compatibility with flood control functions of the Yolo Bypass;
- 25 ■ ensuring that designs would be compatible and provide synergistic species
26 and ecosystem benefits with proposed restoration of floodplain habitats in
27 the Yolo Bypass and a new Deep Water Ship Channel Bypass as described
28 under Conservation Measures FLOO1.1 and FLOO2.1, respectively;
- 29 ■ coordination with land owners, the Lower Yolo Bypass Planning Forum,
30 and other conservation planning efforts;
- 31 ■ the need to incorporate design features and management strategies to
32 preclude or minimize the establishment of *Egeria* and other undesirable
33 non-native species;
- 34 ■ the need to incorporate design features that will promote the natural
35 establishment of marsh-associated covered plant species;
- 36 ■ consideration for the effects of restoration-induced dampening of the tidal
37 range on subsequent marsh restoration designs;
- 38 ■ potential for increasing mercury methylation and resuspension of
39 contaminants;

- 1 ▪ locating and designing levee breaches to maximize the development of
- 2 intertidal marsh and minimize hydrodynamic conditions that favor non-
- 3 native predatory fish;
- 4 ▪ potential effects on existing populations of covered plant species;
- 5 ▪ determining the appropriate allowable land uses and management activities
- 6 on transitional grasslands conserved to accommodate future sea level rise;
- 7 and
- 8 ▪ the need to address the likely adverse effects of the Barker Slough Pumping
- 9 Plant intake on entrainment of food produced from and fish inhabiting
- 10 restored marshes before restoring habitats south of Lindsey Slough.

11
12 **Resiliency to future changes:** This conservation measure is expected to be
13 resilient to future changes in hydrology and sea levels. Conserving higher
14 elevation transitional grassland habitat along the margins of restored intertidal
15 marsh would provide sufficient lands to accommodate the upslope establishment
16 of intertidal marsh as sea level rises.

17
18 **Uncertainties/risks:** Restoration of subtidal aquatic habitats could result in
19 infestation by non-native submerged aquatic vegetation and increase the
20 abundance of non-native predators or vulnerability of covered fish species to
21 predation. Methylation of mercury may occur in intertidal zones, making
22 methylmercury bioavailable to plants, fish, and wildlife in and downstream of
23 restored marshes (Alpers et al. 2006). It is uncertain if altering habitat conditions
24 in this area could adversely affect delta smelt spawning in this area if salinity
25 gradients, turbidity, or temperature conditions that support delta smelt habitat are
26 degraded as a result of restoration actions. Additionally, there could be a short-
27 term risk associated with mobilizing pesticides, herbicides, and other
28 contaminants into the Delta following initial introduction of tidal flow onto
29 agricultural lands.

30
31 **Monitoring and adaptive management considerations:** [Note to reviewers:
32 this section is a general summary; more detail will be provided in future
33 iterations.] Opportunities for adaptive management are related to assessing the
34 effectiveness of restored marshes and adjacent shallow subtidal habitats to
35 develop as functional covered species habitats and to produce food and organic
36 carbon in support of food web processes. Results of monitoring the development
37 of early marsh restorations would help inform improvements in the design and
38 management of subsequent marsh restoration projects. Results of monitoring
39 early restorations could also be used to develop cost effective management
40 techniques, if needed, to control the establishment of non-native species in
41 restored marshes. Some of the monitoring considerations include:

- 42 ▪ type and extent of use by covered fishes;
- 43 ▪ extent of phytoplankton, zooplankton, and macroinvertebrate production in
- 44 marsh channels;

- 1 ▪ load of organic carbon, phytoplankton, zooplankton, and macroinvertebrates
- 2 produced in emergent marshes and subsequently exported into the Delta;
- 3 ▪ extent of native vegetation relative to non-native vegetation on the marsh plain;
- 4 ▪ extent of native aquatic vegetation relative to non-native aquatic vegetation;
- 5 ▪ growth and survival of rearing Sacramento splittail and Chinook salmon in
- 6 shallow subtidal aquatic habitats;
- 7 ▪ change in abundance of non-native predatory fish species;
- 8 ▪ ongoing use of the Cache Slough complex by spawning delta smelt;
- 9 ▪ the establishment of habitat conditions suitable for the natural establishment of
- 10 marsh-associated covered plant species; and
- 11 ▪ levels of mercury methylation and biological uptake.

12
13 **Reversibility:** This conservation measure would be difficult to reverse because it
14 would require re-construction of levees to re-isolate restored habitat areas from
15 tidal flow and pumping to remove water from reclaimed habitat areas.

16
17 **Conservation Measure FIMA1.2: Restore a mosaic of [redacted] to [redacted] acres of freshwater**
18 **intertidal marsh, shallow subtidal aquatic, and transitional habitat within the**
19 **Cosumnes/Mokelumne ROA.** Restored freshwater intertidal marsh and shallow
20 subtidal aquatic habitats would be designed to support the physical and biological
21 attributes described in Attachment A. The mosaic of habitats would include at least [redacted]
22 acres of freshwater intertidal marsh habitat. Areas suitable for restoration within the
23 Cosumnes/Mokelumne ROA (see Figure 1) include McCormack-Williamson Tract, New
24 Hope Tract, Canal Ranch Tract, Bract Tract, Terminous Tract north of State Highway 12,
25 and lands adjoining Snodgrass Slough, South Stone Lake, and Lost Slough. Design
26 elements of this conservation measure could include:

- 27 ▪ acquisition of lands in fee-title or through conservation easements suitable for
- 28 restoration of intertidal and subtidal habitats and for accommodating future sea
- 29 level rise;
- 30 ▪ constructing levees to isolate deeply subsided lands and protect private
- 31 property;
- 32 ▪ planting tules or placing fill material to raise elevations of shallowly subsided
- 33 lands,
- 34 ▪ creating channels to promote the development of tidal channels; and
- 35 ▪ breaching levees to reintroduce tidal exchange to currently leveed lands.

36 If the eastern alignment of an around-Delta conveyance facility is constructed, the canal
37 levees may be incorporated into the design of intertidal emergent wetland restoration.
38 For example, in locations where the conveyance canal is located at elevations at or below
39 elevations suitable for restoration of intertidal marsh, marsh may be restored to the east of
40 canal levee, with the canal levee forming the western boundary of the restored marsh.

1
2 **Rationale:** Restoring freshwater intertidal marsh and shallow subtidal aquatic
3 habitats within the Cosumnes/Mokelumne River ROA ([see Figure 1](#)) is expected to
4 reduce the adverse effects of stressors related to food and habitat availability for
5 the covered fish species by:

- 6 ▪ increasing rearing habitat area for Sacramento splittail and Cosumnes and
7 Mokelumne River fall-run Chinook salmon and possibly steelhead (Healey
8 2001, Brown 2003);
- 9 ▪ increasing the production of food for rearing salmonids, splittail, and other
10 [covered](#) species migrating to and from the Cosumnes and Mokelumne Rivers
11 (Kjelson et al. 1982, Siegel 2007);
- 12 ▪ increasing the availability and production of food in the east and central Delta
13 by exporting organic material from the marsh plain and phytoplankton,
14 zooplankton, and other organisms produced in intertidal channels into the Delta
15 (Siegel 2007);
- 16 ▪ locally providing areas of cool water refugia for delta smelt (C. Enright pers.
17 comm.);
- 18 ▪ increasing the extent of habitat available for colonization by Mason's lilaeopsis,
19 and
- 20 ▪ increasing the extent of habitat for giant garter snake, California black rail, and
21 tricolored blackbird.

22
23 **Recommended Implementation Timeframe:** [Restoration of marsh could be](#)
24 [initiated during the BDCP near-term implementation period at locations within this](#)
25 [ROA that would not be affected by or would be dependent on construction of an](#)
26 [around-Delta conveyance facility \(e.g., McCormack-Williamson Tract\). Locations](#)
27 [for marsh restoration within this ROA that would be affected by or would be](#)
28 [dependent on construction of an around-Delta conveyance facility would be](#)
29 [implemented in the the BDCP long-term implementation period.](#)
30

31 **Implementation Considerations:** Implementation considerations include:

- 32 ▪ the feasibility for subsidence reversal using tule plantings or other
33 technique to raise ground surface elevations before breaching levees;
- 34 ▪ ensuring compatibility with flood control functions of north Delta levees
35 and channels (e.g., McCormack-Williamson Tract);
- 36 ▪ restoration effects on upstream and downstream flood risk;
- 37 ▪ the need to incorporate design features and management strategies to
38 preclude or minimize the establishment of non-native submerged aquatic
39 vegetation and other undesirable non-native species;

- 1 ▪ locating and designing levee breaches to maximize the development of
2 intertidal marsh and minimize hydrodynamic conditions that favor non-
3 native predatory fish;
- 4 ▪ the need to incorporate design features that will promote the natural
5 establishment of marsh-associated covered plant species;
- 6 ▪ consideration for the effects of restoration-induced dampening of the tidal
7 range on subsequent marsh restoration designs;
- 8 ▪ potential for increasing mercury methylation and resuspension of
9 contaminants;
- 10 ▪ compatibility with the footprint and facilities associated with an around-
11 Delta conveyance facility;
- 12 ▪ determining appropriate allowable land uses and management activities on
13 transitional grasslands conserved to accommodate future sea level rise;
- 14 ▪ securing fee title or easements for implementing restoration; and
15 ▪ designing habitat restorations to protect privately owned lands within the
16 ROA.

17
18 **Resiliency to future changes:** This conservation measure is expected to be fairly
19 resilient to future changes in hydrology and sea levels. Conserving higher
20 elevation transitional grassland habitats along the margins of restored marsh will
21 provide sufficient lands to accommodate the upslope establishment of intertidal
22 marsh as sea level rises. If the alignment of an around-Delta conveyance facility
23 is upslope of restored habitats, however, the area available for accommodating sea
24 level rise may be constrained.

25
26 **Uncertainties/risks:** Restoration of subtidal aquatic habitats could result in
27 infestation of non-native submerged aquatic vegetation and increase the
28 abundance of non-native predators or vulnerability of covered fish species to
29 predation. Methylation of mercury may occur in intertidal zones, making
30 methylmercury bioavailable to plants, fish, and wildlife in and downstream of
31 restored marshes (Alpers et al. 2006). Additionally, there could be a short-term
32 risk associated with mobilizing pesticides, herbicides, and other contaminants into
33 the Delta following initial introduction of tidal flow onto agricultural lands.

34
35 **Monitoring and adaptive management considerations:** [Note to reviewers:
36 this section is a general summary; more detail will be provided in future
37 iterations.] Opportunities for adaptive management are related to assessing the
38 effectiveness of restored marshes to develop as functional covered species
39 habitats and to produce food and organic carbon in support of food web processes.
40 Results of monitoring the development of early marsh restorations would help
41 inform improvements in the design and management of subsequent marsh
42 restorations. Results of monitoring early restoration projects could also be used to

- 1 develop cost effective management techniques, if needed, to control the
2 establishment of non-native species in restored marshes. Some of the monitoring
3 considerations include:
- 4 ▪ type and extent of use by covered fishes;
 - 5 ▪ extent of phytoplankton, zooplankton, and macroinvertebrate production in
6 marsh channels;
 - 7 ▪ load of organic carbon, phytoplankton, zooplankton, and macroinvertebrates
8 produced in marshes and subsequently exported into the Delta;
 - 9 ▪ extent of native vegetation relative to non-native vegetation on the marsh plain;
 - 10 ▪ extent of native aquatic vegetation relative to non-native aquatic vegetation;
 - 11 ▪ change in abundance of non-native predatory fish species;
 - 12 ▪ growth and survival of rearing Sacramento splittail and Chinook salmon in
13 shallow subtidal aquatic habitats;
 - 14 ▪ the establishment of habitat conditions suitable for the natural establishment of
15 marsh-associated covered plant species; and
 - 16 ▪ levels of mercury methylation and biological uptake.

17
18 **Reversibility:** This conservation measure would be difficult to reverse because it
19 would require construction of new levees to re-isolate restored habitat areas from
20 tidal flow and pumping to remove water from reclaimed habitat areas.

21
22 **Conservation Measure FIMA1.3: Restore a mosaic of [redacted] to [redacted] acres of intertidal**
23 **marsh and shallow subtidal aquatic habitat within the West Delta Restoration**
24 **Opportunity Area.** Restored freshwater intertidal marsh and shallow subtidal aquatic
25 habitats would be designed to support the physical and biological attributes described in
26 Attachment A. The mosaic of habitats would include at least [redacted] acres of freshwater
27 intertidal marsh habitat. Areas suitable for restoration include Decker Island, portions of
28 Sherman Island, Jersey Island, Bradford Island, Twitchell Island, and Brannon Island,
29 and along portions of the north bank of the Sacramento River where elevations and
30 substrates are suitable. The purpose of restoring intertidal marsh in the west Delta is to
31 provide a continuous corridor of habitat and food productivity linking current and future
32 restored habitat in the Cache Slough Complex with habitat in Suisun Marsh and Bay and
33 to provide intertidal marsh habitat within the anticipated future eastward position of the
34 low salinity zone with sea level rise.

35
36 Design elements of this conservation measure are anticipated to include:
37

- 1 ▪ placing fill material on shallowly subsided restoration sites to raise land
 - 2 surfaces to elevations suitable for restoration of intertidal marsh³;
 - 3 ▪ planting tules, or other techniques, to raise ground surface elevations suitable
 - 4 for intertidal marsh restoration on shallowly subsided portions of islands and
 - 5 breaching levees when target elevations are achieved;
 - 6 ▪ breaching and setting back levees to provide for tidal exchange with restored
 - 7 habitats; and
 - 8 ▪ excavating channels and/or creating berms to encourage the development of
 - 9 dendritic channel networks within restored marshes.
- 10
- 11 **Rationale:** Restoring freshwater intertidal marsh and shallow subtidal aquatic
- 12 habitats is expected to reduce the adverse effects of stressors related to food and
- 13 habitat availability for the covered species by:
- 14 ▪ increasing rearing habitat area for Chinook salmon, Sacramento splittail, and
 - 15 possibly steelhead (Healey 2001, Brown 2003);
 - 16 ▪ improving future habitat areas for delta smelt and longfin smelt within the
 - 17 anticipated eastward movement of the low salinity zone with sea level rise;
 - 18 ▪ increasing the production of food for rearing salmonids, splittail, and other
 - 19 covered species (Kjelson et al. 1982; Siegel 2007);
 - 20 ▪ increasing the availability and production of food in the western Delta and
 - 21 Suisun Bay by exporting organic material via tidal flow from the marsh plain
 - 22 and organic carbon, phytoplankton, zooplankton, and other organisms produced
 - 23 in intertidal channels into the Delta (Siegel 2007);
 - 24 ▪ locally providing areas of cool water refugia for delta smelt (C. Enright pers.
 - 25 comm.);
 - 26 ▪ increasing the extent of habitat available for colonization by Mason’s lilaeopsis;
 - 27 and
 - 28 ▪ increasing the extent of habitat for California black rail and tricolored blackbird.
- 29 Lands within the West Delta ROA (see Figure 1) represent the only location to
- 30 implement intertidal marsh restorations within the anticipated future location of
- 31 the low salinity zone with sea level rise. A substantial proportion of the suitable
- 32 restoration sites in this area are in public ownership.
- 33
- 34 **Recommended Implementation Timeframe:** This conservation measure could
- 35 be initiated in the BDCP near-term implementation period and continue to be
- 36 implemented over the term of the BDCP as restoration opportunities are identified.
- 37

³ Sources of fill material could include dredge material from ongoing dredging operations and dredge spoils and sand deposits on Decker Island, Brannon Island, and other nearby suitable sites.

- 1 **Implementation Considerations:** Implementation considerations include:
- 2 ▪ the availability of suitable fill material and feasibility for subsidence reversal;
- 3 ▪ consideration for the effects of restoration-induced dampening of the tidal
- 4 range on subsequent marsh restoration designs and local tidal
- 5 hydrodynamics;
- 6 ▪ the need to design levees and provide elevations suitable to accommodate
- 7 future sea level rise;
- 8 ▪ locating and designing levee breaches to maximize the development of
- 9 intertidal marsh and minimize hydrodynamic conditions that favor non-native
- 10 predatory fish;
- 11 ▪ coordination with Delta levee programs to ensure that restored habitats are
- 12 protected from adverse effects that could be associated with future levee
- 13 failures;
- 14 ▪ determining the appropriate allowable land uses and management activities
- 15 on transitional grasslands conserved to accommodate future sea level rise;
- 16 ▪ the need to incorporate design features and management strategies to
- 17 preclude or minimize the establishment and abundance of undesirable non-
- 18 native species;
- 19 ▪ potential for increasing mercury methylation and resuspension of
- 20 contaminants;
- 21 ▪ the need to incorporate design features that will promote the natural
- 22 establishment of marsh-associated covered plant species; and
- 23 ▪ the likelihood for removal of food produced from restored intertidal marshes
- 24 by non-native clams.

25

26 **Resiliency to future changes:** The resiliency of this conservation measure to

27 accommodate future sea level rise is limited because of the extent of subsidence

28 in the west Delta. It is expected, however, that, **to the extent practicable,**

29 restoration designs would incorporate elements that would provide land surface

30 elevations sufficient to accommodate the upslope establishment of marsh over

31 time as sea level rises.

32

33 **Uncertainties/risks:** Restoration of subtidal aquatic habitats could result in

34 establishment of *Egeria* and other non-native plants that reduce the ecological

35 benefits for restored subtidal aquatic habitats to covered species. The abundance

36 of non-native predators and competitor abundance could increase and the ability

37 to control these species is uncertain. Methylation of mercury may occur in

38 intertidal zones, making methylmercury bioavailable to plants, fish, and wildlife

39 in and downstream of restored marshes (Alpers et al. 2006). Large scale levee

40 failures, in the central Delta could reduce species and ecosystem benefits

41 associated with restored marshes in the west Delta depending on the effects of

1 changed hydrodynamic conditions on tidal range and salinity gradients in the west
2 Delta. There could be a short-term risk associated with mobilizing pesticides,
3 herbicides, and other contaminants into the Delta following initial introduction of
4 tidal flow onto agricultural lands.

5
6 **Monitoring and adaptive management considerations:** *[Note to reviewers:
7 this section is a general summary; more detail will be provided in future
8 iterations.]* Opportunities for adaptive management are related to assessing the
9 effectiveness of restored marshes to develop as functional covered species
10 habitats and to produce food and organic carbon in support of food web processes.
11 Results of monitoring the development of early marsh restoration projects would
12 help inform improvements in the design and management of subsequent marsh
13 restorations. Results of monitoring early restorations could also be used to
14 develop cost effective management techniques, if needed, to control the
15 establishment of non-native species in restored marshes. Some of the monitoring
16 considerations include:

- 17 ▪ type and extent of use by covered fishes;
- 18 ▪ extent of phytoplankton, zooplankton, and macroinvertebrate production in
19 marsh channels;
- 20 ▪ load of phytoplankton, zooplankton, and macroinvertebrates exported into
21 the Delta and Suisun Bay;
- 22 ▪ extent of food produced from restored habitats that are consumed by non-
23 native clams;
- 24 ▪ extent of native vegetation relative to non-native vegetation in the restored
25 marsh;
- 26 ▪ extent of native relative to non-native submerged aquatic vegetation;
- 27 ▪ *change in abundance of non-native predatory fish species;*
- 28 ▪ effects of habitat restoration on salinity gradients in the west Delta;
- 29 ▪ levels of mercury methylation and biological uptake;
- 30 ▪ organic carbon production in restored marshes and export to the Delta and
31 Suisun Bay; and
- 32 ▪ growth and survival of rearing Sacramento splittail and Chinook salmon in
33 shallow subtidal aquatic habitats.

34
35 **Reversibility:** This conservation measure would be difficult to reverse because
36 reversing the measure would require construction of new levees to re-isolate
37 restored habitat areas from tidal flow.

38
39 **Conservation Measure FIMA1.4: Restore a mosaic of ■ to ■ acres of intertidal**
40 **marsh, shallow subtidal aquatic, and transitional grassland habitat within the South**
41 **Delta Restoration Opportunity Area.** Restored freshwater intertidal marsh and shallow

1 subtidal aquatic habitats would be designed to support the physical and biological
2 attributes described in Attachment A. The mosaic of habitats would include at least
3 acres of freshwater intertidal marsh habitat. Suitable sites for restoring freshwater
4 intertidal marsh include Fabian Tract, Union Island, Middle Roberts Island, and Lower
5 Roberts Island. Sites selected for restoration would be depend on the location and design
6 of the selected conveyance pathway and operations for the through-Delta component of
7 the dual conveyance facility. Selected sites would be those that would provide
8 substantial species and ecosystem benefits with the selected through-Delta conveyance
9 configuration.

10
11 Design elements of this conservation measure could include:

- 12 ▪ planting tules or other techniques to raise currently subsided ground surface
13 elevations suitable for intertidal marsh restoration on shallowly subsided portions
14 of islands and breaching levees when target elevations are achieved;
- 15 ▪ scalping higher elevation portions of islands to provide fill for placement on
16 subsidied portions of islands to raise surface elevations;
- 17 ▪ breaching and setting back levees to provide for tidal exchange with restored
18 habitats;
- 19 ▪ constructing cross levees where appropriate to protect property and preclude
20 inundation of deeply subsided portions of islands;
- 21 ▪ locating and designing levee breaches to maximize the development of intertidal
22 marsh and minimize hydrodynamic conditions that favor non-native predatory
23 fish; and
- 24 ▪ excavating channels to initiate development of dendritic channel networks within
25 restored marshes.

26 **Rationale:** Restoring freshwater intertidal marsh and shallow subtidal aquatic
27 habitats is expected to reduce the adverse effects of stressors related to food
28 availability and habitat availability for the covered species by:

- 29 ▪ increasing rearing habitat area for Sacramento splittail, Chinook salmon
30 produced in the San Joaquin River and other eastside tributaries, and possibly
31 steelhead (Healey 2001, Brown 2003);
- 32 ▪ increasing the production of food for rearing salmonids, splittail, and other
33 covered species (Kjelson et al. 1982; Siegel 2007);
- 34 ▪ increasing the availability and production of food in the Delta and Suisun Bay
35 by export from the south Delta of organic material via tidal flow from the new
36 marsh plain and organic carbon, phytoplankton, zooplankton, and other
37 organisms produced in new intertidal channels (Siegel 2007);
- 38 ▪ locally providing areas of cool water refugia for delta smelt (C. Enright pers.
39 comm.);
- 40 ▪ increasing the extent of habitat available for colonization by Mason's lilaeopsis;
41 and

- 1 ▪ increasing the extent of habitat for California black rail and tricolored blackbird.
2
3 Additionally, in conjunction with dual conveyance operations, marsh restoration in
4 the south Delta could expand the current distribution of delta smelt into formerly
5 occupied habitat areas.

6 **Recommended Implementation Timeframe:** This conservation measure would
7 need to be implemented following completion of the around-Delta facilities to
8 minimize adverse affects of through-Delta operations on restoration benefits.
9 Restoration planning, however, could be initiated in the near-term implementation
10 period.

11
12 **Implementation Considerations:** Implementation considerations include:

- 13 ▪ selecting the location for habitat restoration (Fabian Tract, Union Island,
14 Middle Roberts Island, or Lower Roberts Island) is dependent on the
15 through-Delta conveyance corridor (i.e., Old River or Middle River)
16 selected for dual operations and therefore the relative influence of South
17 Delta SWP/CVP pumping operations on the restored habitat;
- 18 ▪ opportunities for designing intertidal marsh restoration along the San
19 Joaquin River to increase the tidal prism such that tidal velocities and
20 mixing are increased sufficiently to improve dissolved oxygen levels in the
21 Stockton Deep Water Ship Channel;
- 22 ▪ feasibility of raising land surface elevations using tule plantings or other
23 techniques to raise ground surface elevations before breaching levees;
- 24 ▪ consideration of the effects of restoration-induced dampening of the tidal
25 range on local tidal hydrodynamics and subsequent marsh restoration
26 designs;
- 27 ▪ coordination with Delta levee programs to ensure that restored habitats are
28 protected from adverse effects that could be associated with future levee
29 failures;
- 30 ▪ locating and designing levee breaches to maximize the development of
31 intertidal marsh and minimize hydrodynamic conditions that favor non-native
32 predatory fish;
- 33 ▪ ensuring that designs for restored intertidal marshes along the San Joaquin
34 River would be compatible and provide synergistic species and ecosystem
35 benefits with proposed restoration of adjoining floodplain habitat upstream of
36 French Camp Slough as described under Conservation Measure FLOO2.1;
- 37 ▪ net level of species and ecosystem benefits that can be achieved with dual
38 conveyance operations;
- 39 ▪ potential for increasing mercury methylation and resuspension of
40 contaminants;

- 1 ▪ determining the appropriate allowable land uses and management activities
2 on transitional grasslands conserved to accommodate future sea level rise;
- 3 ▪ the need to incorporate design features and management strategies to
4 preclude or minimize the establishment and abundance of undesirable non-
5 native species;
- 6 ▪ the need to incorporate design features that will promote the natural
7 establishment of marsh-associated covered plant species; and
- 8 ▪ securing fee title or easements for implementing restoration; and
9 ▪ designing habitat restorations to protect privately owned lands within the
10 ROA.

11
12 **Resiliency to future changes:** This conservation measure is expected to be fairly
13 resilient to future changes in hydrology and sea level. Conserving higher
14 elevation transitional grassland habitats along the margins of restored marsh will
15 provide sufficient lands to accommodate the upslope establishment of intertidal
16 marsh as sea level rises.

17
18 **Uncertainties/risks:** Restoration of subtidal aquatic habitats could result in
19 establishment of *Egeria* and other non-native plants that reduce the ecological
20 benefits of restored marsh for covered species. The abundance of non-native
21 predator and competitor abundance could increase and the ability to control them
22 is uncertain. Methylation of mercury may occur in intertidal zones, making
23 methylmercury bioavailable to plants, fish, and wildlife in and downstream of
24 restored marshes (Alpers et al. 2006). Large scale levee failures in the central
25 Delta could reduce species and ecosystem benefits associated with restored
26 marshes in the south Delta depending on the effects of changed hydrodynamic
27 conditions on tidal range and salinity gradients.

28
29 **Monitoring and adaptive management considerations:** [Note to reviewers:
30 this section is a general summary; more detail will be provided in future
31 iterations.] Opportunities for adaptive management are related to assessing the
32 effectiveness of restored marshes to develop as functional covered species
33 habitats and to produce food and organic carbon in support of food web processes.
34 Results of monitoring the development of early marsh restorations would help
35 inform improvements in the design and management of subsequent marsh
36 restorations. Results of monitoring early restorations could also be used to
37 develop cost effective management techniques, if needed, to control the
38 establishment of non-native species in restored marshes. Some of the monitoring
39 considerations include:

- 40 ▪ type and extent of use by covered fishes;
- 41 ▪ extent of phytoplankton, zooplankton, and macroinvertebrate production in
42 marsh channels;

- 1 ▪ load of phytoplankton, zooplankton, and macroinvertebrates exported into
2 the central and west Delta;
- 3 ▪ organic carbon production in restored marshes and exported to the central
4 and west Delta;
- 5 ▪ levels of mercury methylation and biological uptake;
- 6 ▪ extent of native vegetation relative to non-native vegetation at marsh
7 surface;
- 8 ▪ change in abundance of non-native predatory fish species;
- 9 ▪ effects of through-Delta operations on the amount of organic carbon and
10 food produced from restored marshes that is successfully exported to the
11 central and west Delta;
- 12 ▪ extent of native relative to non-native aquatic vegetation; and
- 13 ▪ growth and survival of rearing Sacramento splittail, Chinook salmon, and
14 other covered fish species in shallow subtidal aquatic habitats.

15
16 **Reversibility:** This conservation measure would be difficult to reverse because
17 reversal would require construction of new levees to re-isolate restored habitat
18 areas from tidal flow.

19
20 **Conservation Measure FIMA1.5: Restore a mosaic of [redacted] to [redacted] acres of intertidal**
21 **marsh, shallow subtidal aquatic, and transitional grassland habitat within the East**
22 **Delta Restoration Opportunity Area.** Restored freshwater intertidal marsh and shallow
23 subtidal aquatic habitats would be designed to support the physical and biological
24 attributes described in Attachment A. The mosaic of habitats would include at least [redacted]
25 acres of freshwater intertidal marsh habitat. Areas suitable for restoration in the East
26 Delta ROA (see Figure 1) include Terminous Tract south of State Highway 12, Shin Kee
27 Tract, Rio Blanco Tract, and Bishop Bract. Design elements of this conservation
28 measure could include:

- 29 ▪ acquisition of lands in fee-title or through conservation easements suitable for
30 restoration of intertidal and subtidal habitats and for accommodating future sea
31 level rise;
- 32 ▪ constructing levees to isolate deeply subsided lands and protect property;
- 33 ▪ planting tules or placing fill material to raise elevations of shallowly subsided
34 lands;
- 35 ▪ creating channels and/or creating berms to encourage the development of
36 dendritic tidal channels; and
- 37 ▪ breaching levees to reintroduce tidal exchange to leveed lands.

38 If the eastern alignment of an around-Delta conveyance facility is constructed, the canal
39 levees may be incorporated into the design of intertidal emergent wetland restoration.
40 For example, in locations where the conveyance canal is located at elevations at or below

1 elevations suitable for restoration of intertidal marsh, marsh may be restored to the east of
2 canal levee, with the canal levee forming the western boundary of the restored marsh.
3

4 **Rationale:** Restoring freshwater intertidal marsh and shallow subtidal aquatic
5 habitats within the East Delta ROA (see Figure 1) is expected to reduce the
6 adverse effects of stressors related to food and habitat availability for the covered
7 fish species by:

- 8 ▪ increasing rearing habitat area for Sacramento splittail and San Joaquin Chinook
9 salmon and possibly steelhead (Healey 2001, Brown 2003);
- 10 ▪ increasing the production of food for rearing salmonids, splittail, and other
11 covered species (Kjelson et al. 1982, Siegel 2007);
- 12 ▪ increasing the availability and production of food in the east and central Delta
13 by exporting organic material from the marsh plain and phytoplankton,
14 zooplankton, and other organisms produced in intertidal channels into the Delta
15 (Siegel 2007);
- 16 ▪ locally providing areas of cool water refugia for delta smelt (C. Enright pers.
17 comm.);
- 18 ▪ increasing the extent of habitat available for colonization by Mason's lilaeopsis,
19 and
- 20 ▪ increasing the extent of habitat for giant garter snake, California black rail, and
21 tricolored blackbird.

22
23 **Recommended Implementation Timeframe:** It is anticipated that this
24 conservation measure would be implemented in the BDCP long-term
25 implementation period because the design of restored freshwater intertidal marshes
26 would be influenced by the construction of a new around-Delta conveyance
27 facilities.
28

29 **Implementation Considerations:** Implementation considerations include:

- 30 ▪ the feasibility for subsidence reversal using tule plantings or other
31 techniques to raise ground surface elevations before breaching levees;
- 32 ▪ the need to incorporate design features and management strategies to
33 preclude or minimize the establishment of *Egeria* and other undesirable
34 non-native species;
- 35 ▪ locating and designing levee breaches to maximize the development of
36 intertidal marsh and minimize hydrodynamic conditions that favor non-
37 native predatory fish;
- 38 ▪ the need to incorporate design features that will promote the natural
39 establishment of marsh-associated covered plant species;
- 40 ▪ consideration for the effects of restoration-induced dampening of the tidal
41 range and local tidal hydrodynamics on subsequent marsh restoration

1 designs;

- 2 ■ the footprint and facilities associated with an around-Delta conveyance
3 facility;
- 4 ■ potential for increasing mercury methylation and resuspension of
5 contaminants;
- 6 ■ determining the appropriate allowable land uses and management activities
7 on transitional grasslands conserved to accommodate future sea level rise;
8 and
- 9 ■ securing fee-title or easements and the protection of privately own lands
10 within the ROA.

11 **Resiliency to future changes:** This conservation measure is expected to be fairly
12 resilient to future changes in hydrology and sea level. Conserving higher
13 elevation transitional grassland habitats along the margins of restored marsh
14 would provide lands to accommodate the upslope establishment of intertidal
15 marsh as sea level rises. If the alignment of an around-Delta conveyance facility
16 is upslope of restored habitats, however, the area available for accommodating sea
17 level rise may be constrained.

18
19 **Uncertainties/risks:** Restoration of subtidal aquatic habitats could result in
20 infestation of non-native submerged aquatic vegetation and increase the
21 abundance of non-native predators and vulnerability of covered fish species to
22 predation. Methylation of mercury may occur in intertidal zones, making
23 methylmercury bioavailable to plants, fish, and wildlife in and downstream of
24 restored marshes (Alpers et al. 2006). Additionally, there could be a short-term
25 risk associated with mobilizing pesticides, herbicides, and other contaminants into
26 the Delta following initial introduction of tidal flow onto agricultural lands.

27
28 **Monitoring and adaptive management considerations:** [Note to reviewers:
29 this section is a general summary; more detail will be provided in future
30 iterations.] Opportunities for adaptive management are related to assessing the
31 effectiveness of restored marshes to develop as functional covered species
32 habitats and to produce food and organic carbon in support of food web processes.
33 Results of monitoring the development of early marsh restoration projects would
34 help inform improvements in the design and management of subsequent marsh
35 restorations. Results of monitoring early restorations could also be used to
36 develop cost effective management techniques, if needed, to control the
37 establishment of non-native species in restored marshes. Some of the monitoring
38 considerations include:

- 39 ■ type and extent of use by covered fishes;
- 40 ■ extent of organic carbon, phytoplankton, zooplankton, and macroinvertebrate
41 production in marsh channels;

- 1 ▪ load of organic carbon, phytoplankton, zooplankton, and macroinvertebrates
- 2 exported into the Delta;
- 3 ▪ extent of native vegetation relative to non-native vegetation on the marsh plain;
- 4 ▪ extent of native submerged aquatic plants relative to non-native submerged
- 5 aquatic vegetation;
- 6 ▪ change in abundance of non-native predatory fish species;
- 7 ▪ growth and survival of rearing Sacramento splittail, Chinook salmon, and other
- 8 covered fish species in shallow subtidal aquatic habitats;
- 9 ▪ the establishment of habitat conditions suitable for the natural establishment of
- 10 marsh-associated covered plant species; and
- 11 ▪ levels of mercury methylation and biological uptake.

12
13 **Reversibility:** This conservation measure would be difficult to reverse because it
14 would require construction of new levees to re-isolate restored habitat areas from
15 tidal flow and pumping to remove water from reclaimed habitat areas.

16 17 18 **Brackish Intertidal Marsh Habitat Restoration** 19 **Conservation Measures**

20
21 **Conservation Measure BIMA1.1 Restore a mosaic of [redacted] to [redacted] acres of brackish**
22 **intertidal marsh, shallow subtidal aquatic, and transitional grassland habitat within**
23 **the Suisun Marsh Restoration Opportunity Area.** Restored brackish intertidal marsh
24 would be designed to support the physical and biological attributes described in
25 Attachment A. The Suisun Marsh Habitat Management, Preservation, and Restoration
26 Plan (in development) currently provides for restoring 6,000-9,000 acres of brackish
27 intertidal marsh (S. Chappell pers. comm.). Under this conservation measure, additional
28 brackish intertidal marsh would be restored opportunistically through amendments to the
29 Suisun Marsh Habitat Management, Preservation, and Restoration Plan over the term of
30 the BDCP as lands become available for restoration. Habitat would be restored as a
31 mosaic of brackish intertidal marsh, shallow subtidal aquatic, and transitional grassland
32 habitats of which at least [redacted] acres would be brackish intertidal marsh. Anticipated
33 actions to restore brackish intertidal marsh habitat include:

- 34 ▪ acquisition of lands in fee-title or through conservation easements suitable for
- 35 restoration of intertidal and subtidal habitats and for accommodating future sea
- 36 level rise from willing landowners;
- 37 ▪ planting tules or other techniques to raise elevations of shallowly subsided
- 38 lands;
- 39 ▪ reconnecting disconnected remnant sloughs to Suisun Bay and removing
- 40 remnant slough dikes to reintroduce tidal connectivity to slough watersheds to
- 41 restore tidal marsh; and

- 1 ▪ breaching dikes to reintroduce tidal exchange to diked lands.

2 Hydrodynamic modeling conducted for the Suisun Marsh Restoration Plan (J. DeGeorge
3 pers. comm.) indicates that restoring marsh north of Montezuma Slough would shift the
4 low salinity zone westward and restoring marsh at sites adjacent to Suisun Bay would
5 shift the low salinity zone eastward, potentially adversely affecting delta smelt habitat
6 and water quality in the west Delta. Consequently, implementation of marsh restoration
7 projects in north and south Suisun Marsh would likely be sequenced such that these
8 potential effects would be minimized.

9
10 As described in Conveyance Action Parameter 7, future reoperation or removal of the
11 Montezuma Slough Salinity Control Gate would increase benefits of restoring brackish
12 intertidal marsh in Suisun Marsh by increasing access for covered fish species to existing
13 and restored tidal aquatic habitat within a large area of Suisun Marsh.

14
15 **Rationale:** Suisun Marsh is located in the low salinity zone of the estuary which
16 serves as a corridor for upstream and downstream passage by migratory fish such
17 as salmon and steelhead, as rearing habitat for species such as delta and longfin
18 smelt, splittail, and sturgeon. Suisun Marsh is also located in the area of the
19 estuary that has high production of phytoplankton, zooplankton, and
20 macroinvertebrates. Suisun Marsh historically functioned as a complex of
21 shallow, tidally inundated, brackish water marshes, wetlands, and adjacent
22 channels. Construction of dikes that isolate low elevation habitat from the
23 surrounding channels and brackish waters have been used to create managed
24 freshwater wetlands, primarily for the benefit of waterfowl. As part of the Suisun
25 Marsh Habitat Management, Preservation, and Restoration Plan and expanded as
26 part of BDCP, diked wetland areas would potentially be returned to brackish
27 water tidal habitat accessible to fish and other aquatic species. These shallow
28 water low saline habitats are expected to provide high quality estuarine habitat
29 that would benefit covered fish, other aquatic species, and wildlife directly as
30 habitat but would also serve to benefit the estuary through the production of
31 nutrients, phytoplankton, zooplankton, macroinvertebrates, and organic carbon.
32 Re-establishing large areas of aquatic habitat within the marsh would also
33 maximize habitat connectivity between Yolo Bypass/Cache Slough and important
34 estuarine habitat within Suisun Marsh and Suisun Bay.

35
36 Restoring brackish intertidal marsh within Suisun Marsh is expected to reduce the
37 adverse effects of stressors related to food and habitat availability for the covered
38 species by:

- 39 ▪ increasing rearing habitat area for Chinook salmon, Sacramento splittail, and
40 possibly steelhead (Healey 2001, Siegel 2007);
- 41 ▪ increasing the production of food for rearing salmonids, splittail, and other
42 covered species (Kjelson et al. 1982);
- 43 ▪ increasing the availability and production of food in Suisun Bay by exporting
44 organic material via tidal flow from the marsh plain and phytoplankton,

- 1 zooplankton, and other organisms produced in intertidal channels into the Bay;
- 2 ▪ locally providing areas of cool water refugia for delta smelt (C. Enright pers.
- 3 comm.);
- 4 ▪ reducing periodic low dissolved oxygen events associated with the discharge of
- 5 waters from lands managed as seasonal freshwater wetlands that would be
- 6 restored as brackish intertidal marsh (Siegel 2007, C. Enright pers. comm.);
- 7 ▪ increasing the extent of habitat available for colonization by Suisun marsh aster
- 8 and soft-bird's beak; and
- 9 ▪ enhancing and increasing the extent of salt marsh harvest mouse and Suisun
- 10 shrew habitat.

11 Additionally, the Suisun Marsh ROA (see Figure 1) encompasses a substantial

12 area of land with elevations suitable for intertidal marsh restoration that would

13 involve few impacts on infrastructure or permanent crops relative to the

14 availability of suitable lands within the Delta.

15

16 **Recommended Implementation Timeframe:** This conservation measure could

17 be initiated in the BDCP near-term implementation period and be implemented

18 over the term of the BDCP as restoration opportunities are identified.

19

20 **Implementation Considerations:** Implementation considerations include:

- 21 ▪ coordination with the Solano Multi-Species Habitat Conservation Plan and
- 22 the Suisun Marsh Habitat Management, Preservation, and Restoration Plan to
- 23 ensure effective implementation of conservation measures among the plans;
- 24 ▪ feasibility for subsidence reversal using tule plantings or other techniques to
- 25 raise ground surface elevations before breaching levees;
- 26 ▪ consideration for the effects of restoration-induced dampening of the tidal
- 27 range and local tidal dynamics on subsequent marsh restoration designs;
- 28 ▪ the need to incorporate design features and management strategies to
- 29 preclude or minimize the establishment and abundance of undesirable non-
- 30 native species;
- 31 ▪ the need to incorporate design features that will promote the natural
- 32 establishment of marsh-associated covered plant species;
- 33 ▪ locating and designing levee breaches to maximize the development of
- 34 intertidal marsh and minimize hydrodynamic conditions that favor non-native
- 35 predatory fish;
- 36 ▪ evaluating the impact of likely removal of food produced from restored
- 37 brackish intertidal marshes by clams;
- 38 ▪ effects of operation of the salinity control gates on species and ecosystem
- 39 benefits provided by restored marshes;
- 40 ▪ potential for increasing mercury methylation and resuspension of

- 1 contaminants;
- 2 ▪ determining the appropriate allowable land uses and management activities
- 3 on transitional grasslands or managed seasonal wetlands conserved to
- 4 accommodate future sea level rise;
- 5 ▪ selecting restoration lands and implementing restoration in a sequence that
- 6 minimizes adverse effects of breaching/removing dikes on position of the low
- 7 salinity zone; and
- 8 ▪ securing fee-title or easements from willing private landowners and the
- 9 protection of privately lands within the ROA.

10

11 **Resiliency to future changes:** This conservation measure is expected to be fairly

12 resilient to future changes in hydrology and sea level. The landward margins of

13 Suisun Marsh border higher elevation transitional grassland habitats that would

14 provide sufficient lands for the upslope re-establishment of brackish intertidal

15 marsh as sea level rises and inundates marshes restored in those locations.

16 Sediment modeling conducted for existing proposed restorations in Suisun Marsh

17 also indicate that sediment supplies entering the marsh from tributaries may be

18 sufficient to allow the marsh plain south of Montezuma Slough to accrete at rates

19 that would keep pace with sea level rise (C. Enright, pers. comm.).

20

21 **Uncertainties/risks:** Restoration of subtidal aquatic habitats could result in

22 establishment of non-native plants that reduce the ecological benefits of restored

23 marsh for covered species. Non-native predator and competitor abundance could

24 increase and the ability to control them is uncertain. Initial studies have indicated

25 that sediment supplies are likely sufficient to allow for subsided lands south of

26 Montezuma Slough to accrete to form marsh plain. If restored habitats are

27 designed around this assumption and sediment supplies are not sufficient, restored

28 habitats would not provide the desired covered species benefits and could increase

29 the abundance of predators and competitors, adversely affecting covered fish

30 species. Altering existing habitat conditions in this area could potentially

31 adversely affect delta smelt habitat if salinity gradients, turbidity, or temperature

32 conditions change significantly as a result of restoration actions.

33

34 **Monitoring and adaptive management considerations:** *[Note to reviewers:*

35 *this section is a general summary; more detail will be provided in future*

36 *iterations.]* Opportunities for adaptive management are related to assessing the

37 effectiveness of restored marshes to develop as functional covered species

38 habitats and to produce food and organic carbon in support of food web processes.

39 Results of monitoring the development of early marsh restoration projects would

40 help inform improvements in the design and management of subsequent marsh

41 restorations project. Results of monitoring early restorations could also be used to

42 develop cost effective management techniques, if needed, to control the

43 establishment of non-native species in restored marshes. Some of the monitoring

44 considerations include:

- 1 ▪ type and extent of use by covered fishes;
- 2 ▪ extent of organic carbon, phytoplankton, zooplankton, and
- 3 macroinvertebrate production in marsh channels;
- 4 ▪ load of organic carbon, phytoplankton, zooplankton, and
- 5 macroinvertebrates exported into Suisun Bay;
- 6 ▪ extent of food produced from restored habitats that are consumed by clams;
- 7 ▪ extent of native marsh vegetation relative to non-native vegetation;
- 8 ▪ change in abundance of non-native predatory fish species;
- 9 ▪ effects of habitat restoration on salinity gradients and local tidal
- 10 hydrodynamics in the western Delta;
- 11 ▪ growth and survival of rearing Sacramento splittail, Chinook salmon, and
- 12 other covered species in shallow subtidal aquatic habitats.

13
14 **Reversibility:** This conservation measure would be difficult to reverse because
15 reversal would require construction of new dikes to re-isolate restored habitat
16 areas from tidal flow.

17
18

19 **Channel Margin Habitat Restoration Conservation Measures**

20

21 **Conservation Measures CHMA1.1. Support development and implementation of**
22 **levee construction and maintenance designs that incorporate aquatic, intertidal**
23 **marsh, and riparian habitat features.** The BDCP Implementing Entity would
24 coordinate with DWR, Central Valley Flood Protection Board, and U.S. Army Corps of
25 Engineers to track planned levee construction and maintenance activities. The BDCP
26 Implementing Entity would participate in planning processes for the construction of new
27 levees, or maintenance of existing levees, located along important habitat areas for
28 covered fish species (e.g., fish migration corridors). These activities will help ensure that
29 levee designs incorporate features that would benefit covered fish species, minimize
30 adverse effects of the actions on covered fish species, and avoid potential adverse effects
31 of proposed actions on the ecological functions provided by existing and planned BDCP
32 conserved habitats.

33

34 **Rationale:** Improperly designed levees could increase habitat for non-native
35 predators, attract covered fish species, and thus contribute to increased predation
36 losses of covered fish species. Properly designed levees can support habitat for
37 salmonids and splittail. Riparian and emergent vegetation provide cover and
38 rearing habitat for covered fish species and organic carbon inputs into adjacent
39 channels (U.S. Fish and Wildlife Service 2004).

40

41 **Implementation timeframe:** This measure could be implemented in the BDCP
42 near-term implementation period and for the duration of the BDCP.

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Implementation Considerations: Implementation considerations include establishing a process that effectively engages the Implementing Entity in DWR, Central Valley Flood Protection Board, and U.S. Army Corps of Engineers levee-related planning processes.

Resiliency to future changes: If levees are sufficiently high and properly designed to support vegetation, then riparian vegetation could move up the levee face with the anticipated rising sea level.

Uncertainties/risks: There are uncertainties related to designing levee habitat features that would improve habitat conditions for covered fish species and degrade habitat conditions for non-native predatory fish. Restoring aquatic levee habitats potentially increase the predation risk for covered fish species.

Monitoring and adaptive management considerations: *[Note to reviewers: this section is a general summary; more detail will be provided in future iterations.]* It is anticipated that lead agencies would include provisions for adaptive management and monitoring in their levee planning documents. Adaptive management opportunities could include monitoring the effectiveness of various levee habitat design components and, based on monitoring results, adjusting levee habitat designs to improve benefits for covered species. Some of the monitoring considerations include:

- monitoring the use of aquatic levee habitats by covered fish species and non-native predatory fish;
- the natural establishment and regeneration of emergent marsh and riparian vegetation on levee slopes; and
- the extent of zooplankton and macroinvertebrate production along restored channel margin habitats compared to unvegetated levees.

Reversibility: Intertidal marsh and riparian habitat components of this measure are moderately reversible as riparian vegetation established on or adjacent to levees could be removed if necessary for levee repair, maintenance, or other reasons. Reversing structural habitat design features (e.g., submerged low rock benches), however, would be difficult.

Conservation Measures CHMA1.2. Provide for the establishment of native riparian woody vegetation and emergent vegetation on BDCP constructed levees. BDCP site-specific habitat restoration designs may require the construction of new levees (e.g., setback levees to restore floodplain habitat area). The BDCP Implementing Entity would design such levees to incorporate design features that would provide for the establishment of riparian and tidal emergent vegetation along low elevation surfaces (e.g., levee benches).

Rationale: Improperly designed levees could increase habitat for non-native

1 predators, attract covered fish species, and contribute to increased predation losses
2 of covered fish species. Properly designed levees can support and enhance habitat
3 for salmonids, splittail, and other covered fish species. Riparian vegetation
4 provides cover for covered fish species, and provides organic carbon inputs into
5 adjacent channels (U.S. Fish and Wildlife Service 2004).

6
7 **Implementation timeframe:** This measure could be implemented in the BDCP
8 near-term implementation period and for the duration of the BDCP.

9
10 **Implementation Considerations:** Implementation considerations include
11 coordinating with the U.S. Army Corps of Engineers, DWR, and other flood
12 control agencies to ensure that BDCP levee designs, as applicable, comply with
13 levee flood control standards.

14
15 **Resiliency to future changes:** If levees are sufficiently high and properly
16 designed to support vegetation, then riparian vegetation could move up the levee
17 face with the anticipated rising sea level.

18
19 **Uncertainties/risks:** There are uncertainties related to designing levee habitat
20 features that would improve habitat conditions for covered fish species and
21 degrade habitat conditions for non-native predatory fish. Restoring aquatic levee
22 habitats potentially increase the predation risk for covered fish species.

23
24 **Monitoring and adaptive management considerations:** *[Note to reviewers:*
25 *this section is a general summary; more detail will be provided in future*
26 *iterations.]* Adaptive management opportunities could include monitoring the
27 effectiveness of various levee habitat design components and, based on
28 monitoring results, adjusting levee habitat designs to improve benefits for covered
29 species. Some of the monitoring considerations include:

- 30
- 31 ■ monitoring the use of aquatic levee habitats by covered fish species and
non-native predatory fish;
 - 32 ■ the natural establishment and regeneration of riparian vegetation on levee
33 slopes; and
 - 34 ■ the extent of zooplankton and macroinvertebrate production along restored
35 channel margin habitats compared to unvegetated levees.
- 36

37 **Reversibility:** Riparian habitat components of this measure are moderately
38 reversible as riparian vegetation established on or adjacent to levees could be
39 removed if necessary for levee repair, maintenance, or other reasons. Reversing
40 structural habitat design features (e.g., submerged low rock benches), however,
41 would be difficult.

42
43 **Conservation Measure CHMA1.3: Enhance channel margin habitats along [redacted] to [redacted]**
44 **miles of Steamboat and Sutter Sloughs to improve habitat conditions for covered**
45 **fish species.** Steamboat and Sutter Sloughs ([see Figure 1](#)) are thought to serve as

1 important rearing habitat and movement corridors for juvenile salmonids outmigrating
2 from the Sacramento River (J. Burau pers. comm.). Habitat conditions for covered fish
3 species would be enhanced along [redacted] to [redacted] miles of Steamboat Slough and [redacted] to [redacted] miles
4 of Sutter Slough. The purpose of this measure is to improve the growth and survival of
5 juvenile salmonids that use these habitat areas.

6
7 Design elements for this conservation measure could include:

- 8 ▪ modifying channel geometry to improve hydrodynamic and structural
9 complexity for native species;
- 10 ▪ establishing woody riparian vegetation along banks that do not support woody
11 riparian vegetation;
- 12 ▪ increasing the complexity of in-channel habitats; and
- 13 ▪ reducing the abundance of non-native fish predators and competitors.

14 Following implementation of habitat enhancements, the BDCP Implementing Entity
15 would undertake actions to encourage the transport of juvenile salmonids into Sutter
16 Slough if monitoring results indicate that survival and growth of juvenile salmonids that
17 rear and pass through Sutter and Steamboat Sloughs is substantially higher than under
18 current conditions. Increasing the proportion of juvenile salmonids transported into the
19 sloughs could be accomplished either by reorienting the upstream mouth of Sutter Slough
20 to the Sacramento River or constructing structures in the Sacramento River channel near
21 the upstream mouths of the sloughs that would guide the movement of fish into
22 Steamboat and Sutter Sloughs. To undertake this action, the BDCP Implementing Entity
23 would need to coordinate with and receive approvals from the U.S. Army Corps of
24 Engineers to either modify the project levees or construct an in-channel structure.

25
26 **Rationale:** Enhancing Steamboat and Sutter Sloughs as fish migration corridors is
27 expected to increase the survival and growth of outmigrating Sacramento River
28 salmonids by:

- 29 ▪ increasing the quality of rearing habitat area for Sacramento River salmonids (J.
30 Burau pers. comm., Siegel 2007);
- 31 ▪ reducing the risk for predation on covered fish species by non-native fish
32 predators (J. Burau pers. comm.); and
- 33 ▪ reducing the risk for entrainment of juvenile salmonids by providing a migration
34 corridor that bypasses the intakes of a new north Delta diversion point, the Delta
35 Cross Channel, and Georgiana Slough.

36
37 **Recommended Implementation Timeframe:** It is anticipated that some habitat
38 improvements described in this conservation measure could be implemented in the
39 BDCP near-term implementation period. Improvements that would change
40 channel geometry or affect flood control functions of these sloughs would likely
41 be implemented in the BDCP long-term implementation period to accommodate
42 coordinating planning efforts with local, state, and federal flood control agencies.

1
2 **Implementation Considerations:** Implementation considerations include:

- 3 ▪ the relative efficacy of various predatory fish control methods;
- 4 ▪ appropriate modifications to the channel geometries of Steamboat and
5 Sutter Sloughs that could effectively improve habitat conditions for
6 juvenile salmonids and other covered species and degrade habitat
7 conditions for non-native predatory fish; and
- 8 ▪ coordination with the U.S. Army Corps of Engineers and other flood
9 control agencies to allow for: 1) modifications to project levees or
10 placement of in-channel structures to improve transport of juvenile
11 salmonids into Steamboat and Sutter Sloughs and 2) modifications to the
12 channel geometry of the sloughs.

13
14 **Resiliency to future changes:** This conservation measure is expected to be fairly
15 resilient to future changes in hydrology and sea levels because the types of habitat
16 improvements are such that they would be expected to continue to provide greater
17 benefits for juvenile salmonids than under future conditions without the
18 improvements.

19
20 **Uncertainties/risks:** The efficacy of the proposed restoration actions for
21 increasing survival and growth of juvenile salmonids by reducing predation risk is
22 uncertain, particularly if flow velocities are substantially reduced as a result of
23 increasing flows into the Yolo Bypass and operating a new Delta diversion.

24
25 **Monitoring and adaptive management considerations:** *[Note to reviewers:*
26 *this section is a general summary; more detail will be provided in future*
27 *iterations.]* Opportunities for adaptive management are related to assessing the
28 effectiveness of restoration actions in improving the survival and growth of
29 juvenile salmonids passing through the sloughs by improving habitat conditions
30 and reducing predation and entrainment risk. Results of monitoring could help
31 inform the BDCP Implementing Entity of subsequent opportunities to improve
32 these sloughs as salmonid rearing habitats and migration corridors.
33 Implementation of this conservation measure would also afford the opportunity to
34 test fish predator control techniques to identify the most efficacious methods for
35 controlling predator populations. Some of the monitoring considerations include
36 assessing the:

- 37 ▪ change in survival and growth of juvenile salmonids using the sloughs relative
38 to current conditions;
- 39 ▪ effectiveness of channel geometry designs for improving salmonid rearing
40 habitat and degrading non-native predatory fish habitat;
- 41 ▪ effectiveness of predatory fish control methods; and
- 42 ▪ effectiveness of channel modifications for increasing the transport of juvenile
43 salmonids into the sloughs.

1 **Reversibility:** This conservation measure could be difficult to reverse depending
2 on the magnitude and nature of channel modifications.
3
4

5 **Riparian Habitat Restoration Conservation Measures**

6
7 **Conservation Measure RIPA1.1. Restore between [redacted] and [redacted] acres of riparian forest**
8 **and scrub communities as a component of restored floodplain, freshwater intertidal**
9 **marsh, and channel margin habitats.** As described in Attachment A, the design of
10 restored floodplain, freshwater intertidal marsh, and channel margin habitats [see
11 Conservation Measures FLOO 1.1, FLOO2.1, FLOO 2.2, FIMA1.1-1.5, BIMA1.1,
12 CHMA1.1 and 1.2] will incorporate restoration of riparian habitats as described below.
13

14 **Floodplain Habitat Restoration.** To the extent consistent with flood control
15 requirements, restored floodplain habitat areas will allow for the natural establishment
16 and growth of woody riparian vegetation on portions of restored floodplains that support
17 appropriate soils and hydrology. At floodplain restoration sites that function
18 hydrologically as flood bypasses (e.g., the Yolo Bypass), riparian vegetation is expected
19 to establish along margins of existing and created drains and channels and other locations
20 with suitable hydrology. In bypasses co-managed for habitat and flood control benefits,
21 locations where riparian vegetation is allowed to establish would be limited to areas
22 where the presence of riparian vegetation would not compromise flood control standards
23 or hydraulic capacity of the flood control bypass.
24

25 Riparian habitat would be allowed to naturally establish in floodplain habitat areas that
26 are restored by setting back levees to expand the extent of the floodplain subject to
27 overbank flow.
28

29 **Freshwater Intertidal Marsh Restoration.** Woody riparian vegetation will be allowed
30 to naturally reestablish along the upper elevation margins of restored intertidal marsh
31 habitats where soils and hydrology are suitable, including segments of stream channels
32 that drain into restored marshes.
33

34 **Channel Margin Habitat Restoration.** As described under Conservation Measure
35 CHMA1.2, BDCP levees will be designed to provide for the establishment and growth of
36 riparian vegetation along levees. Levees constructed and maintained by other entities
37 that incorporate “green” levee components would also increase the extent of riparian
38 habitat within the Planning Area by allowing for the establishment and growth of riparian
39 vegetation on levee surfaces.
40

41 **Rationale:** Restoring riparian forest and riparian scrub habitats is expected to
42 provide the following ecosystem and covered species benefits:
43

- 44 ▪ increasing the extent of valley elderberry longhorn beetle habitat and nesting
45 habitat for Swainson’s hawk and yellow breasted chat;

- 1 ▪ increasing the extent of shaded riverine aquatic cover and increasing instream
2 cover by through contributions of instream woody material (U.S. Fish and
3 Wildlife Service 2004);
- 4 ▪ providing inputs of organic material (e.g., leave and twig drop) in support of
5 aquatic foodweb processes;
- 6 ▪ increased production and export of terrestrial invertebrates into the aquatic
7 ecosystem (Nakano S. and M. Murakami 2001); and
- 8 ▪ increasing cover for rearing juvenile salmonids and Sacramento splittail.

9
10 **Recommended Implementation Timeframe:** It is anticipated that elements of
11 this conservation measure would be implemented in both near-term and long-term
12 BDCP implementation period.

13
14 **Implementation Considerations:** Implementation considerations include
15 ensuring that designs for the floodplain, intertidal marsh, and channel margin
16 habitat restorations described under Conservation Measures FLOO 1.1, FLOO2.1,
17 FLOO 2.2, FIMA1.1-1.6, BIMA1.1, CHMA1.1 and 1.2 provide for the restoration
18 of at least [redacted] acres of riparian forest and scrub habitat and the potential need for
19 periodic control of non-native invasive plant species. Additionally, current and
20 future U.S. Army Corps of Engineer policies regarding the establishment and
21 maintenance of woody riparian vegetation on Project levees and floodways would
22 need to be considered in determining locations restoring riparian habitats. Other
23 implementation considerations for this conservation measure are included under
24 implementation considerations for Conservation Measures FLOO 1.1, FLOO2.1,
25 FLOO 2.2, FIMA1.1-1.5, BIMA1.1, CHMA1.1 and 1.2.

26
27 **Resiliency to future changes:** Restored riparian habitats are expected to be
28 fairly resilient to future changes in hydrology and sea level rise because habitats
29 will be restored within large sites that would be expected to provide a sufficient
30 range of site characteristics (e.g., elevation and soil gradients) to allow for the
31 ongoing reestablishment of riparian vegetation in response to changes in
32 hydrologic and sea level conditions over time.

33
34 **Uncertainties/risks:** Allowing for the natural establishment of native riparian
35 vegetation could result in the establishment of riparian habitats dominated by non-
36 native invasive species.

37
38 **Monitoring and adaptive management considerations:** [Note to reviewers:
39 this section is a general summary; more detail will be provided in future
40 iterations.] Opportunities for adaptive management include improving the design
41 and management of restored floodplain, channel margin, and freshwater intertidal
42 marsh to provide for the successfully establishment, growth, and benefits of
43 restored riparian habitats based on monitoring of the development of previously
44 restored riparian habitats. For example, if the natural establishment and growth of

1 native riparian vegetation is substantially impaired by competition with non-
2 native plants, restoration projects may need to provide for the control of non-
3 native plants or require that riparian plantings be installed to improve restoration
4 success. Some of the monitoring considerations include assessing the:

- 5 ▪ use of restored riparian habitats by valley elderberry longhorn beetle,
6 Swainson's hawk, yellow-breasted chat, and riparian brush rabbit;
- 7 ▪ factors governing the natural establishment and growth of native riparian
8 vegetation over a range of site conditions associated with restored floodplain,
9 channel margin, and intertidal marsh habitat areas;
- 10 ▪ the need to control non-native plants to provide for the natural establishment of
11 native riparian vegetation; and
- 12 ▪ ability for native riparian vegetation to reestablish in patterns that provide
13 desired ecosystem and covered species benefits.

14 **Reversibility:** The reversibility of riparian habitat restorations are the same as
15 described for each of the ROA restoration actions described under Conservation
16 Measures FLOO 1.1, FLOO2.1, FLOO 2.2, FIMA1.1-1.5, BIMA1.1, CHMA1.1
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28 conducted on July 28, 2008.

1 **Attachment A. Restoration Concepts for Habitats**

2
3 **Definitions of Restoration Concepts**

4
5 This attachment describes the floodplain, intertidal marsh, and channel margin restoration
6 concepts developed by the Habitat Restoration Program Technical Team (HRPTT).
7 These descriptions are intended to provide guidance to the BDCP Implementing Entity
8 for planning habitat restoration actions and to initially define the range of physical and
9 biological conditions that must be present in restored habitat areas in order for the
10 restoration to be considered successful. The draft information presented in the restoration
11 concept descriptions will be developed further and incorporated into the BDCP
12 Conservation Strategy chapter. Each description includes the following information:

13
14 **Restoration Variables:** Brief descriptions of the key physical parameters that can be
15 manipulated through restoration design and operations to restore habitat under the
16 concept.

17
18 **Design Targets:** Narrative description of the desired physical and biological conditions
19 that are expected to develop in restored habitat areas as a result of manipulating
20 restoration variables.

21
22 **Desired Ecological Benefits:** Brief descriptions of covered fish species stressor effects
23 expected to be reduced with implementation of the restoration concept.

24
25 **Potential Performance Criteria (monitoring needs and adaptive management**
26 **triggers):** Physical and biological parameters that can be measured and that are
27 indicators of the extent of desired ecological functions to be provided by habitats restored
28 under the concept. The performance criteria represent the range of indicators that may be
29 appropriate to monitor to assess the effectiveness of restored habitats in achieving desired
30 covered species and ecosystem benefits. Results of monitoring may be used to trigger
31 adaptive management responses through the BDCP adaptive management process to
32 improve the effectiveness of restored habitats to provide desired benefits.

33
34 **Key Uncertainties:** Brief descriptions of major unknowns with respect to designing
35 habitat restorations and benefits that are expected to be afforded by restoration habitats.

36
37 **Potential Ecological Risks:** Brief descriptions of potential unintended adverse physical
38 and biological impacts that could be associated with implementing the restoration
39 concept.

Floodplain Restoration Concept

Restoration Variables

- Seasonal timing of inundation
- Interannual frequency of inundation
- Spatial extent of inundation
- Depth of inundation
- Water velocity
- Connectivity with intertidal marsh and open water habitats
- Accessibility to migrating fish
- Design related to stranding risk and fish passage
- Vegetation type and cover
- Dry season land use (compatible farming practices)
- Grading/slope

Design Targets

Inundated Floodplain

- Shallow with highly variable depth (2 feet deep on average)
- Adequate hydraulic residence time to promote primary and secondary food production and export and turbidity export (number of days to produce desired food resources)
- Average velocities of about 1.5 foot/sec, but highly variable spatially and temporally
- Duration of inundation about 30-45 days
- Relatively large area (>1,000 acres) to accrue substantive benefit to fish populations
- Stranding avoided through good drainage
- Provides for passage around weirs or other inflow control structures
- Minimized risk for problem levels of methyl mercury and other contaminants
- Inundated during periods that favor native fish and disfavor non-native fish predators – generally late winter to early-mid spring
- Hydrodynamic variability through floodplain cross-section via heterogeneous topography

- 1 ▪ Flows exit floodplain via a channel system that, where possible, flows through
- 2 intertidal marsh towards open water
- 3 ▪ Natural connectivity to adjacent uplands to provide transitional habitats and
- 4 accommodate species movement

5

6 **Dry Floodplain**

7

- 8 ▪ Minimized use of persistent pesticides that are toxic to aquatic organisms
- 9 ▪ Cover and type of residual standing crop biomass (for floodplains with flood
- 10 protection function) or riparian and perennial vegetation (for floodplains without
- 11 flood protection function)
- 12 ▪ Allow for the natural establishment of woody riparian vegetation to the extent
- 13 consistent with desired land uses and flood control requirements

14

15 **Desired Ecological Benefits**

16

- 17 ▪ Primary and secondary production
- 18 ▪ Primary and secondary production export to Delta
- 19 ▪ Export of allochthonous material to Delta
- 20 ▪ Substantial increase in high quality splittail spawning and rearing habitat and
- 21 Chinook salmon (all runs) and steelhead rearing habitat relative to existing in-
- 22 Delta habitat conditions
- 23 ▪ Reduction in stranding/poaching losses of adult sturgeon and salmonids below
- 24 Fremont Weir
- 25 ▪ Improved habitat connectivity between upstream and downstream habitats
- 26 ▪ Improved survival/escapement of juvenile salmonids
- 27 ▪ Improved turbidity conditions (?)

28

29 **Potential Performance Criteria (possible monitoring needs and adaptive**

30 **management triggers)**

31

- 32 ▪ Extent of phytoplankton/zooplankton/macrobenthos production on
- 33 floodplain
- 34 ▪ Extent of phytoplankton/zooplankton/macrobenthos exported to the Delta
- 35 ▪ Growth rate of juvenile salmonids on floodplains
- 36 ▪ Proportion of outmigrating juvenile salmonids accessing floodplain habitats (by
- 37 run)
- 38 ▪ Extent of splittail spawning

- 1 ▪ Extent of native fish stranding
- 2 ▪ Extent of successful upstream passage of adult salmonids and sturgeon
- 3 ▪ Extent of mercury methylation
- 4 ▪ Contaminant load exported to Delta
- 5 ▪ Extent of habitat connectivity along migratory routes for anadromous fishes

6 7 **Key Uncertainties** 8

- 9 ▪ Proper depth for optimizing fish habitat conditions and food production
- 10 ▪ Proper inundation duration/residence time for optimizing fish growth and
11 survival and food production
- 12 ▪ Conditions necessary for the natural establishment of channel-associated
13 covered plant species in floodplains restored by setting back levees
- 14 ▪ Benefits of floodplain inundation to sturgeon, particularly juveniles, are
15 undocumented

16 17 **Potential Ecological Risks**

- 18 ▪ Mercury methylation
- 19 ▪ Establishment of non-native invasive species into created habitat

20 21 22 **Freshwater Intertidal Marsh Restoration Concept**

23 24 **Restoration Variables** 25

- 26 ▪ Spatial distribution of restored habitats within the Delta
- 27 ▪ Extent, location, and configuration of restored habitat
- 28 ▪ Amplitude of tidal exchange
- 29 ▪ Size and location of levee breaches
- 30 ▪ Channel cross sectional profile (elevation of marsh plain, topographic diversity,
31 depth, and slope)
- 32 ▪ Intertidal marsh channel density

33 34 **Design Targets** 35

- 36 ▪ Dominated by native freshwater emergent vegetation (predominantly tules,)

- 1 ▪ Presence of sinuous, dendritic channel networks of high density
- 2 ▪ Sufficient tidal exchange to promote primary and secondary production and its
- 3 export into the aquatic food web
- 4 ▪ Located throughout the Delta for optimal use by and benefit to covered species
- 5 ▪ Located where it can filter non-point source pollution from surface or subsurface
- 6 infiltration
- 7 ▪ High velocity, shallow channels to potentially prevent establishment of non-
- 8 native submerged aquatic vegetation that supports non-native predator habitat
- 9 ▪ Large tidal connectivity to open water areas to minimize steep flow velocity
- 10 gradients that promote establishment of non-native submerged aquatic
- 11 vegetation and provide predatory fish habitats
- 12 ▪ Natural connectivity to adjacent uplands to provide transitional habitats and
- 13 accommodate species movement
- 14 ▪ Accessible to fish, but does not trap fish
- 15 ▪ Connectivity with other intertidal marshes and with floodplain, open water,
- 16 channel margin, and low gradient upland habitats
- 17 ▪ Located such that other stressors (e.g., diversions) do not substantially reduce
- 18 functions beneficial to covered species
- 19 ▪ Designed to allow localized reductions in water temperature though nocturnal
- 20 thermal reduction

21 22 **Desired Ecological Benefits**

- 23
- 24 ▪ Primary and secondary production
- 25 ▪ Primary and secondary production export to Delta channels
- 26 ▪ Reduced summer/fall water temperature through nocturnal thermal exchange
- 27 and reintroduction of cooled water to Delta waterways
- 28 ▪ Filter for contaminants or site for transformation of contaminants
- 29 ▪ Splittail and salmonid rearing habitat
- 30 ▪ Potential delta smelt, longfin smelt, and splittail spawning habitat

31 32 **Potential Performance Criteria (possible monitoring needs and adaptive**

33 **management triggers)**

- 34
- 35 ▪ Type and extent of use by covered fishes
- 36 ▪ Extent of in-marsh phytoplankton/zooplankton/macroinvertebrate production
- 37 ▪ Extent of phytoplankton/zooplankton/macroinvertebrate exported into the Delta

- 1 ▪ Extent of native vegetation relative to non-native vegetation at marsh surface
- 2 ▪ Extent of native relative to non-native submerged aquatic vegetation
- 3 ▪ Extent of organic carbon production and export to Delta channels

4 5 **Key Uncertainties** 6

- 7 ▪ Ability to control non-native submerged aquatic vegetation and fish
- 8 ▪ Ability to restore native plant species (e.g., Delta tule pea)
- 9 ▪ Availability of adequate sediment supply and rate of tule growth for marsh
10 accretion
- 11 ▪ Extent and effectiveness for providing aquatic covered species and ecosystem
12 benefits
- 13 ▪ Effects of increased dampening of the tidal range as marsh restorations are
14 implemented on the ability to implement subsequent restorations
- 15 ▪ Effect of freshwater tidal marsh restoration on water quality and hydrodynamics
16 upstream and downstream

17 18 **Potential Ecological Risks** 19

- 20 ▪ Possibility of establishment of non-native invasive species into restored habitats
- 21 ▪ Depending on location, benefits may be reduced by diversions (project and non-
22 project)

23 24 25 **Brackish Intertidal Marsh Restoration** 26

27 **Restoration Variables** 28

- 29 ▪ Extent, location, and configuration of restored habitat
- 30 ▪ Distribution along salinity gradient
- 31 ▪ Amplitude of tidal exchange
- 32 ▪ Delta freshwater outflow
- 33 ▪ Size and location of dike breaches
- 34 ▪ Channel cross sectional profile (elevation of marsh plain, topographic diversity,
35 depth, and slope)
- 36 ▪ Intertidal marsh channel density

37

1 **Design Targets**

2

- 3 ▪ Dominated by native brackish marsh vegetation (e.g., pickleweed, saltgrass)
- 4 ▪ Presence of sinuous, dendritic channel networks of high density
- 5 ▪ Adjacent to higher elevation uplands to accommodate future with sea level rise
- 6 ▪ Primarily low marsh
- 7 ▪ Sufficient tidal exchange to promote primary and secondary production and its
- 8 export into the estuarine food web
- 9 ▪ Natural connectivity to adjacent uplands to provide transitional habitats and
- 10 accommodate species movement
- 11 ▪ Restore habitats that provide a range of salinity gradients
- 12 ▪ Accessible to fish, but does not trap fish
- 13 ▪ Connectivity with other intertidal marshes and with floodplain, open water,
- 14 channel margin, and upland habitats
- 15 ▪ Located such that other stressors (e.g., diversions) do not substantially reduce
- 16 functions beneficial to covered species
- 17 ▪ Designed to allow localized reductions in water temperature though nocturnal
- 18 thermal reduction

19

20 **Desired Ecological Benefits**

21

- 22 ▪ Primary and secondary production
- 23 ▪ Primary and secondary production export to Suisun Bay
- 24 ▪ Reduced summer/fall water temperature through nocturnal thermal exchange
- 25 and reintroduction of cooled water to Delta waterways
- 26 ▪ Filter for contaminants or site for transformation of contaminants
- 27 ▪ Splittail, salmonid, and sturgeon rearing habitat

28

29 **Potential Performance Criteria (possible monitoring needs and adaptive**

30 **management triggers)**

31

- 32 ▪ Type and extent of use by covered fishes
- 33 ▪ Extent of in-marsh phytoplankton/zooplankton/macroinvertebrate production
- 34 ▪ Extent of phytoplankton/zooplankton/macroinvertebrate exported into Suisun
- 35 Bay
- 36 ▪ Extent of native vegetation relative to non-native vegetation at marsh surface

- 1 ▪ Extent of organic carbon production and export into Suisun Bay

2

3 **Key Uncertainties**

4

- 5 ▪ Ability to control non-native fish (e.g., inland silversides)
- 6 ▪ Ability to restore native plant species (Suisun Marsh aster and soft bird's-beak)
- 7 ▪ Availability of adequate sediment supply for marsh accretion
- 8 ▪ Extent and effectiveness for providing aquatic covered species and ecosystem
- 9 benefits
- 10 ▪ Effects of increased dampening of the tidal range as marsh restorations are
- 11 implemented on the ability to implement subsequent restorations
- 12 ▪ Effect of brackish tidal marsh restoration on the position of the low salinity zone

13

14 **Potential Ecological Risks**

15

- 16 ▪ Possibility of establishment of non-native invasive species into restored habitat

17

18

19 **Channel Margin Habitat Restoration Concept**

20

21 **Restoration Variables**

22

- 23 ▪ Spatial distribution, extent, and location within the Delta
- 24 ▪ Length of restored habitat along channel margins
- 25 ▪ Cross sectional profile (elevation of habitat, topographic diversity, width,
- 26 variability in edge and bench surfaces, depth, and slope)
- 27 ▪ Amount and distribution of installed large woody debris
- 28 ▪ Extent of shaded riverine aquatic cover and vegetation needed to provide future
- 29 inputs of large woody debris

30

31 **Design Targets**

32

- 33 ▪ Incorporate large woody debris in banks (i.e., complex structure refugia)
- 34 ▪ Provide range of hydrodynamic conditions to benefit natives and minimize the
- 35 colonization of non-native submerged aquatic vegetation and predators
- 36 ▪ Provide woody riparian vegetation to create overhead cover and refuge from
- 37 predators in roots
- 38 ▪ Located and configured to connect to existing patches of habitat

- 1 ▪ Minimize use by predatory fish
- 2 ▪ Minimize occurrence of non-native submerged aquatic vegetation
- 3 ▪ Located along fish movement corridors and rearing habitats

Desired Ecological Benefits

- 7 ▪ Improved local and diurnal water temperatures at a local scale
- 8 ▪ Splittail spawning habitat
- 9 ▪ Splittail and salmonid rearing habitat
- 10 ▪ Source of allochthonous material
- 11 ▪ Phytoplankton/zooplankton/macrobenthos production
- 12 ▪ Increased hydrodynamic complexity in channels

Potential Performance Criteria (possible monitoring needs and adaptive management triggers)

- 17 ▪ Type and extent of use by covered fishes
- 18 ▪ Type and extent of use by non-native predatory fish
- 19 ▪ Extent of overhead cover and woody riparian vegetation
- 20 ▪ Extent of native vegetation relative to non-native vegetation
- 21 ▪ Extent of phytoplankton/zooplankton/macrobenthos production

Key Uncertainties

- 25 ▪ Cost:benefit ratio associated with improving channel margin habitats along levees

Potential Ecological Risks

- 30 ▪ Possibility of establishment of non-native invasive species into created habitat