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3.1 Introduction

[***Note to Reviewers****: The text of this section of Chapter 3 is subject to change and revision as the BDCP planning process progresses. This section, however, has been drafted and formatted to appear as it may in a draft HCP/NCCP. Although this section includes declarative statements (e.g., the Implementing Entity will…), it is nonetheless a "working draft" that will undergo further modification based on input from the BDCP Steering Committee, state and federal agencies, and the public.*]

This chapter sets out the BDCP Conservation Strategy, which consists of multiple components that are designed collectively to achieve the BDCP overall planning goals and objectives of ecosystem restoration and water supply reliability. The chapter further describes the plan's intended biological outcomes and details the means by which these outcomes will be achieved. The Conservation Strategy includes the BDCP's biological goals and objectives, and identifies a set of conservation measures necessary to provide for the conservation and management of covered species and natural communities upon which they depend, and to avoid, minimize, and compensate for the potential impacts of covered activities on these resources (*see* Chapter 4, *Covered Activities*). The Conservation Strategy also includes comprehensive plans for monitoring and adaptive management. The BDCP Conservation Strategy has been developed to meet the regulatory standards of sections 7 and 10 of the federal Endangered Species Act (ESA), the State's Natural Community Conservation Planning Act (NCCPA), and, as appropriate, the California Endangered Species Act.

The Conservation Strategy responds to the challenge of restoring key ecosystem functions in the highly altered environment of the Delta. The Delta was once a vast marsh and floodplain intersected by meandering channels and sloughs that provided habitat for a rich diversity of fish, wildlife, and plants. The Delta of today is a system of artificially channeled and dredged waterways constructed into static geometries, initially designed to support farming and, later, limited urban development on Delta islands, to protect against flooding and to convey water supplies to cities and farms in the Bay Area, San Joaquin Valley and southern California. The physical disturbances within the Delta, the introduction of non-native species that have disrupted the foodweb, along with multiple other environmental challenges to the ecosystem have contributed to declines in fish, wildlife, and plant species and other organisms. In recent years, these factors have caused a significant drop in the population of key native fish species, which has triggered significant reductions in water supply.

There is a growing urgency to address the challenges of the Delta from both an ecological and water supply perspective. At-risk species have become further imperiled, litigation contesting the adequacy of existing approaches to meet conservation and water supply objectives has intensified, and regulatory requirements governing the water system have continuously shifted in response, resulting in increasing unpredictability. To further compound these challenges, fundamental changes to the Delta are certain to occur; the Delta is not a static ecological system. The anticipated effects of climate change will result in elevated sea levels, altered annual and inter-annual hydrological cycles, changed salinity and water temperature regimes in and around the Delta, and accelerated shifts in species composition and distribution. In addition, the risk of significant flood events has greatly increased, driven in part by the likelihood of significant seismic events over the next several decades. These changes add to the difficulty of resolving the increasingly intensifying conflict between the ecological needs of a range of at-risk Delta species and natural communities and the need to provide adequate and reliable water supplies for people, communities, agriculture, and industry. Anticipating, preparing for, and adapting to these changes are key underlying drivers for the BDCP.

The approach embodied in the BDCP and its Conservation Strategy reflects a significant departure from the manner in which at-risk Delta fish species and their habitats have been managed in the past. The BDCP approach seeks to contribute to the restoration of the health of the Delta's ecological systems by focusing on ecological functions and processes at a broad landscape scale and not by just addressing its discrete parts. Unlike past regulatory approaches that have relied almost exclusively on iterative adjustments to the operations of the State Water Project and the Central Valley Project, including those reflected in recent biological opinions issued by both the U.S. Fish and Wildlife Service and the National Marine Fisheries Service,[1] the BDCP proposes actions that will allow for fundamental, systemic, long-term physical changes to the Delta, including substantial alterations to water conveyance infrastructure and water management regimes and extensive restoration of habitat. These ecosystem-wide changes are intended to enhance substantially the productivity of its ecological processes and advance the conservation of multiple species and communities that depend upon them.

The geographic scope of the BDCP Planning Area is the statutory Sacramento-San Joaquin Delta as defined in California Water Code Section 12220. Because the state and federal water infrastructure operates as an integrated system, the effects of the BDCP will extend beyond the Bay Delta, both upstream and downstream, and will implicate both water operational parameters and species and their habitats. Therefore, the BDCP will take into account these upstream and downstream effects, both positive and negative, to ensure that the overall effects of the BDCP are fully analyzed and understood.

The BDCP Conservation Strategy is built upon and reflects the extensive body of scientific investigation, study, and analysis of the Delta compiled over several decades (see The State of Bay-Delta Science, 2008), including the results and findings of numerous studies initiated under the CALFED Bay-Delta Science program and Ecosystem Restoration Program, the long-term monitoring programs conducted by the Interagency Ecological Program (IEP), research and monitoring conducted by state and federal resource agencies, and research contributions of academic investigators.

In addition, the BDCP Steering Committee has considered a number of other recent reports on the Delta, including reports of the Governor's Delta Vision Blue Ribbon Task Force (January and October 2008) and several recent reports of the Public Policy Institute of California.[2] Many elements of the BDCP Conservation Strategy parallel the recommendations of these other reports and reflect broad agreement that the Delta is dysfunctional from both an ecological and water supply reliability perspective and that fundamental change is necessary.

To ensure that the BDCP would be based on the best scientific and commercial data available, the BDCP Steering Committee also undertook a rigorous process to develop new and updated

[1] Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP) (U.S. Fish and Wildlife Service 2008). Biological Opinion and Conference Opinion on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan (National Marine Fisheries Service 2009).

[2] See, e.g. Comparing Futures for the Sacramento-San Joaquin Delta (Public Policy Institute of California 2008).

information and to evaluate a wide variety of issues and approaches as it formulated a cohesive, comprehensive Conservation Strategy. This effort included an evaluation, early in 2009, conducted by multiple teams of experts of BDCP conservation options using the CALFED Bay-Delta Ecosystem Restoration Program's DRERIP[3] evaluation process. Reflecting the requirements of the NCCPA planning process, the BDCP Steering Committee also sought and utilized independent scientific advice at several key stages of the planning process, enlisting well-recognized experts in ecological and biological sciences to produce recommendations on a range of relevant topics, including conservation planning for both aquatic and terrestrial species and developing adaptive management and monitoring programs.[4]

This chapter contains a description of the basic elements of the conservation strategy by which the BDCP will achieve its objectives. It includes a description of the overall approach to conservation in section 3.2; the biological goals and objectives of the plan in section 3.3; the specific conservation measures in section 3.4; the monitoring and research program in section 3.5, and the adaptive management program in section 3.6.

3.1.1 Biological Goals and Objectives

The BDCP biological goals and objectives describe the expected outcome of the plan, and are contained in section 3.3, below. The biological goals serve as the broad principles to guide the Conservation Strategy; while the biological objectives express measurable targets for achieving the biological goals. The objectives in the BDCP are generally measured on the basis of outcomes related to habitat or to species, and have been described with as much specificity as practicable. These goals and objectives establish the parameters and benchmarks for the BDCP conservation measures, and provide direction to the monitoring and adaptive management programs.

BDCP biological goals and objectives are expressed in an ecological-scale hierarchy with ecosystem-level, natural community-level, and species-specific goals and objectives. For example, the plan includes an ecosystem goal to "improve hydrodynamic conditions to support the movement of adult life stages of native fish species to natal spawning habitats"; a natural community goal to "protect, enhance, and restore natural communities to provide habitat and ecosystem functions to increase the natural production (reproduction, growth, and survival), abundance, and distribution of native Delta species"; and a species goal to "create conditions that support a self-sustaining population of delta smelt in the Delta and Suisun Bay." They thus reflect both the broad scale and scope of the BDCP, and also are structured to address other more geographically targeted and species-specific needs.

3.1.2 Conservation Measures

Section 3.4 describes the conservation measures of the BDCP. The term "conservation measures" refers to those specific actions that will be implemented to achieve the goals and objectives of the Plan. The BDCP conservation measures will provide for the conservation and management of covered species, appropriately minimize and mitigate for any adverse effects to covered species likely to result from covered activities, and ensure that the plan will not jeopardize the continued existence of any covered species or adversely modify designated critical habitats.

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[3] Delta Regional Ecosystem Restoration Implementation Plan

[4] Insert citation to additional information identifying experts.

The measures are grouped into several categories: water facilities and operations, which include measures to improve the method, timing, and amount of flow and quality of water into and through the Delta to benefit covered species and covered natural communities; physical habitat restoration, which expand the extent and quality of intertidal, floodplain, and other habitats; habitat protection, which provides for protection of existing habitats necessary to address the conservation of species (mainly terrestrial species); and other stressors, which address a range of stressors that adversely affect covered species, including toxic contaminants, non-native predators and competitors, illegal harvest, and genetic threats. This comprehensive, ecosystem-based approach to moderating the adverse effects of these multiple stressors is essential to making significant contributions to the recovery of covered species and to the restoration of a naturally functioning ecosystem, while securing an improved and more reliable freshwater supply for human use. Section 3.2, *The BDCP Approach to Conservation: An Overview*, describes the general components of each of these program elements and their rationale, while section 3.4, *Conservation Measures*, specifically describes each of the conservation measures.

These conservation measures should be assessed in the context of the time frame governing the implementation of the BDCP, which has been designed as a fifty year conservation plan. The Conservation Strategy delineates measures and actions which will occur in the near-term [***Note to Reviewers****: Near-term water operations are currently under development*], pending the completion of the major new water infrastructure called for by the plan, and measures and actions that will be implemented over the long-term, after completion of the new conveyance facilities. This distinction between near-term and long-term implementation periods is defined by the transition from the sole reliance on existing water conveyance infrastructure to the operation of a new north Delta diversion and around-Delta conveyance facility, which is a cornerstone to the improve of the water management system under the BDCP. A number of conservation measures cannot be implemented until the north Delta diversion is operational and therefore are considered to be long-term actions. Those measures that are not dependent on operations of the new facilities will largely be initiated in the near-term period. These actions include habitat restoration to accelerate new productivity in the Delta, the development of several new in-Delta operational facilities to reduce fish entrainment at diversions and improve flow patterns, and modifications to flow and water management regimes to enhance productivity. Prompt and decisive implementation of these near term measures pending the completion of systemic changes in the water conveyance system is likely to be central to the success of the BDCP Conservation Strategy.

Designing the conservation measures to address the large spatial scale of the Delta is another important feature of the BDCP. This emphasis on spatial scales underscores the timing and sequencing of habitat restoration measures across the northern, western, eastern and southern regions within the Delta. These measures are, in turn, closely integrated with the water facilities and operational measures to ensure that the flow and physical habitat parameters for improving habitat function and distribution across the Delta are unified and coordinated.

There is a close correlation between the characterization of certain measures as “conservation measures” and the parallel designation of them as “covered activities;” in numerous instances, measures can be both. Where an activity is being undertaken that will contribute to achieving the BDCP conservation goals and objectives – e.g. provide benefits to covered species – then it is characterized as a conservation measure. Where the activity may also result in the incidental take of listed species and will therefore require an incidental take authorization, it may also constitute a covered activity under the plan in order to secure that authorization.

Finally, these characterizations should be understood to be species-specific and not sweeping generalizations that relate to all species and all habitats. Certain activities may provide benefits for some covered species, and have either no effect or some limited negative effect on other species. Examples of this include certain habitat restoration projects that may benefit listed aquatic species but also entail certain unavoidable adverse effects on terrestrial species. Another example is the proposed construction and operation of a new isolated conveyance system, which may provide substantial benefits to certain aquatic species over the existing system, but will also entail potential adverse impacts on other species, both terrestrial and aquatic.

3.1.3 Monitoring, Research and Adaptive Management

The monitoring, research and adaptive management components of the Conservation Strategy are intended to guide the near- and long-term decision-making processes during plan implementation, evaluate progress, improve the efficiency and effectiveness of the conservation measures in achieving the BDCP biological goals and objectives, and adjust measures and approaches as more is learned about the Delta. The monitoring and research program, described in section 3.5, *Monitoring and Research Program*, includes a combination of system-wide and conservation measure-specific monitoring and research to provide increased knowledge of the effectiveness of conservation actions through BDCP implementation. The adaptive management program described in section 3.6, *Adaptive Management Program*, will rely on continuous input of data, knowledge, and up-to-date scientific information to enhance the efficacy of the BDCP conservation measures and increase their capacity to meet the goals and objectives of the plan. The adaptive management process will inform the implementation of conservation measures and allow for those measures to be modified or discontinued in response to results from BDCP monitoring and research programs and other new scientific information.

3.2 The BDCP Approach to Conservation: An Overview

[***Note to Reviewers***: *The text of this section of Chapter 3 is subject to change and revision as the BDCP planning process progresses. This section, however, has been drafted and formatted to appear as it may in a draft HCP/NCCP. Although this section includes declarative statements (e.g., the Implementing Entity will…), it is nonetheless a "working draft" that will undergo further modification based on input from the BDCP Steering Committee, State and federal agencies, and the public.*]

3.2.1 Introduction

This section provides an overview of the primary substantive components of the Conservation Strategy for the BDCP, describing the rationale underling each major component and how they collectively will achieve the overall planning goals and objectives and the more specific biological goals and objectives for the plan. The central aim of the Conservation Strategy is to support the restoration of ecological productivity of the Delta and adjacent areas to advance the conservation of covered species and the natural communities upon which they depend while meeting water supply reliability goals. Over the course of the BDCP planning process, the Steering Committee convened independent scientists on several occasions to provide their advice and recommendations on some of the basic concepts that should guide the planning effort, including the following:

- Land use changes within the Delta have reduced the quality and availability of aquatic habitat suitable for various life stages of covered fish – the conservation strategy should contribute to an increase in the quality, availability, spatial diversity, and complexity of aquatic habitat within the Delta.
- Achieving the goals of the BDCP will require more than manipulation of Delta flow patterns alone. A number of key ecosystem drivers are unrelated to freshwater flow patterns, and these drivers must also be addressed directly.
- The conservation strategy should improve connectivity among aquatic habitats, facilitate migration and movement of covered fish among habitats, and provide transport flows for the dispersal of planktonic material (organic carbon), phytoplankton, zooplankton, macroinvertebrates, and fish eggs and larvae.
- Synchrony between environmental cues and conditions and the life history of covered fish and their food resources within the upstream rivers, Delta, and Suisun Bay is important. The conservation strategy should consider hydrologic seasonal synchrony within the watershed, seasonal water temperature gradients, salinity gradients, turbidity, and other environmental cues.
- There are currently a number of stressors and sources of mortality affecting covered fish within the Delta – the conservation strategy should identify and implement actions to reduce sources of direct mortality and other stressors on the covered fish and the aquatic ecosystem within the Delta.
- Hydrology and SWP and CVP operations within the Delta are integrated with conditions both upstream and downstream of the Delta – the conservation strategy should consider

effects on habitat conditions for covered fish in upstream river reaches, within the Delta, and downstream within the low salinity zone of the estuary in Suisun Bay.

- To the extent possible, the conservation strategy should rely on natural physical habitat and biological processes to support and maintain covered fish species and their habitat.

These concepts informed the development of the BDCP Conservation Strategy. One cornerstone of the BDCP strategy is the widely shared conclusion that the existing water conveyance system is fundamentally flawed and that continued reliance on that system as it currently exists is incompatible with the long-term restoration needs of the Delta. Given the incapacity of the existing conveyance system to meet ecological and water supply goals, and in light of the ongoing and anticipated changing conditions of the Delta brought on by climate change, anticipated seismic events, invasive species and other stressors, the BDCP contemplates wholesale, systemic modifications to the Delta. Modifying the water conveyance infrastructure to convey water around the Delta is essential to creating new opportunities to restore the ecological health of the Delta and to achieve improvements in water supply reliability.

Implementing these major changes in the water conveyance system and pursuing the significant habitat and other productivity improvements afforded by these changes constitutes the key components of the BDCP long-term Conservation Strategy. Both the movement of diverted freshwater around the Delta and improvements to the operations of existing infrastructure (described as dual facilities operations) are expected to provide the flexibility to operate the water export system to bring about substantial improvements over existing conditions for covered fish species and their habitats. The flexibility associated with the operation of dual facilities is expected to allow for habitat restoration to be implemented in the western, eastern, and south Delta and enhanced organic production generated from these restored habitats to pass through the interior Delta with a corresponding reduction of fish entrainment at the south Delta facilities.

A second major aspect of the BDCP Conservation Strategy is its comprehensive scope. Restoring the Delta requires a broader set of actions beyond changes to water operations and conveyance to address the range of conditions that currently impair the long-term function of the Delta ecosystem. Extensive land use changes over the last century within the Delta have substantially reduced the quality and availability of wetland and aquatic habitat suitable for various life-stages of covered fish. The BDCP Conservation Strategy is intended to result in a major increase in the quality, availability, spatial diversity, and complexity of wetland and aquatic habitat within the Delta over both the near-term and the long-term. The Conservation Strategy includes actions to improve connectivity among aquatic habitats, facilitate migration and movement of covered fish among habitats, and provide transport flows for the dispersal of planktonic material, phytoplankton, zooplankton, macroinvertebrates, and fish eggs and larvae.

An important third aspect of the Conservation Strategy is the inclusion of a range of other measures to address other stressors that result in direct and indirect mortality to covered species, including predation, illegal harvests, entrainment, exposure to contaminants, and low dissolved oxygen that affect biological productivity at lower trophic levels and affect fish survival at various life-stages. While the scope of the BDCP Conservation Strategy is bounded by well-defined parameters, it includes measures to moderate the impacts of certain other stressors that have some relation to the operations of the SWP and the CVP or that may be feasibly implemented through the BDCP Implementing Entity to further advance the biological goals and objectives of the BDCP.

Another feature of the BDCP Conservation Strategy that deserves emphasis is its long-term duration, and the organization of the strategy into both near-term and long-term periods. The break between near-term and long-term BDCP implementation periods is defined by the completion and initiation of operations of the north Delta diversion and around-Delta conveyance facility. A number of conservation measures cannot be implemented until the north Delta diversion is operable and, therefore, will be implemented during the long-term period.

Those measures that are not dependent on operations of the new diversion facilities will be initiated in the near-term period. The implementation of conservation measures in the near-term is important to immediately address certain highly degraded ecological conditions, while building the foundation to substantially improve long-term ecological productivity. These near term measures include early restoration actions for tidal marsh and riparian habitats, implementation of many of the other stressor conservation measures, and acquisition of terrestrial and wetlands habitat for wildlife and plants to offset impacts of BDCP actions. Near-term actions include the construction of several in-Delta facilities designed to enhance the ability to manage flows within specific geographic areas of the Delta to reduce risks to covered species and improve productivity. They also include a range of modified water management parameters for the system that are designed to compliment the physical habitat restoration program so as to maximize opportunities to enhance primary and secondary productivity.

Completion and operation of the isolated conveyance facility will facilitate the implementation of other key conservation measures, including restoration of tidal and floodplain habitat in the south Delta with reduced risk of entrainment of covered fish species into the south Delta SWP/CVP facilities.

Finally, the close integration of conservation actions across both time and geography is central to the success of the BDCP Conservation Strategy. A complex web of important interrelationships exists among the conservation measures. There are interrelationships and interdependencies among all the water operations conservation measures because changes in water operations in any one part of the Delta results in effects on hydrodynamics in other parts of the Delta. For example, diversions in the north Delta reduces Delta outflow but also reduces the need to export at the south Delta diversions, thereby reducing reverse flows in Old and Middle rivers. The coordinated operations of new and existing water facilities in a flexible and adaptable plan will allow for the optimal combination of improvements to aquatic habitat and reliability of water supply.

Restoration of large portions of the Delta to tidal habitat will affect the hydrodynamics and water quality in immediately surrounding channels and, in some cases channels distant from the restoration site, by increasing the tidal prism and reducing the tidal range. For example, restoration of tidal habitats in the Cache Slough area is projected to result in reduced tidal range and greater unidirectional flows in Sutter and Steamboat Sloughs, which may reduce the risk of predation on juvenile salmonids migrating through these sloughs. The reduction in contaminants, such as pesticides and herbicides, is expected to interact synergistically with improvements in organic and nutrient input from restored tidal marsh and floodplains to benefit the aquatic food web. Hence, understanding the interconnections amongst the BDCP conservation measures across program elements, across the wide geography of the Delta, and across time is an important aspect of the understanding the strategy; it is intended to be more than the sum of its parts.

All of the above features are reflected in the key components of the Conservation Strategy, as set forth below. The conservation measures themselves are described in detail in 3.4.1 *Water Operations Conservation Measures*, 3.4.2 *Physical Habitat Conservation Measures*, and 3.4.3 *Other Stressors Conservation Measures*.

3.2.2 Water Facilities and Operations

The water-related conservation measures of the BDCP consist of new water conveyance and other water management facilities both within and around the Delta and improvements in the operational parameters associated with existing and new facilities. These facilities and operations are organized into both near-term and long-term periods to distinguish those measures that may be implemented in the near-term from those other measures that are dependent upon the completion of the new diversion and conveyance facilities.

The near term measures include those facilities that are designed to avoid or minimize the impacts of existing operations on covered species by reducing entrainment, improving migration of juvenile or adult fish, or otherwise enhancing the hydrological conditions of the Delta to increase productivity for covered species in close conjunction with a comprehensive physical habitat restoration program that will occur during both the near and long term phases of the BDCP. Near- term measures also include improvements in the operational parameters associated with the existing and new facilities that are intended advance the BDCP biological goals and objectives.

[***Note to Reviewers:*** *When ready, an expanded description of near-term operational parameters will be added here.*]

The primary long term conservation measure related to water conveyance is the construction and operation of new north Delta diversion facilities along the Sacramento River and an isolated conveyance facility to carry water to the existing south SWP and CVP facilities. The combination of moving freshwater around the Delta via an isolated conveyance facility and improving operations relating to the conveyance of freshwater through the Delta (described as "dual operations") are expected to provide the flexibility necessary to improve conditions for covered fish species. The operations of these dual facilities are expected to benefit different species at different times and under a variety of conditions. Dual operation of new and existing diversion facilities is expected to reduce levels of entrainment of native fish at the south Delta SWP/CVP facilities, particularly delta and longfin smelt.

To minimize the potential for entrainment of fish (particularly juvenile Sacramento River salmonids and splittail) at the new diversion facilities on the Sacramento River, state-of-the-art positive-barrier fish screens will be constructed at each of five intakes and flexible operational methods in the timing and rate of diversion will be coordinated among the intake facilities. Constructing state-of-the-art positive barrier fish screens on in-river and on-river intakes along the Sacramento River and employing flexible operational scenarios will minimize fish mortality at the new north Delta diversion sites. The positive barrier fish screens will be designed and operated in accordance with current design criteria (e.g., screen mesh size, approach velocity) established by CDFG, NMFS, and USFWS. These operational measures have been devised to ensure that any potential risks to migrating salmonids from the operation of the new north diversion facility will be avoided or otherwise fully addressed.

An important parameter of the water operations program is the range of water diversion rates and bypass flows in the Sacramento River at the diversions that reflect seasonal movement patterns of covered fish species, particularly when they occupy the area of the diversions. These parameters have been developed to better reflect seasonal synchrony with hydrologic conditions within the river and upstream watersheds. In developing the hydrologic and water supply operational criteria, the effects of Delta operations on upstream habitat that is important as spawning and juvenile rearing areas for covered salmon and steelhead have also been taken into account. SWP and CVP operations affect reservoir storage, coldwater pool volumes within the reservoirs, and instream flows and seasonal water temperatures in the rivers downstream of Project dams and reservoirs. The BDCP Conservation Strategy takes into account such changes where they affect habitat of protected species. Bypass criteria proposed by the BDCP reflect the variation in the seasonal periods of hydrology. The criteria includes both a minimum river flow and, for the wetter winter and early spring period when many of the covered species are spawning or the juveniles are migrating within the Sacramento River, a requirement based on a percentage of the river flow that would be passed by the diversions. Extensive hydrologic simulation modeling has been used to evaluate and develop the range of water diversion criteria included in the Conservation Strategy. Detailed information on the proposed Sacramento River bypass and diversion operations is presented in section 3.4.1 *Water Operations Conservation Measures*.

Proposed water operations measures include actions to improve flows through the Yolo Bypass floodplain, ensure sufficient water for fish transport in the Sacramento River (i.e., north Delta diversion or Hood “bypass flows”), prevent fish from being drawn into the central Delta through the Delta Cross Channel, provide quality habitat for delta smelt and longfin smelt in the Delta and Suisun Bay, and minimize entrainment of fish at the south Delta SWP/CVP diversions. The flexibility associated with the operation of dual facilities in the north and south Delta is expected to allow for physical habitat restoration to be implemented in the western, eastern, and south Delta. Some of the enhanced production of carbon, zooplankton and phytoplankton generated from these restored habitats is expected to pass through the interior Delta, while some should also be consumed by fish within and adjacent to the marshes. The flexibility of this dual approach will also allow for a substantial reduction in fish entrainment at the south Delta facilities while, at the same time, meet the water supply reliability goals of the BDCP. In addition, water supply reliability will substantially improve with the north Delta diversion and canal facility because these facilities will be constructed to be more resistant to catastrophic events (e.g., levee breaching from earthquakes and floods) and sea level rise than the existing through-Delta conveyance system.

Also proposed is the modification of Fremont Weir (lowering a portion of the weir and installing an operable gate facility) and changes to its operations to improve the inundation regime in the Yolo Bypass to benefit covered fish species. Research suggests that covered fish species, particularly splittail and Chinook salmon, would benefit significantly from optimizing the frequency, duration, and timing of seasonal inundation of the Yolo Bypass floodplain habitat (Sommer et al. 1997, 2001, 2004). In addition, increased phytoplankton, zooplankton, and other organic material transported from the Yolo Bypass floodplain to Cache Slough, the lower Sacramento River, the western Delta, and Suisun Bay is expected to increase the food supply for delta smelt and longfin smelt in those areas.

Since the Conservation Strategy includes continued operation of the existing south Delta SWP and CVP export facilities over both the near-term and the long-term, the BDCP also includes operational criteria that consist of seasonal limits to exports based on Old and Middle River (OMR) reverse flows. Results of studies have shown that high rates of exports from the south Delta, particularly during the late winter and spring months, result in high levels of OMR reverse flow and increased levels of fish salvage at the SWP and CVP export facilities. To reduce the risk that south Delta exports, under the dual facility operations, result in direct losses or salvage of covered fish or increases in the export of nutrients and food resources produced in restored south and central Delta marshes, the Conservation Strategy includes seasonally adjusted year-round limits on OMR reverse flows. Detailed information on OMR operations criteria is presented in Section 3.4.1, *Water Operations Conservation Measures.*

Further downstream, the Bay-Delta system functions as an estuarine mixing zone for freshwater passing downstream from the tributary rivers and saltwater intrusion from coastal waters through San Francisco Bay. Suisun Bay and the western Delta serve as the low salinity mixing area that has been found to be important rearing and foraging habitat for the covered fish species. The estuarine habitat is also important to the production of phytoplankton and zooplankton as well as many other fish that are the prey of covered fish. The dynamics of the estuarine zone are determined largely by tides and the balance of the magnitude of Delta inflow and Delta outflow. The seasonal period when habitat conditions and salinity gradients in the Suisun Bay and western Delta are most important to the covered fish is during the winter and spring months. The BDCP therefore proposes, as part of its water management program, seasonally adjusted Delta flows designed to better foster the functions of the estuarine habitat. Additional detailed information on the Delta flows included in the Conservation Strategy for estuarine function is presented in Section 3.4.1, *Water Operations Conservation Measures*.

3.2.3 Physical Habitat Restoration

A second major program element for the BDCP Conservation Strategy is the protection, enhancement, and restoration of habitats and natural communities in the Planning Area and outside the Planning Area at Suisun Marsh that support covered species. Habitat restoration in the context of the BDCP involves both reestablishing habitat in locations that historically supported such habitat and creating habitat on altered landscapes that historically did not support such habitat. Habitat enhancement refers to improving the ecological functions of existing habitat that supports covered species. Habitat protection refers to the preservation of existing habitat currently susceptible to changes in land use by human activity.

The Conservation Strategy includes a commitment to restore a substantial amount of natural habitat; 80,000 acres of tidal aquatic and marsh habitats, seasonal floodplains, and adjacent transition uplands. These habitat restoration actions will bring back natural habitat mosaics and gradients at a scale not seen in the Delta for over 70 years. The Conservation Strategy commits to the protection and restoration of up to 65,000 acres of tidal wetland and associated estuarine habitat distributed across the Delta, but primarily located within Suisun Marsh and the north Delta Cache Slough complex; 5,000 acres of riparian habitat distributed across the Delta; and 10,000 acres of new floodplain habitat along major channels in addition to the enhancement of floodplain in the Yolo bypass. These conservation actions provide for the restoration of large tracts of Delta estuarine and associated riparian and seasonal floodplain habitats of sufficient size to enable the development of functioning habitats that will substantially increase the extent of physical habitat for covered species (including cover, rearing habitat, nesting habitat, and food resources) and improve overall food web productivity in the restoration areas and adjacent aquatic habitat.

Physical habitat protection and restoration will focus on freshwater tidal marsh, brackish tidal marsh, channel margin habitat, riparian habitat, seasonally inundated floodplain habitat, agricultural habitat, grassland preservation and management, natural seasonal wetland restoration and preservation, managed seasonal wetland preservation, non-tidal perennial aquatic habitat, and non-tidal freshwater permanent emergent marsh restoration and preservation. These actions are expected to benefit covered species by enhancing the extent and quality of habitat, increasing hydraulic residence time, improving survival rates, and enhancing food productivity, and improving the geographic distribution of habitat. "Restoration Opportunity Areas" (ROAs) are identified within the Delta and Suisun Marsh that support suitable physical conditions for tidal marsh restoration, although restoration may occur outside these areas as well (see Figure 3.1). The ROAs encompass potential restoration areas that could support covered fish species that use main channels, distributaries, and sloughs of the Sacramento, San Joaquin, and Mokelumne rivers in the Delta and the channels and sloughs of Suisun Marsh.

The physical habitat program, like the water conveyance program, consists of both near-term and long-term components and will be phased in over time, with each phase reflecting a commitment to an identified amount of restoration by habitat type. Rebuilding the habitat base of the Delta and managing flows in a complimentary manner is a core component of the BDCP Conservation

Strategy. Therefore, the near-term phase of the physical habitat program concentrates on those areas that provide the greatest opportunities to restore productivity, concentrating on the Cache Slough and Suisun Marsh ROAs to expand these key habitat areas for delta smelt and longfin smelt and to beneficially affect flows in the Sacramento River and its distributaries for the benefit of Sacramento river Salmonids. Constructing the new north-Delta diversions and isolated conveyance facility will open up significant additional habitat restoration opportunities that do not now exist. Accordingly, the long-term phase of the physical habitat program contemplates an expanded emphasis of habitat to restoration of floodplain and intertidal marsh habitats in the west and south Delta to mainly benefit San Joaquin, Mokelumne, and Cosumnes river salmonids as well as green and white sturgeon and splittail while, at the same time, maintaining south Delta SWP/CVP diversions at levels and timing to avoid and minimize adverse effects on fish using these new habitat areas.

3.2.4 Measures to Address Other Stressors

An important third component of the BDCP Conservation Strategy consists of measures that seek to reduce the direct and indirect adverse effects of other stressors on the ecological functions of the Delta and covered species and natural communities. A number of factors have been identified that adversely affect covered fish species through their impact on the species themselves, prey resources or habitat conditions. Many of these conservation measures address activities that are not related directly to water Project operations or facilities or habitat restoration activities, but offer high value opportunities to reduce adverse impacts or otherwise improve productivity. These other stressors include toxic contaminants, poor water quality (e.g., low dissolved oxygen), non-native species, hatcheries, entrainment by non-Project diversions, and recreational activities. Implementation of conservation measures addressing these other stressors is expected to reduce their adverse effects upon or improve productivity for covered species.

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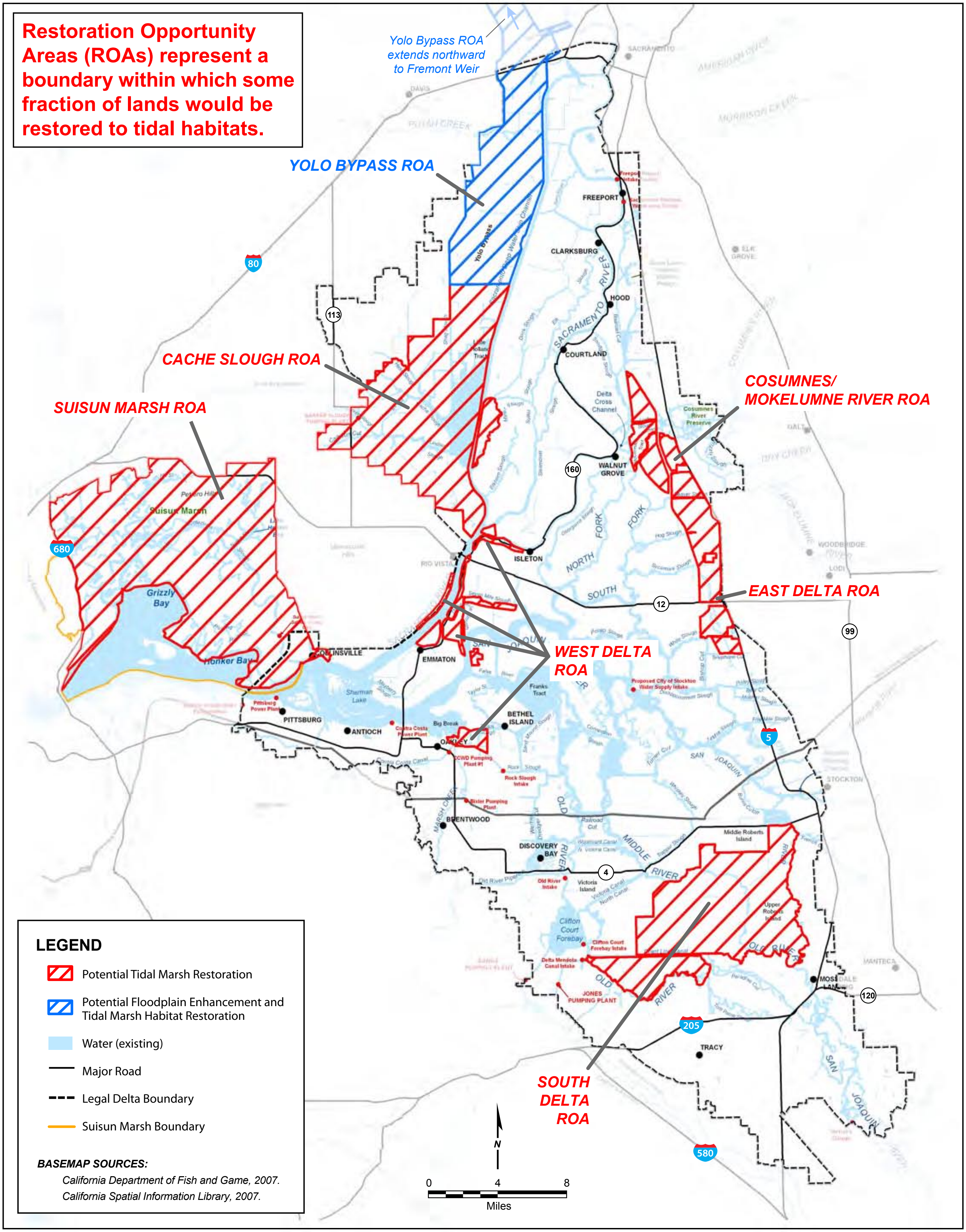

Figure 3.1
Restoration Opportunity Areas (ROAs)

Certain measures are intended to reduce inputs of pesticides, herbicides and other agricultural chemicals by working with growers through existing and new management programs; by reducing loads of toxic contaminants in urban runoff to the Delta through programs administered by local stormwater agencies; by reducing ammonia and endocrine disruptor discharge from wastewater treatment plants that may be having adverse effects on the foodweb and covered species by coordinating with regional sanitation/wastewater districts; and by reducing inputs of methylated mercury into the aquatic system. The measures also include targeted efforts to remove submerged and floating aquatic vegetation that may support habitat for bass and other predatory fish in specific reaches important to juvenile salmonid migration, thereby reducing predation rates on juvenile salmonids. Expanded and new conservation hatcheries for delta smelt and longfin smelt will establish refugial populations to avoid species extinction and allow repopulation of habitat. Other measures to improve dissolved oxygen conditions in specific problem areas important to salmonid migration, reduce covered fish species entrainment in diversions other than the SWP/CVP facilities, prevent new invasions by non-native species, and enforce harvest regulations will also be important to providing for the conservation of covered fish species.

3.2.5 Measures to Conserve Terrestrial and Wetland Wildlife and Plants

[***Note to Reviewers:*** *The measures discussed in this section are under development and are not ready for review by the Steering Committee*.]

The construction of new water diversion, conveyance, and operational control facilities and the reintroduction of tidal action to restore tidal marsh and tidal riparian habitats will adversely affect terrestrial habitats that support covered wildlife and plant species. Conservation measures to avoid and minimize the impacts on covered wildlife and plant species resulting from the development of new conveyance and associated facilities and construction of new tidal habitats are therefore included in the BDCP. In addition, actions to protect existing terrestrial (including grasslands and agricultural lands) and non-tidal wetlands (included seasonal and perennial wetlands) habitats will be implemented to offset impacts of facilities and habitat restoration construction. Seasonal wetlands will also be restored to compensate for the loss of habitat from new construction. Measures will also be implemented to ensure that the BDCP Conservation Strategy provides for the conservation of covered wildlife and plant species. As such, the Conservation Strategy includes measures to support and complement conservation strategies reflected in geographically overlapping regional HCPs and/or NCCPs approved or under development in Yolo, Solano, Sacramento, Contra Costa, and San Joaquin counties.

3.2.6 Monitoring, Research, and Adaptive Management Programs

The Conservation Strategy includes a monitoring and research program that will support a broad and robust adaptive management program that will track, test, and adjust the conservation measures to ensure a steady improvement in the effectiveness and efficiency of plan implementation over time, which may include adjusting existing conservation measures or deferring further pursuit of those measures that have not proven to be effective. The monitoring and research program will include the following types of monitoring to be conducted during plan implementation:

- Preconstruction surveys
- Construction monitoring

- Compliance monitoring
- Effectiveness monitoring
- System monitoring

The monitoring and research program will identify specific research questions and include scientific studies that will be pursued to gain additional information and understanding to enhance the effectiveness of the conservation measures. While the BDCP conservation measures have been developed with the best scientific information and knowledge currently available, much scientific uncertainty remains such that the expected outcomes that these measures are predicated on may be based on specific hypotheses that later prove false. The purpose of the monitoring and research program is to generate the information and data over the course of implementation that will be used to evaluate if these expected outcomes are occurring or, if not, what adjustments may be warranted.

As more is understood about the Delta ecosystem, modifications to the implementation of many of the BDCP conservation measures will be necessary. The BDCP adaptive management process affords the BDCP Implementing Entity (see Chapter 7, *Implementation Structure*) flexibility to make these adjustments to address substantial existing and future uncertainties, including modifications of, additions to, and removal of conservation measures and changes to the monitoring program or monitoring metrics as indicated by new scientific information (i.e., results of relevant monitoring and research). The BDCP adaptive management process would shape and guide the implementation of various components of the BDCP Conservation Strategy, including:

- approaches for implementing habitat restoration, water operations, and other stressors conservation measures;
- revising metrics and targets for biological objectives;
- revising and discarding conservation measures;
- adjusting funding levels for conservation measures;
- setting priorities and timetables for implementing actions;
- developing and adjusting research and adaptive management experiments conducted to inform implementation;
- revising adaptive management triggers;
- identifying new subjects of monitoring;
- determining changes to the duration and scope of monitoring; and
- revising monitoring methods, analytical tools, and metrics.

The adaptive management program will serve to enhance the effectiveness of the BDCP Conservation Strategy and its capacity to respond to increasing knowledge and understanding about the Delta ecosystem, natural communities, and species and to unforeseen events.

Based on the foregoing, the Plan Participants anticipate that the BDCP Conservation Strategy will provide the conditions necessary to substantially improve the Delta ecosystem and provide for the conservation of covered species over the long-term while meeting water supply reliability goals. The Conservation Strategy is expected to reconcile the protracted conflicts between the ecological needs of the Delta and its associated species and the needs related to a reliable water supply. It does so in the context of a dynamic and changing system, and one that will require adaptations necessitated by a changing climate and all that it entails.

3.3 Biological Goals and Objectives

[***Note to Reviewers****: The text of this section of Chapter 3, including the biological goals and objectives described, is subject to change and revision as the BDCP planning process progresses. This section, however, has been drafted and formatted to appear as it may in a draft HCP/NCCP. Although this section includes declarative statements (e.g., the Implementing Entity will…), it is nonetheless a "working draft" that will undergo further modification based on input from the BDCP Steering Committee, state and federal agencies, and the public.*]

3.3.1 Introduction

This section describes the biological goals and objectives for the BDCP. Biological goals are defined as broad guiding principals for development of the conservation strategy that can be parsed into more manageable subsets of biological objectives. These objectives, in turn, provide measureable metrics by which to measure progress in meeting plan goals and help inform the adaptive management process. The BDCP biological goals and objectives are consistent with the guidance provided in the federal Five-Point Policy for Habitat Conservation Plans[1] and with the BDCP Planning Agreement conservation goals and objectives. These biological goals are intended to be broad principles designed to guide the conservation strategy to meet the statutory criteria of the NCCPA and sections 7 and 10 of the ESA. These objectives may be either habitat or species based, and they are described as specific, measurable objectives.[2] Specific biological goals and objectives set parameters and benchmarks for the development and implementation of the plan's conservation measures, and help frame the monitoring and adaptive management programs.

The biological goals and objectives are purposefully framed to reflect and respond to the significant ecological complexity of the Delta and the substantial scientific uncertainties associated with it. They are designed to serve several important functions in the Conservation Strategy. The first is to describe the desired biological outcomes of the Conservation Strategy, and how those outcomes will contribute to the long-term conservation of covered species and their habitats. The second is to serve as important yardsticks by which to measure progress in achieving those outcomes across multiple temporal and spatial scales. A third, closely related function, is to provide the context and framework for the monitoring program and monitoring metrics by which to evaluate the effectiveness of the conservation measures themselves, and to inform the adaptive management program through which adjustments to the Conservation Strategy may occur over the course of its implementation.

As is standard practice in conservation planning, these biological goals and objectives are themselves not intended to constitute permit conditions or otherwise serve as hard regulatory targets for the permittees. Rather, the purpose of biological goals and objectives is to guide the development and implementation of the conservation strategy. As long as permittees properly implement the conservation strategy elements (such as the impact minimization and mitigation measures, the identified adjustments in the conservation measures through adaptive management

1 See 65 FR No. 106 at 35242 (June 1, 2000)

2 According to the federal Five Point HCP Policy, "the Services and the applicants must determine the appropriate unit of measure such as numbers of individuals at a particular life stage, all life stages, or quantity or quality of habitat." 65 Fed. Reg. 35242, 35244 (June 1, 2000).

responses, or the remedial measures for changed circumstances) they will be fulfilling their plan obligations in compliance with their section 10 and section 2835 permits.[3]

The ecological complexity of the Delta and the extent of scientific uncertainty associated with this complexity require a Conservation Strategy that is flexible, testable, and scientifically grounded. The BDCP draft Conservation Strategy is built on a set of core hypotheses about how to restore the ecological processes and functions necessary to achieve biological goals and objectives over time. The core hypotheses are articulated as problem statements that are associated with each of the biological goals and are intended to provide an orderly, scientifically-disciplined approach to managing complexity and uncertainty. These core hypotheses will be tested and evaluated, verified or adjusted as implementation proceeds through an adaptive management process. The biological goals and objectives are part of this overall approach. They are designed as a conceptual hierarchy, the components of which are measurable, transparent and verifiable. They are intended to be consistent with the goals and objectives of existing recovery plans and other regional species plan goals that have been established for the covered species so that the implementation of the BDCP contributes to the long-term conservation of covered species and their habitats.

The biological goals and objectives are organized hierarchically on the basis of the following ecological scale:

- **Ecosystem Goals and Objectives**. Ecosystem goals and objectives are focused on improvements to the overall condition of hydrological, physical, chemical, and biological processes in the Delta in support of achieving goals and objectives for natural communities and covered species.
- **Natural Community Goals and Objectives**. Natural community goals and objectives are focused on maintaining or enhancing ecological functions and values of natural communities. Achieving natural community goals and objectives also serve to conserve habitat of associated covered species and other native species.
- **Species-Specific Goals and Objectives**. Species-specific goals and objectives address species-specific stressors and habitat needs that are not addressed under the higher order ecosystem and natural community goals and objectives and, for the covered fish species, species-specific viability parameters as they relate to life stage occurrence of covered fish species in the Delta.

These goals and objectives are intended to encompass the ecological functions within the Delta that are important for covered species. They thus relate directly to the functions of habitats within the Delta that have been designated as “critical habitats” for covered species by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. Table 3.1 correlates these goals and objectives to the elements of critical habitats within the Delta deemed important by both Services for species proposed to be covered by the BDCP.

[3] As the federal fish and wildlife agencies have stated, “[w]hether the HCP is based on prescriptions, results, or both, the permittee’s obligation for meeting the biological goals and objectives is proper implementation of the operating conservation program. In other words, under the No Surprises assurances, a permittee is required only to implement the HCP, IA, if any, and terms and conditions of the permit.” 65 Fed. Reg. at 35251.

Table 3.1. Goals and Objectives that Address Primary Constituent Elements of Critical Habitat Designated for Covered Fish Species[4]

Primary Constituent Element of Critical Habitat	*Goals and Objectives that Address Primary Constituent Elements*	
	Goals	**Objectives**
Central Valley Spring-run Chinook salmon critical habitat[1]		
Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development.	Not applicable[2]	Not applicable[2]
Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.	ECSY1	ECSY1.3
		ECSY1.4
	ECSY2	ECSY2.1
	ECSY3	ECSY3.1
		ECSY3.2
	ECSY4	ECSY4.1
	ECSY5	ECSY5.1
	NACO1	NACO1.1
		NACO1.2
	GECF1	GECF1.1
		GECF1.2
		GECF1.3
		GECF1.4
	CHIN1	CHIN1.1
		CHIN1.3
	CHIN2	CHIN2.1
	CHIN3	CHIN3.1
Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.	ECSY1	ECSY1.1
		ECSY1.2
		ECSY1.3
		ECSY1.4
		ECSY1.5
	ECSY3	ECSY3.1
		ECSY3.2
	ECSY4	ECSY4.1
	ECSY5	ECSY5.1
	NACO1	NACO1.1
		NACO1.2
		NACO1.3
	GECF1	GECF1.1
		GECF1.2
		GECF1.3
		GECF1.4
	CHIN1	CHIN1.1
		CHIN1.3
	CHIN2	CHIN2.1
	CHIN3	CHIN3.1
	CHIN4	
Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.	ECSY1	ECSY1.3
		ECSY1.4
	ECSY2	ECSY2.1
	ECSY3	ECSY3.1
		ECSY3.2
	ECSY4	ECSY4.1
	ECSY5	ECSY5.1
	NACO1	NACO1.2
	CHIN1	CHIN1.1
		CHIN1.3
	CHIN2	CHIN2.1
	CHIN3	CHIN3.1

[4] Each of the goals and objectives in this table are fully described later in the text this section, and are only summarized here.

Table 3.1. Goals and Objectives that Address Primary Constituent Elements of Critical Habitat Designated for Covered Fish Species[4]

Primary Constituent Element of Critical Habitat	*Goals and Objectives that Address Primary Constituent Elements*	
	Goals	**Objectives**
Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates, and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.	Not applicable[2]	Not applicable[2]
Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.	Not applicable[2]	Not applicable[2]
Sacramento Winter-run Chinook salmon critical habitat[3]		
Access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River.	ECSY1	ECSY1.2
		ECSY1.3
		ECSY1.4
		ECSY1.5
	ECSY5	ECSY5.1
	NACO1	NACO1.1
	CHIN3	CHIN3.1
	CHIN4	
Availability of clean gravel for spawning substrate.	Not applicable[2]	Not applicable[2]
Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles.	ECSY1	ECSY1.1
		ECSY1.3
		ECSY1.4
		ECSY1.5
	ECSY5	ECSY5.1
	NACO1	NACO1.1
	CHIN3	CHIN3.1
Water temperatures between 42.5 and 57.5 °F (5.8 and 14.1 °C) for successful spawning, egg incubation, and fry development.	Not applicable[2]	Not applicable[2]
Habitat areas and adequate prey that are not contaminated.	ECSY1	ECSY1.3
		ECSY1.4
	ECSY2	ECSY2.1
	ECSY4	ECSY4.1
	ECSY5	ECSY5.1
	NACO1	NACO1.1
		NACO1.2
	CHIN1	CHIN1.1
	CHIN2	CHIN2.1
	CHIN3	CHIN3.1
Riparian habitat that provides for successful development and survival.	ECSY5	ECSY5.1
		NACO1.3
Access to downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean.	ECSY1	ECSY1.1
		ECSY1.3
		ECSY1.4
		ECSY1.5
	ECSY5	ECSY5.1
	NACO1	NACO1.1
	GECF1	GECF1.1
		GECF1.2
	CHIN1	CHIN1.1
	CHIN3	CHIN3.1

Table 3.1. Goals and Objectives that Address Primary Constituent Elements of Critical Habitat Designated for Covered Fish Species[4]

Primary Constituent Element of Critical Habitat	*Goals and Objectives that Address Primary Constituent Elements*	
	Goals	**Objectives**
Central Valley Steelhead critical habitat[4]		
Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development.	Not applicable[2]	Not applicable[2]
Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.	ECSY1	ECSY1.3
		ECSY1.4
	ECSY2	ECSY2.1
	ECSY3	ECSY3.1
		ECSY3.2
	ECSY4	ECSY4.1
	ECSY5	ECSY5.1
	NACO1	NACO1.1
		NACO1.2
	GECF1	GECF1.1
		GECF1.2
		GECF1.3
		GECF1.4
	STEE1	STEE1.1
		STEE1.2
	STEE2	STEE2.1
		STEE2.2
	STEE3	STEE3.1
Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.	ECSY1	ECSY1.1 ECSY1.2 ECSY1.3 ECSY1.4 ECSY1.5
	ECSY3	ECSY3.1
		ECSY3.2
	ECSY4	ECSY4.1
	ECSY5	ECSY5.1
	NACO1	NACO1.1
		NACO1.2
		NACO1.3
	GECF1	GECF1.1
		GECF1.2
		GECF1.3
		GECF1.4
	STEE1	STEE1.1
		STEE1.2
	STEE2	STEE2.1
		STEE2.2
	STEE3	STEE3.1
	STEE4	
Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.	ECSY1	ECSY1.3
		ECSY1.4
	ECSY2	ECSY2.1
	ECSY3	ECSY3.1
		ECSY3.2
	ECSY4	ECSY4.1
	ECSY5	ECSY5.1
	NACO1	NACO1.2
	STEE1	STEE1.1
		STEE1.2
	STEE2	STEE2.1
		STEE2.2
	STEE3	STEE3.1

Table 3.1. Goals and Objectives that Address Primary Constituent Elements of Critical Habitat Designated for Covered Fish Species[4]

Primary Constituent Element of Critical Habitat	Goals and Objectives that Address Primary Constituent Elements	
	Goals	Objectives
Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates, and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.	Not applicable[2]	Not applicable[2]
Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.	Not applicable[2]	Not applicable[2]
Green sturgeon, Southern Distinct Population Segment critical habitat[5]		
Freshwater riverine		
Food resources	ECSY1	ECSY1.3
	ECSY2	ECSY2.1
	ECSY3	ECSY3.1
		ECSY3.2
	ECSY5	ECSY5.1
Substrate type or size (i.e., structural features of substrates)	Not applicable[2]	Not applicable[2]
Water flow	ECSY1	ECSY1.1
		ECSY1.2
		ECSY1.4
		ECSY1.5
Water quality	ECSY1	ECSY1.3
	ECSY4	ECSY4.1
Migratory corridor	ECSY1	ECSY1.1
		ECSY1.2
	ECSY3	ECSY3.1
		ECSY3.2
	ECSY5	ECSY5.1
	GRST1	
Water depth		
Sediment quality		
Coastal marine		
Migratory corridor		
Water quality		
Food resources		
Delta smelt critical habitat (proposed primary constituent elements[6]		
Physical habitat (for spawning)	ECSY1	ECSY1.2
Water (for spawning, larval and juvenile transport, juvenile rearing, and adult migration)	ECSY1	ECSY1.1
		ECSY1.2
		ECSY1.3
		ECSY1.4
	ECSY2	ECSY2.1
	ECSY3	ECSY3.2
	ECSY4	ECSY4.1
	ECSY5	ECSY5.1
	NACO1	NACO1.1
		NACO1.2
	GECF1	GECF1.1
		GECF1.2
	DESM1	DESM1.2

Table 3.1. Goals and Objectives that Address Primary Constituent Elements of Critical Habitat Designated for Covered Fish Species[4]

Primary Constituent Element of Critical Habitat	Goals and Objectives that Address Primary Constituent Elements	
	Goals	Objectives
River Flow (for spawning, larval and juvenile transport, and adult migration)	ECSY1	ECSY1.1
		ECSY1.2
		ECSY1.3
		ECSY1.4
		ECSY1.5
	ECSY2	ECSY2.1
	ECSY3	ECSY3.2
	ECSY4	ECSY4.1
	ECSY5	ECSY5.1
	NACO1	NACO1.1
		NACO1.2
	GECF1	GECF1.1
		GECF1.2
	DESM1	DESM1.2
Salinity (spawning, larval and juvenile transport, juvenile rearing, and adult migration)	ECSY1	ECSY1.1
		ECSY1.2
		ECSY1.3
		ECSY1.4
	ECSY2	ECSY2.1
	ECSY3	ECSY3.1
		ECSY3.2
	ECSY5	ECSY5.1
	DESM1	DESM1.2
	DESM2	

Notes:

1. From Final Rule, Federal Register, Vol. 70, No. 170, Sep 2, 2005, pp. 52488-52627.
2. This primary constituent element is present outside of the BDCP Planning Area and, therefore, is not addressed by BDCP biological goals and objectives.
3. From Final Rule, Federal Register, Vol. 58, No. 114, June 16, 1993, pp. 33212-35219.
4. From Final Rule, Federal Register, Vol. 70, No. 170, Sep 2, 2005, pp. 52488-52627
5. From Proposed Rule, Federal Register, Vol. 73, No. 174, Sep 8, 2008, pp. 52084-52110.
6. From Final Rule, Federal Register, Vol. 59, No. 242, December 19, 1994. pp. 65256-65279.

Monitoring metrics and metric values or "targets" that may be associated with these monitoring metrics accompany these objectives and are described in Section 3.5, *Monitoring Plan*. The purpose of the metrics and targets is to describe how progress will be measured towards or away from these goals and objectives over the course of BDCP implementation. They are intended to enable the BDCP Implementing Entity and other interested parties to track how the implementation of the conservation measures may be effectuating improvements in the system as a whole at the larger scale of these objectives. In some cases, these metrics may be identical to those used to track the effectiveness of individual conservation measures; in other cases, the metrics may differ from those established for conservation measures.

The metrics and targets for biological objectives differ from the firm, measurable commitments described in the conservation measures (see Section 3.4, *Conservation Measures*), which are intended to define with specificity the obligations of the BDCP Applicants. These commitments (e.g. total acreages, quantified water operations parameters, or level of investments) are built into the conservation measures themselves and will be elements of the BDCP Implementing Agreement and the terms and conditions in the ensuing permits.

The metrics for these biological objectives are at this juncture under development, and will be included into the Monitoring and Research Program described in section 3.5. Moreover, these metrics will likely change over the term of the BDCP as new capabilities emerge to track performance in achieving the objectives and as the scientific understanding of the ecological and biological functions of the Bay Delta evolve. They are intended to serve as an essential component of the monitoring and adaptive management program for the plan, and may be changed through the BDCP adaptive management decision making process (see Section 3.6, *Adaptive Management*).

3.3.1.1 Covered Fish Species

Biological goals and objectives that address the needs of the covered fish species are to directed at improving the hydrodynamic and water quality conditions within the Delta and Suisun Bay/Marsh that support dependent life stages of the covered fish species and at reducing stressors that operate within the Delta and Suisun Bay/Marsh that suppress the survival and reproduction of the covered fish species. These stressors are described in Appendix A, Species Accounts and the biological objectives that address each of the stressors by life stage for each of the covered fish species are presented in Appendix __ [***Note to Reviewers:*** *This appendix is under development and not included in this draft*].

Figures 3.2 and 3.3 illustrate these hierarchical relationships for the covered fish species between the broad, species-level goals, the BDCP-specific biological goals and objectives, the conservation measures that are designed to achieve the biological goals and objectives (see Section 3.4, *Conservation Measures*), and the monitoring and adaptive management components of the Conservation Strategy (see Section 3.5, *Monitoring Plan* and Section 3.6, *Adaptive Management*). Figure 3.2 is focused on the relationship among the different tiers of the BDCP goals and objectives themselves, and how these tiers tie back into the viability attributes. Figure 3.3 depicts the relationship between overall general species conservation and recovery goals – at the top of the pyramid – and the key substantive components of the BDCP plan itself: the biological goals and objectives for the BDCP, the conservation measures of the BDCP, and the monitoring and adaptive management measures for the BDCP. It also describes the key attributes of long-term species viability in terms of abundance, diversity, spatial distribution and growth rates so as to demonstrate graphically how the BDCP goals and objectives and its conservation measures are intended to contribute to the achieving of these attributes. Together, these two figures are intended to illustrate the tiered conceptual hierarchy both within the BDCP itself and how it will contribute to the larger conservation goals for those species covered by the plan.

3.3.1.2 Covered Wildlife and Plant Species

Biological goals and objectives for the covered wildlife and plant species are directed towards contributing to the conservation of these species within the Delta and Suisun Marsh and for mitigating for impacts of the covered activities and conservation measures (see Chapter 4, *Covered Activities* and Section 3.4, *Conservation Measures*) on these species. The approach to conservation is anticipated to be primarily through preservation, enhancement, and restoration of covered wildlife and plant species habitats. Therefore, the anticipated metrics and targets for achieving covered wildlife and plant covered species objectives will be the extent of each species habitat (described in acres) that is preserved, enhanced, or restored, as described in the conservation measures themselves (see Section 3.4, *Conservation Measures*).

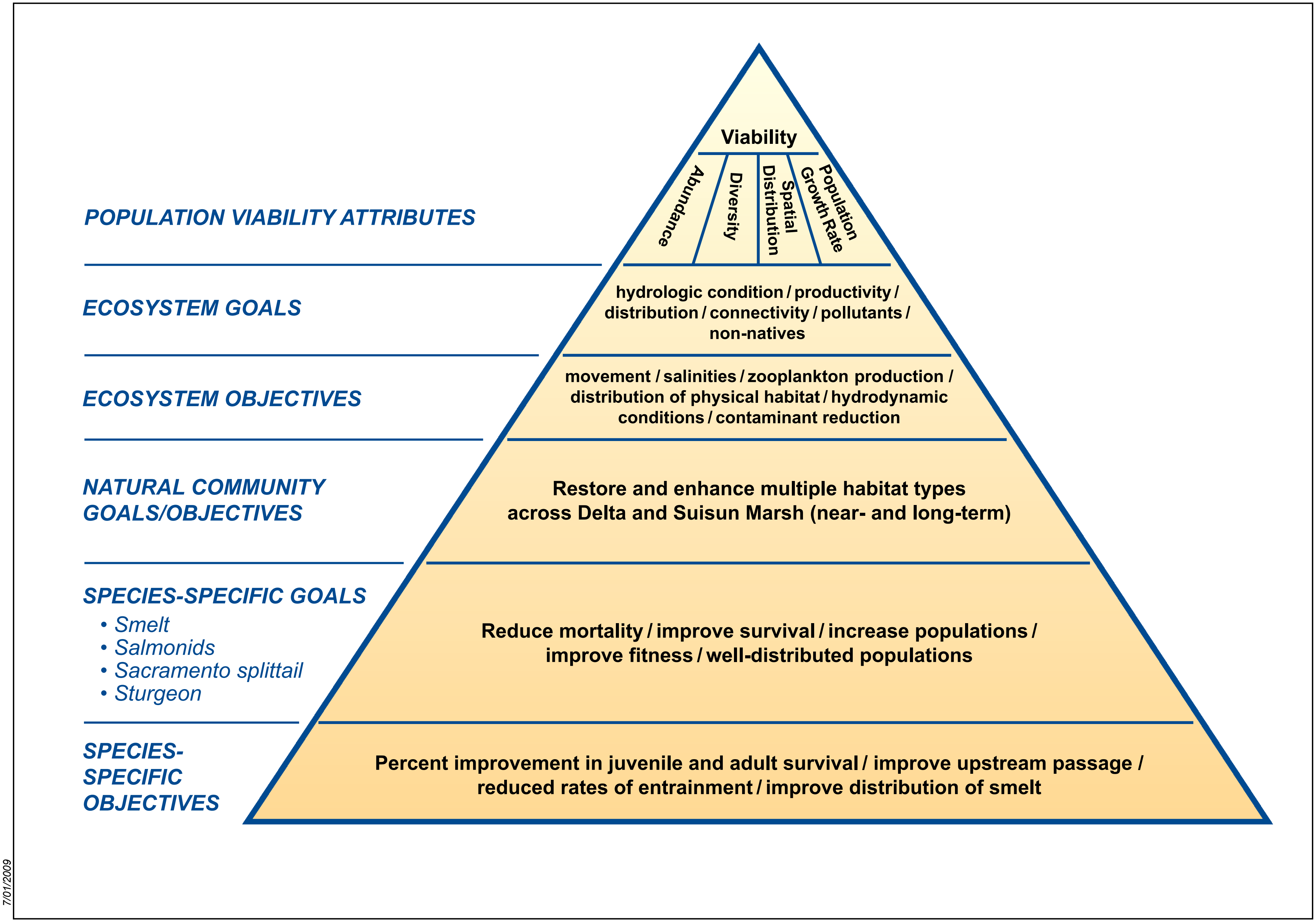

Figure 3.2
Relationships Among Goals and Objectives Tiers

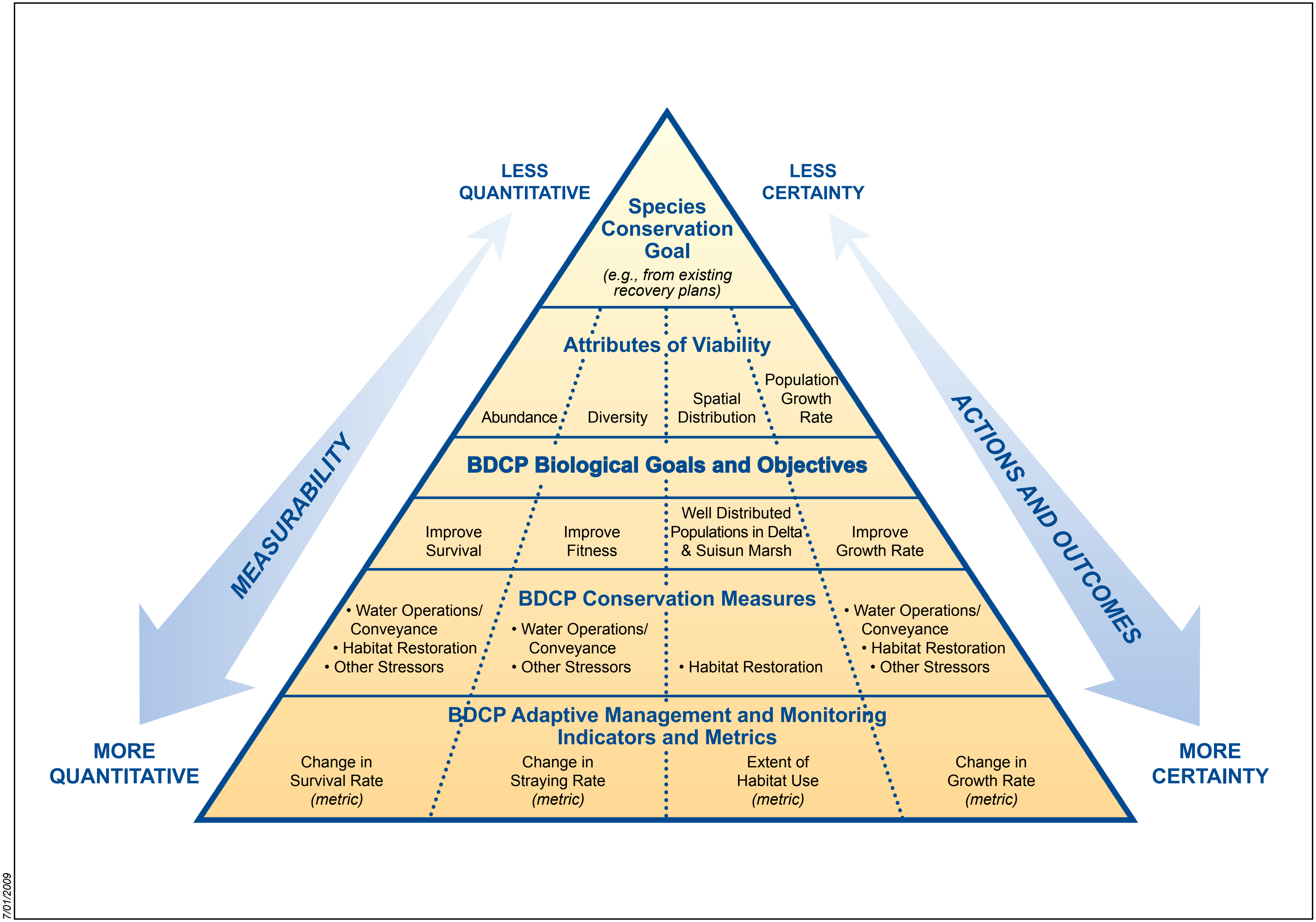

Figure 3.3
Biological Goals and Objectives: Relationships with Broader Goals, Conservation Measures, Adaptive Management, and Monitoring

The biological goals and objectives for covered wildlife and plant species are crafted such that implementation of the conservation measures that will achieve the objectives will provide for coverage of all the terrestrial covered species under the Natural Community Conservation Planning Act (NCCPA). Coverage is anticipated to be primarily provided through conservation of sufficient covered species habitats through proposed BDCP physical habitat restoration actions, undertaken in conjunction with the conservation actions under approved and planned HCP/NCCPs that intersect the BDCP planning area and Suisun Marsh. If further analysis reveals that the BDCP terrestrial conservation measures may not be well suited to the conservation standards under the NCCPA for a particular terrestrial species that will be affected by BDCP implementation because the scope of the BDCP effects on those terrestrial communities and species is relatively modest in comparison to the scale of those communities and species the BDCP Permit Applicants may seek incidental take authorizations for those species under the California Endangered Species Act.

3.3.2 Goal and Objective Statements

This section presents the ecosystem, natural community, and species-specific biological goals and objectives. These biological goals and objectives may be modified as new information is developed (e.g., results of the impact and conservation benefits assessment) through the BDCP planning process. Each goal and objective is assigned a unique alpha-numeric code that will assist with monitoring of implementation of the BDCP Conservation Strategy. A problem statement is associated with each of the biological goals. These problem statements identify the general underlying problem that the conservation measures that are designed to achieve each of the biological objectives associated with each of the goals are intended to address. The conservation measures intended to achieve each of the biological objectives are presented in Table 3.2 *[**Note to reviewers:** information for covered wildlife and plant species and terrestrial natural communities are not included in this draft]*. As is demonstrated by this table, many of the conservation measures are expected to address multiple goals and objectives, reflecting both the hierarchy of these goals and objectives and the inter-relationships amongst them.

3.3.2.1 Ecosystem Goals and Objectives

Goal ECSY1: Provide hydrodynamic conditions within Delta waterways that mimic more natural patterns of flow within the BDCP planning area and Suisun Marsh.

Problem Statement: Current hydrodynamic conditions within the Delta act as ecosystem stressors by affecting species movement among habitats (straying), natural hydrologic variability, including the timing and range of salinity gradients across the Delta, limiting habitat availability and suitability, creating conditions favoring non-native invasive species, and limiting food production. Improving these hydrodynamic conditions, so they are more naturally dynamic, will reduce the adverse effects of these functions of the Delta ecosystem for covered species.

Covered Species Benefiting: Delta Smelt, longfin smelt, splittail, all runs of Chinook, steelhead, green and white sturgeon. Achieving this goal will also address certain elements of critical habitat requirements for spring-run and winter-run Chinook salmon and Central Valley steelhead (i.e., estuarine rearing and migration area), and delta smelt (i.e., spawning habitat, larval and juvenile transport, rearing habitat, and adult migration) in the area of the BDCP.[5]

[5] See Table 3.1

Objective ECSY1.1: Improve hydrodynamic conditions to support the movement of larval and juvenile life stages of native fish species to downstream rearing habitats.

Objective ECSY1.2: Improve hydrodynamic conditions to support the movement of adult life stages of native fish species to natal spawning habitats.

Objective ECSY 1.3: Improve hydrodynamic conditions to provide salinity regimes and other water quality conditions within the Delta to help restore suitable native fish habitat and to support the effective movement of and food production for native fishes.

Objective ECSY1.4: Improve flows throughout the Delta that mimic the annual and interannual variability present in the natural hydrograph to maintain or increase life history diversity of native fishes and to provide for a diversity of rearing conditions for native fishes over time.

Objective ECSY 1.5: Improve the east to west freshwater flow patterns in the Delta to better mimic the historical east-west flow patterns that had characterized the Delta to provide increased connectivity between low salinity zone habitats and upstream freshwater habitats and availability of spawning habitats for native pelagic species.

Goal ECSY2: Increase aquatic primary and secondary production in the Delta and Suisun Marsh to increase the abundance and availability of food for native aquatic organisms.

Problem Statement: Current hydrodynamic conditions, water quality, quantity of functional inter-tidal and floodplain habitat, and the presence of non-native invasive species limit primary and secondary production in the Delta affecting its ability to support delta smelt, longfin smelt, juvenile salmonids and other native species. Increasing primary and secondary production will improve food web processes and the availability and abundance of food items at multiple trophic levels.

Covered Species Benefiting: Delta smelt, longfin smelt, all runs of salmon, steelhead, green and white sturgeon, splittail, river lamprey, and Pacific lamprey.

The following ecosystem and natural community objectives that also contribute towards achieving this goal include: ECSY1.3, ECSY3.1-3.2, ECSY4.1, ECSY5.1, and NACO1.1-1.3.

Objective ECSY2.1: Over the term of the BDCP, increase the abundance of aquatic invertebrate species that provide food and support food production for covered fish species in Delta waterways.

Goal ECSY3: Reduce the adverse effects of non-native species on Delta ecosystem processes and native aquatic species.

Problem Statement: Alterations of the Delta ecosystem caused by non-native species have reduced habitat suitability (e.g., turbidity effect, changes in habitat structure) and changed predator-prey and competitive relationships between native and non-native species are major stressors on covered fish species. Reducing the adverse effects of non-native species is expected to increase survival and abundance of covered fish species.

Table 3.2. Relationship of Goals and Objectives to Conservation Measures

Objectives	*Conservation Measures that Address the Objective*
Goal ECSY1: Provide hydrodynamic conditions within Delta waterways that mimic more natural patterns of flow within the BDCP planning area and Suisun Marsh.	
ECSY1.1: Improve hydrodynamic conditions to support the movement of larval and juvenile life stages of native fish species to downstream rearing habitats.	WOCML1, WOCMN5, WOCML5, WOCMN6, WOCML6, WOCMN8, WOCMN9, WOCML9, WOCMN11, WOCML11, WOCMN12, WOCML12
ECSY1.2: Improve hydrodynamic conditions to support the movement of adult life stages of native fish species to natal spawning habitats.	WOCML1, WOCML2, WOCMN6, WOCML6, WOCMN9, WOCML9, WOCMN12, WOCML12
ECSY 1.3: Improve hydrodynamic conditions to provide salinity regimes and other water quality conditions within the Delta to help restore suitable native fish habitat and to support the effective movement of and food production for native fishes.	WOCML1, WOCMN5, WOCML5, WOCMN6, WOCML6, WOCMN8, WOCMN9, WOCML9, WOCMN11, WOCML11, WOCMN12, WOCML12, WOCMN14, WOCML14, WOCML#
ECSY1.4: Improve flows throughout the Delta that mimic the annual and interannual variability present in the natural hydrograph to maintain or increase life history diversity of native fishes and to provide for a diversity of rearing conditions for native fishes over time.	WOCML1, WOCML2, HRCM17, WOCMN6, WOCML6, WOCMN9, WOCML9, WOCMN11, WOCML11, WOCMN12, WOCML12, WOCML#
ECSY 1.5: Improve the east to west freshwater flow patterns in the Delta to better mimic the historical east-west flow patterns that had characterized the Delta to provide increased connectivity between low salinity zone habitats and upstream freshwater habitats and availability of spawning habitats for native pelagic species.	WOCML1, WOCML2, WOCMN5, WOCML5, WOCMN6, WOCML6, WOCMN9, WOCML9, WOCMN11, WOCML11, WOCMN12, WOCML12, WOCML#
Goal ECSY2: Increase aquatic primary and secondary production in the Delta and Suisun Marsh to increase the abundance and availability of food for native aquatic organisms.	
ECSY2.1: Over the term of the BDCP, increase the abundance of aquatic invertebrate species that provide food and support food production for covered fish species in Delta waterways.	HRCM1/HRCM2, HRCM3, HRCM4, HRCM5, HRCM6, HRCM7, HRCM8, HRCM9, HRCM11/HRCM14, HRCM12, HRCM13, HRCM15, HRCM 16, HRCM ##, OSCM1, OSCM4, OSCM5, OSCM21, WOCML1, WOCML2, HRCM17, WOCMN12, WOCML12
Goal ECSY3: Reduce the adverse effects of non-native species on Delta ecosystem processes and native aquatic species.	
ECSY3.1: Manage the distribution and abundance of established non-native invasive species in the Delta to reduce non-native species predation on and competition with native fishes and to rehabilitate aquatic ecosystem processes.	HRCM12, HRCM13, HRCM15, HRCM##, OSCM13, OSCM14, OSCM24, WOCML#
ECSY3.2: Minimize the likelihood for future invasions and establishment of non-native species into the Delta's aquatic ecosystem.	OSCM10, OSCM11
Goal ECSY4: Reduce the adverse effects of contaminants on the Delta's aquatic ecosystem.	
ECSY4.1: Contribute to specific actions which have a demonstrated positive effect in improving the aquatic ecosystem by reducing the load of contaminants of concern entering the Delta.	OSCM1, OSCM2, OSCM3, OSCM4, OSCM5, OSCM8

Table 3.2. Relationship of Goals and Objectives to Conservation Measures

Objectives	*Conservation Measures that Address the Objective*
Goal ECSY5: Increase the extent and improve the amount, spatial distribution, function, and connectivity of natural communities across the Delta and the connectivity with communities upstream and downstream of the Delta to support ecosystem productivity and the effective movement and genetic exchange of covered species within and among natural communities both inside and outside of the BDCP Planning Area.	
ECSY5.1: Protect and expand the availability of spatially well-distributed aquatic and terrestrial natural communities to support increased distribution of covered species, aquatic productivity, and improved connectivity among natural communities within and adjacent to the BDCP planning area.	HRCM1/HRCM2, HRCM3, HRCM4, HRCM5, HRCM6, HRCM7, HRCM8, HRCM9, HRCM12, HRCM13, HRCM11/HRCM14, HRCM15, HRCM 16. HRCM##, OSCM7, WOCML1, WOCML2, HRCM17, WOCMN5, WOCML5, WOCMN6, WOCML6, WOCMN9, WOCML9, WOCMN11, WOCML11, WOCMN12, WOCML12
Goal NACO1: Protect, enhance, and restore natural communities to provide habitat and ecosystem functions to increase the natural production (reproduction, growth, and survival), abundance, and distribution of native Delta species.	
NACO1.1: Increase hydrologic connectivity of Delta waterways with existing and historical floodplains to support habitat and food production for associated native species.	HRCM1/HRCM2, HRCM3, WOCML2, HRCM17, WOCML#
NACO1.2: Increase the extent and spatial distribution of tidal marsh within the Planning Area and Suisun Marsh to support habitat and food production for associated native species.	HRCM4, HRCM5, HRCM6, HRCM7, HRCM8, HRCM9, HRCM 16
NACO1.3: Increase the extent and spatial distribution of riparian forest and scrub within the Planning Area to support habitat and food production for associated native species and increase connectivity among native habitats within and adjacent to the Planning Area.	*HRCM12, HRCM13, HRCM11/HRCM14, HRCM15, HRCM##*
NACO1.4: Preserve agricultural lands, including rice, alfalfa, field crops, and other irrigated croplands in and adjacent to the Planning Area that are managed to support habitat for native species.	[*Terrestrial Species Conservation Measures to come.*]
NACO1.5: Preserve grassland communities in and adjacent to the Planning Area that support habitat for associated native species.	[*Terrestrial Species Conservation Measures to come.*]
NACO1.6: Preserve natural seasonal wetlands, including vernal pool, vernal pool complex, alkaline/saline seasonal wetland, and alkaline sink scrub habitats and their watersheds, and managed wetlands in and adjacent to the Planning Area that support habitat for associated native species.	[*Terrestrial Species Conservation Measures to come.*]
Objective NACO1.7: Preserve non-tidal perennial aquatic and associated non- perennial permanent emergent marsh communities in and adjacent to the Planning Area that support habitat for associated native species.	[*Terrestrial Species Conservation Measures to come.*]
Goal GECF1: Increase the abundance of covered fish species by reducing sources of unnatural mortality.	
GECF1.1: Reduce entrainment mortality of covered fish species at non-project diversions.	OSCM21, OSCM25, WOCML#
GECF1.2: Minimize the adverse effects of harvest on longfin smelt, green and white sturgeon, splittail, and all runs of Chinook salmon.	OSCM14, OSCM16, OSCM17, OSCM19

Table 3.2. Relationship of Goals and Objectives to Conservation Measures

Objectives	*Conservation Measures that Address the Objective*
Goal GECF2: Reduce impacts of hatcheries on the genetic integrity of artificially propagated and natural populations of covered fish species.	
GECF2.1: Minimize the adverse effects of salmonid hatcheries on the genetic integrity of wild Chinook salmon and steelhead populations.	OSCM18, OSCM19
GECF2.2: Maintain or establish genetic refugia for delta smelt and longfin smelt to reduce the risk for the extinction of delta smelt and the extirpation of longfin smelt.	OSCM20
Goal DESM1: Create conditions that support a self-sustaining population of delta smelt in the Delta and Suisun Bay.	
DESM1.1: Increase the abundance of delta smelt within the Delta and Suisun Bay to levels that will support a self-sustaining delta smelt population.	HRCM4, HRCM6, HRCM16, OSCM1, OSCM2, OSCM4, OSCM5, OSCM8, OSCM10, OSCM11, OSCM13, OSCM20, OSCM21, OSCM24, WOCML1, WOCML2, HRCM17, WOCMN5, WOCML5, WOCMN6, WOCML6, WOCMN8, WOCMN9, WOCML9, WOCMN11, WOCML11, WOCMN12, WOCML12
DESM1.2: Increase delta smelt population growth rates in future years from growth rates observed during years of comparable hydrology under existing conditions to levels that will contribute to the long-term sustainability of the smelt population in the Delta and Suisun Bay.	HRCM1/HRCM2, HRCM3, HRCM4, HRCM5, HRCM6, HRCM7, HRCM8, HRCM9, HRCM12, HRCM13, HRCM11/HRCM14, HRCM15, HRCM16, HRCM##, OSCM1, OSCM4, OSCM5, OSCM10, OSCM11, WOCML1, WOCML2, HRCM17, WOCMN6, WOCML6, WOCMN11, WOCML11
Goal LOSM1: Create conditions that support a self-sustaining population of longfin smelt in the Delta and Suisun Bay.	
LOSM1.1: Increase the abundance of longfin smelt within the Delta and Suisun Bay to levels that will contribute to supporting a self-sustaining longfin smelt population.	HRCM6, HRCM16, OSCM1, OSCM2, OSCM4, OSCM5, OSCM8, OSCM10, OSCM11, OSCM13, OSCM16, OSCM20, OSCM21, OSCM24, WOCML1, WOCMN5, WOCML5, WOCMN6, WOCML6, WOCMN8, WOCMN9, WOCML9, WOCMN11, WOCML11, WOCMN12, WOCML12
LOSM1.2: Increase longfin smelt population growth rates in the Delta and Suisun Bay to levels that will contribute to the long-term sustainability of the longfin smelt population in the Delta and Suisun Bay.	HRCM1/HRCM2, HRCM3, HRCM4, HRCM5, HRCM6, HRCM7, HRCM8, HRCM9, HRCM12, HRCM13, HRCM11/HRCM14, HRCM15, HRCM16, HRCM##, OSCM1, OSCM4, OSCM5, OSCM10, OSCM11, WOCML1, WOCMN6, WOCML6, WOCMN11, WOCML11
Goal CHIN1: Increase the survival of juvenile Chinook salmon rearing in and migrating through the Delta to contribute to the long-term viability of Chinook salmon populations.	
CHIN1.1: Increase the survival of juvenile Sacramento Basin spring-, fall-, and winter-runs of Chinook salmon rearing in and migrating through the Delta to Chipps Island to levels that will contribute to the long-term viability of their populations.	HRCM12, HRCM11/HRCM14, HRCM15, HRCM##, OSCM1, OSCM4, OSCM5, OSCM8, OSCM10, OSCM11, OSCM13, OSCM14, OSCM16, OSCM21, OSCM24, WOCML2, HRCM17, WOCMN5, WOCML5, WOCMN6, WOCML6, WOCMN8, WOCMN12, WOCML12
CHIN1.2: Increase the survival of juvenile San Joaquin Basin fall-run Chinook salmon, including the Mokelumne and Cosumnes River salmon, rearing in and migrating through the Delta to Chipps Island to levels that will contribute to the long-term viability of the population.	HRCM11/HRCM14, OSCM1, OSCM4, OSCM5, OSCM7, OSCM8, OSCM10, OSCM11, OSCM13, OSCM14, OSCM16, OSCM21, OSCM24, WOCML1, WOCMN12, WOCML12

Table 3.2. Relationship of Goals and Objectives to Conservation Measures

Objectives	*Conservation Measures that Address the Objective*
CHIN1.3: When a spawning population of spring-run Chinook salmon is established in the San Joaquin River, provide for survival of San Joaquin Basin spring-run Chinook salmon rearing in and migrating through the Delta to Chips Island to levels that will support the long-term viability of the population.	HRCM11/HRCM14, OSCM1, OSCM4, OSCM5, OSCM7, OSCM8, OSCM10, OSCM11, OSCM13, OSCM14, OSCM16, OSCM21, OSCM24, WOCML1, WOCMN12, WOCML12
Goal CHIN2: Increase the growth of juvenile Chinook salmon that pass through and rear in the Delta to increase the survival of juvenile Chinook salmon in San Francisco Bay and ocean habitats.	
CHIN2.1: Increase the mean weight and length of juvenile Sacramento Basin spring-run Chinook salmon, fall/late fall-run Chinook salmon, and winter-run Chinook salmon rearing in and migrating through the Delta to Chipps Island.	HRCM4, HRCM6, HRCM9, HRCM12, HRCM11/HRCM14, HRCM15, HRCM16, HRCM##, OSCM1, OSCM4, OSCM5, OSCM10, OSCM11, WOCML2, HRCM17, WOCMN11, WOCML11
CHIN2.2: Increase the mean weight and length of juvenile San Joaquin Basin fall-run Chinook salmon, including the Mokelumne and Cosumnes River salmon, rearing in and migrating through the Delta to Chipps Island.	HRCM1/HRCM2, HRCM3, HRCM5, HRCM6, HRCM7, HRCM8, HRCM9, HRCM13, HRCM11/HRCM14, HRCM15, HRCM16, HRCM##, OSCM1, OSCM4, OSCM5, OSCM10, OSCM11, WOCMN11, WOCML11
Goal CHIN3: Increase the life history diversity of all runs of Chinook salmon.	
CHIN3.1: Increase the survival of juvenile and adult Chinook salmon in populations using the Delta across the temporal distributions for each run.	HRCM1/HRCM2, HRCM3, HRCM4, HRCM5, HRCM6, HRCM7, HRCM8, HRCM9, HRCM12, HRCM13, HRCM15, HRCM16, HRCM##, OSCM18, WOCML1, WOCML2, HRCM17
Goal CHIN4: Increase the proportion of each run of adult Chinook salmon that migrate successfully through the Delta to upstream spawning habitats.	
<No specific objectives>	OSCM7, OSCM19, WOCML2, WOCMN5, WOCML5, WOCMN6, WOCML6
Goal STEE1: Increase the survival of juvenile Central Valley steelhead rearing in and migrating through the Delta to contribute to the long-term viability of that steelhead population.	
STEE1.1: Increase the survival of juvenile Sacramento Basin steelhead rearing in and migrating through the Delta to Chipps Island to levels that will contribute to the long-term viability of the population.	HRCM12, HRCM11/HRCM14, HRCM15, HRCM##, OSCM1, OSCM4, OSCM5, OSCM8, OSCM10, OSCM11, OSCM13, OSCM14, OSCM16, OSCM21, OSCM24, WOCML2, HRCM17, WOCMN5, WOCML5, WOCMN6, WOCML6, WOCMN8, WOCMN12, WOCML12
STEE1.2: Increase the survival of juvenile San Joaquin Basin steelhead, including the Mokelumne and Cosumnes River steelhead, rearing in and migrating through the Delta to Chipps Island to levels that will contribute to the long-term viability of the population.	HRCM13, HRCM11/HRCM14, HRCM15, HRCM##, OSCM1, OSCM4, OSCM5, OSCM7, OSCM8, OSCM10, OSCM11, OSCM13, OSCM14, OSCM16, OSCM21, OSCM24, WOCML1, WOCMN12, WOCML12
Goal STEE2: Increase the growth of juvenile steelhead that migrate through and rear in the Delta to increase the likelihood for survival of juvenile steelhead in San Francisco Bay and ocean habitats.	
STEE2.1: Increase the mean weight and length of juvenile Sacramento Basin steelhead rearing in and migrating through the Delta to Chipps Island.	HRCM4, HRCM6, HRCM9, HRCM12, HRCM11/HRCM14, HRCM15, HRCM16, HRCM##, OSCM1, OSCM4, OSCM5, OSCM10, OSCM11, WOCML2, HRCM17, WOCMN11, WOCML11

Table 3.2. Relationship of Goals and Objectives to Conservation Measures

Objectives	*Conservation Measures that Address the Objective*
STEE2.2: Increase the mean weight and length of juvenile San Joaquin Basin steelhead, including the Mokelumne and Cosumnes River steelhead, rearing in and migrating through the Delta to Chipps Island.	HRCM1/HRCM2, HRCM3, HRCM5, HRCM6, HRCM7, HRCM8, HRCM9, HRCM13, HRCM11/HRCM14, HRCM15, HRCM16, HRCM##, OSCM1, OSCM4, OSCM5, OSCM10, OSCM11, WOCML1, WOCMN11, WOCML11
Goal STEE3: Increase the life history diversity of Central Valley steelhead.	
STEE3.1: Increase the survival of juvenile and adult steelhead in populations using the Delta across the temporal distributions for each run.	HRCM1/HRCM2, HRCM3, HRCM4, HRCM5, HRCM6, HRCM7, HRCM8, HRCM9, HRCM12, HRCM13, HRCM15, HRCM16, HRCM##, OSCM18
Goal STEE4: Increase the proportion of all adult Central Valley steelhead populations that migrate successfully through the Delta to upstream spawning habitats.	
<No specific objectives>	OSCM7, OSCM13, WOCML2, WOCMN5, WOCML5
Goal SASP1: Maintain and conserve a self-sustaining population of Sacramento splittail in the Delta.	
SASP 1.1: Contribute towards increasing the abundance of Sacramento splittail within the Delta and Suisun Bay.	HRCM1/HRCM2, HRCM3, HRCM12, HRCM13, HRCM15, HRCM##, OSCM1, OSCM2, OSCM3, OSCM4, OSCM5, OSCM8, OSCM10, OSCM11, OSCM13, OSCM17, OSCM21, OSCM24, WOCML1, WOCML2, HRCM17, WOCMN5, WOCML5, WOCMN8, WOCMN9, WOCML9, WOCMN12, WOCML12
SASP1.2: Maintain the distribution of Sacramento splittail within the Delta and Suisun Bay to achieve target distribution values.	HRCM1/HRCM2, HRCM3, HRCM4, HRCM5, HRCM6, HRCM7, HRCM8, HRCM9, HRCM12, HRCM13, HRCM15, HRCM16, HRCM##, OSCM1, OSCM2, OSCM13, OSCM14, OSCM21, WOCML2, HRCM17, WOCMN11, WOCML11, WOCMN14, WOCML14
SASP1.3: Maintain connectivity between Central Valley and Napa/Petaluma Sacramento splittail populations.	HRCM6, HRCM9, HRCM16, WOCMN9, WOCML9, WOCMN12, WOCML12:
SASP1.4: Maintain multiple spawning cohorts of Sacramento splittail as part of the breeding population.	WOCML2, HRCM17
Goal GRST1: Increase the number of green sturgeon successfully migrating upstream and downstream through the Delta.	
<No specific objectives>	OSCM2, OSCM16, WOCML2, WOCMN11, WOCML11
Goal GRST2: Increase the spatial distribution of juvenile green sturgeon within the Delta.	
<No specific objectives>	HRCM4, HRCM6, HRCM9, HRCM16, WOCMN11, WOCML11
Goal WHST1: Increase the number of white sturgeon successfully migrating upstream and downstream through the Delta.	
<No specific objectives>	OSCM2, WOCML2, WOCMN11, WOCML11
Goal WHST2: Increase the spatial distribution of white sturgeon within the Delta.	
<No specific objectives>	HRCM4, HRCM5, HRCM6, HRCM7, HRCM8, HRCM9, HRCM16, WOCMN11, WOCML11
Goal WHST3: Maintain multiple age classes of spawning cohorts of white sturgeon.	
<No specific objectives>	OSCM16, WOCML1, WOCMN12, WOCML12

Table 3.2. Relationship of Goals and Objectives to Conservation Measures

Objectives	*Conservation Measures that Address the Objective*
Goal RILA1: Maintain the ecological functions of the Delta that support a self-sustaining population of river lamprey in the Central Valley.	
<No specific objectives>	OSCM1, OSCM2, OSCM3, OSCM4, OSCM5, OSCM10, OSCM11, OSCM21, WOCML1, WOCML2, WOCMN6, WOCML6, WOCMN9, WOCML9, WOCMN12, WOCML12
Goal PALA1: Maintain the ecological functions of the Delta that support a self-sustaining population of river lamprey in the Central Valley.	
<No specific objectives>	OSCM1, OSCM2, OSCM3, OSCM4, OSCM5, OSCM10, OSCM11, OSCM21, WOCML1, WOCML2, WOCMN6, WOCML6, WOCMN9, WOCML9, WOCMN12, WOCML12

Covered Species Benefiting: Delta smelt, longfin smelt, all runs of salmon, steelhead. Achieving this goal will also address certain elements of critical habitat requirements for spring-run and winter-run Chinook salmon and Central Valley steelhead (i.e., estuarine rearing and migration area) in the area of the BDCP.[6]

> **Objective ECSY3.1:** Manage the distribution and abundance of established non-native invasive species in the Delta to reduce non-native species predation on and competition with native fishes and to rehabilitate aquatic ecosystem processes.

> **Objective ECSY3.2:** Minimize the likelihood for future invasions and establishment of non-native species into the Delta's aquatic ecosystem.

Goal ECSY4: Reduce the adverse effects of contaminants on the Delta's aquatic ecosystem.

Problem Statement: A variety of contaminants entering Delta waterways are known or believed to have direct lethal and sublethal effects on fish species and food web processes that adversely affect food abundance and availability. Reducing the loads of contaminants of concern entering the Delta is expected to increase survival and abundance of covered fish species.

Covered Species Benefiting: Delta smelt, longfin smelt, all runs of salmon, steelhead, green and white sturgeon, splittail, river lamprey, and Pacific lamprey. Achieving this goal will also address certain elements of critical habitat requirements for spring-run and winter-run Chinook salmon and Central Valley steelhead (i.e., estuarine rearing and migration area in the area of the BDCP).[7]

> **Objective ECSY4.1:** Contribute to specific actions which have a demonstrated positive effect in improving the aquatic ecosystem by reducing the load of contaminants of concern entering the Delta.

Goal ECSY5: Increase the extent and improve the amount, spatial distribution, function, and connectivity of natural communities across the Delta and the connectivity with communities upstream and downstream of the Delta to support ecosystem productivity and the effective movement and genetic exchange of covered species within and among natural communities both inside and outside of the BDCP Planning Area.

Problem Statement: Insufficient area, function, and connectivity among and accessibility to natural communities within and outside the BDCP Planning Area inhibit proper ecosystem function and support for native species. Expanding the extent and improving the function and connectivity between and accessibility to natural communities will enhance ecosystem processes and productivity to support improved abundance, distribution, diversity, and growth of covered species populations and other native species.

Covered Species Benefiting: All covered species are expected to benefit from this goal. Achieving this goal will also address certain elements of critical habitat requirements for spring-run and winter-run Chinook salmon and Central Valley steelhead (i.e., freshwater rearing, freshwater migration corridors, and estuarine rearing and migration area), and delta smelt (i.e., spawning habitat, larval and juvenile transport, rearing habitat, and adult migration) in the area of the BDCP.[8]

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[6] See Table 3.1

[7] See Table 3.1

[8] See Table 3.1

The following ecosystem and natural community objectives also contribute towards achieving this goal: ECSY1.1-1.3 and NACO1.1-1.5.

> **Objective ECSY5.1:** Protect and expand the availability of spatially well-distributed aquatic and terrestrial natural communities to support increased distribution of covered species, aquatic productivity, and improved connectivity among natural communities within and adjacent to the BDCP planning area.

3.3.4 Natural Community Goals and Objectives

Note to Reviewers: The natural community goals and objectives described below are currently under review by the BDCP Terrestrial Resources Subgroup and may be revised on approval by the BDCP Steering Committee of any recommendations for such changes that may be proposed as a result of the Subgroup's review.

Goal NACO1: Protect, enhance, and restore natural communities to provide habitat and ecosystem functions to increase the natural production (reproduction, growth, and survival), abundance, and distribution of native Delta species.

Problem Statement: Habitat essential for the spawning, incubation, rearing, and foraging of native fishes has been degraded in and around the Planning Area, and this has restricted species distribution, life history diversity, and growth of covered fish species. Increasing aquatic habitats and preserving, enhancing, and restoring terrestrial habitats that support the aquatic environment is expected to increase the distribution, life history diversity and growth of covered fish species populations. Substantial reduction in the extent, distribution, and condition of historical wetland and upland habitats supporting native wildlife and plants in and around the Planning Area has also reduced the distribution and abundance of these native species. Preserving, enhancing, and restoring native habitats and agricultural habitats that now support native wildlife is expected to increase the abundance and distribution of native wildlife and plant species, improve connectivity among habitat areas within and adjacent to the Planning Area, and improve genetic interchange among species' populations.

Covered Species Benefiting: All BDCP covered species are expected to benefit from achievement of the natural community biological objectives.

> **Objective NACO1.1:** Increase hydrologic connectivity of Delta waterways with existing and historical floodplains to support habitat and food production for associated native species.

> **Objective NACO1.2:** Increase the extent and spatial distribution of tidal marsh within the Planning Area and Suisun Marsh to support habitat and food production for associated native species.

> **Objective NACO1.3:** Increase the extent and spatial distribution of riparian forest and scrub within the Planning Area to support habitat and food production for associated native species and increase connectivity among native habitats within and adjacent to the Planning Area.

Objective NACO1.4: Preserve agricultural lands, including rice, alfalfa, field crops, and other irrigated croplands in and adjacent to the Planning Area that are managed to support habitat for native species.

Objective NACO1.5: Preserve grassland communities in and adjacent to the Planning Area that support habitat for associated native species.

Objective NACO1.6: Preserve natural seasonal wetlands, including vernal pool, vernal pool complex, alkaline/saline seasonal wetland, and alkaline sink scrub habitats and their watersheds, and managed wetlands in and adjacent to the Planning Area that support habitat for associated native species.

Objective NACO1.7: Preserve non-tidal perennial aquatic and associated non-tidal perennial permanent emergent marsh communities in and adjacent to the Planning Area that support habitat for associated native species.

3.3.5 General Covered Fish Species Goals and Objectives

The general covered fish species goals and objectives apply to several of the covered fish species. Biological goals and objectives specific to each of the covered fish species are presented in Section 3.3.6, *Covered Fish Species Goals and Objectives*.

Goal GECF1: Increase the abundance of covered fish species by reducing sources of unnatural mortality.

Problem Statement: Non-natural sources of mortality are a substantial factor inhibiting the abundance and distribution of covered species and the diversity and growth of their populations. Reducing the proportion of covered fish species populations that are subject to loss from these sources of mortality will support increasing the abundance, distribution, diversity, and growth of covered fish species populations.

Covered Species Benefiting: All covered fish species are expected to benefit from achieving this goal. Achieving this goal include will also address certain elements of critical habitat requirements for spring-run and winter-run Chinook salmon and Central Valley steelhead (i.e., estuarine rearing and migration area), and delta smelt (i.e., spawning habitat, larval and juvenile transport, rearing habitat, and adult migration) in the area of the BDCP (see Table 3.1).

Objective GECF1.1: Reduce entrainment mortality of covered fish species at non-project diversions.

Objective GECF1.2: Minimize the adverse effects of harvest on longfin smelt, green and white sturgeon, splittail, and all runs of Chinook salmon.

Goal GECF2: Reduce impacts of hatcheries on the genetic integrity of artificially propagated and natural populations of covered fish species.

Problem Statement: Fish hatcheries may lower the genetic fitness of wild fish populations. Hatcheries may also support negative interactions between hatchery and wild fish (e.g., competition for spawning and rearing habitat and food), which inhibit the abundance, life history diversity, and growth of self-sustaining populations of covered species. Reducing the negative impacts of hatcheries on the wild fish populations will support improved abundance, distribution, diversity, and growth of these wild populations.

Objective GECF2.1: Minimize the adverse effects of salmonid hatcheries on the genetic integrity of wild Chinook salmon and steelhead populations.

Objective GECF2.2: Maintain or establish genetic refugia for delta smelt and longfin smelt to reduce the risk for the extinction of delta smelt and the extirpation of longfin smelt.

3.3.6 Covered Fish Species Goals and Objectives

Delta Smelt

Goal DESM1: Create conditions that support a self-sustaining population of delta smelt in the Delta and Suisun Bay.

Problem Statement: Existing conditions at the ecological, natural community, and species-specific scales are leading to the extinction of delta smelt. Self-sustaining delta smelt populations require conditions that provide for adequate spatial distribution, abundance, and population growth. These ecological, natural community and species specific conditions can be changed sufficiently in the Delta and Suisun Bay to provide characteristics that will support a self-sustaining delta smelt population.

Objective DESM1.1: Increase the abundance of delta smelt within the Delta and Suisun Bay to levels that will support a self-sustaining delta smelt population.

Objective DESM1.2: Increase delta smelt population growth rates in future years from growth rates observed during years of comparable hydrology under existing conditions to levels that will contribute to the long-term sustainability of the smelt population in the Delta and Suisun Bay.

Other biological objectives that contribute towards achieving this goal include: ECSY1.1-1.5, ECSY2.1, ECSY3.1-3.2, ECSY4.1, ECSY5.1, NACO1.1-1.3, GECF1.1-1.3, and GECF2.2.

Longfin Smelt

Goal LOSM1: Create conditions that support a self-sustaining population of longfin smelt in the Delta and Suisun Bay.

Problem Statement: Existing conditions at the ecological, natural community, and species-specific scales have led to a large decline in longfin smelt population size. Self-sustaining populations require conditions that provide for adequate spatial distribution, abundance, and population growth. These ecological, natural community, and specific-specific conditions can be changed sufficiently in the Delta and Suisun Bay to provide characteristics to support a self-sustaining longfin smelt population.

Objective LOSM1.1: Increase the abundance of longfin smelt within the Delta and Suisun Bay to levels that will contribute to supporting a self-sustaining longfin smelt population.

Objective LOSM1.2: Increase longfin smelt population growth rates in the Delta and Suisun Bay to levels that will contribute to the long-term sustainability of the longfin smelt population in the Delta and Suisun Bay.

Other biological objectives that contribute towards achieving this goal include: ECSY1.1-1.5, ECSY2.1, ECSY3.1-3.2, ECSY4.1, ECSY5.1, NACO1.1-1.3, GECF1.1-1.4, and GECF2.2.

Chinook Salmon

Goal CHIN1: Increase the survival of juvenile Chinook salmon rearing in and migrating through the Delta to contribute to the long-term viability of Chinook salmon populations.

Problem Statement: Mortality rates of juvenile Chinook salmon attributable to multiple factors within the Delta inhibit the growth of Chinook salmon populations. Reducing mortality rates of juvenile Chinook salmon in the Delta will support improved abundance, distribution, diversity, and growth of Chinook salmon populations.

Objective CHIN1.1: Increase the survival of juvenile Sacramento Basin spring-, fall-, and winter-runs of Chinook salmon rearing in and migrating through the Delta to Chipps Island to levels that will contribute to the long-term viability of their populations.

Objective CHIN1.2: Increase the survival of juvenile San Joaquin Basin fall-run Chinook salmon, including the Mokelumne and Cosumnes River salmon, rearing in and migrating through the Delta to Chipps Island to levels that will contribute to the long-term viability of the population.

Objective CHIN1.3: When a spawning population of spring-run Chinook salmon is established in the San Joaquin River, provide for survival of San Joaquin Basin spring-run Chinook salmon rearing in and migrating through the Delta to Chips Island to levels that will support the long-term viability of the population.

Other biological objectives that contribute towards achieving this goal include: ECSY1.1, ECSY1.3-1.5, ECSY2.1, ECSY3.1-3.2, ECSY4.1, ECSY5.1, NACO1.1-1.3, GECF1.1-1.4, and GECF2.1.

Goal CHIN2: Increase the growth of juvenile Chinook salmon that pass through and rear in the Delta to increase the survival of juvenile Chinook salmon in San Francisco Bay and ocean habitats.

Problem Statement: Vulnerability to poor ocean conditions is believed to increase when Chinook salmon smolts enter the ocean smaller than optimal. Since riverine ecosystems tend to be less productive than estuarine ecosystems for salmon rearing purposes, young salmon (smolts) encountering these estuarine habitats need to grow rapidly to ensure adequate ocean survivals. Increasing growth of juvenile Chinook in the Delta is expected to increase the likelihood of ocean survival of juvenile salmon.

Objective CHIN2.1: Increase the mean weight and length of juvenile Sacramento Basin spring-run Chinook salmon, fall/late fall-run Chinook salmon, and winter-run Chinook salmon rearing in and migrating through the Delta to Chipps Island.

Objective CHIN2.2: Increase the mean weight and length of juvenile San Joaquin Basin fall-run Chinook salmon, including the Mokelumne and Cosumnes River salmon, rearing in and migrating through the Delta to Chipps Island.

Other biological objectives that contribute towards achieving this goal include: ECSY1.1, ECSY2.1, ECSY3.1-3.2, ECSY4.1, ECSY5.1, and NACO1.1-1.3.

Goal CHIN3: Increase the life history diversity of all runs of Chinook salmon.

Problem Statement: The loss of life history diversity reduces the viability of Chinook salmon populations. Life history is defined as the lifetime patterns in growth, life stage differentiation, and reproduction. For salmon, life history traits include the timing of downstream juvenile out-migrations, the timing and patterns of ocean rearing and migrations, the timing of adult upstream in-migrations, and the age of returning spawners. Retention of life history diversity is important for Chinook salmon because it helps to buffer those populations from increased environmental variability (e.g., changing hydrologic conditions) and random environmental events, and thereby improve the persistence of populations under a wide range of conditions.

Objective CHIN3.1: Increase the survival of juvenile and adult Chinook salmon in populations using the Delta across the temporal distributions for each run.

Other biological objectives that contribute towards achieving this goal include: ECSY1.4.

Goal CHIN4: Increase the proportion of each run of adult Chinook salmon that migrate successfully through the Delta to upstream spawning habitats.

Problem Statement: All migrating adult Chinook salmon in the Sacramento River and San Joaquin River watersheds must pass through the Delta on their way to upstream spawning grounds. Increasing the proportion of adult migrants that successfully move through the Delta helps ensure a greater proportion of these adults reach these spawning habitats.

The following biological objectives achieve this goal: ECSY1.2 and NACO1.1.

Central Valley Steelhead

Goal STEE1: Increase the survival of juvenile Central Valley steelhead rearing in and migrating through the Delta to contribute to the long-term viability of that steelhead population.

Problem Statement: Mortality rates of juvenile Central Valley steelhead attributable to multiple factors within the Delta are inhibiting the growth of the steelhead population. Reducing mortality rates of juvenile steelhead in the Delta will support improved abundance, distribution, diversity, and growth of the Central Valley steelhead population.

Objective STEE1.1: Increase the survival of juvenile Sacramento Basin steelhead rearing in and migrating through the Delta to Chipps Island to levels that will contribute to the long-term viability of the population.

Objective STEE1.2: Increase the survival of juvenile San Joaquin Basin steelhead, including the Mokelumne and Cosumnes River steelhead, rearing in and migrating through the Delta to Chipps Island to levels that will contribute to the long-term viability of the population.

Other biological objectives that contribute towards achieving this goal include: ECSY1.1, ECSY1.3-1.5, ECSY2.1, ECSY3.1-3.2, ECSY4.1, ECSY5.1, NACO1.1-1.3, GECF1.1-1.4, and GECF2.1.

Goal STEE2: Increase the growth of juvenile steelhead that migrate through and rear in the Delta to increase the likelihood for survival of juvenile steelhead in San Francisco Bay and ocean habitats.

Problem Statement: Vulnerability to poor ocean conditions increases when steelhead smolts enter the ocean smaller than optimal. Since riverine ecosystems are less productive than estuarine ecosystems for steelhead rearing purposes, smolts encountering these estuarine habitats need to grow rapidly to improve their ocean survivals. Increasing growth of juvenile steelhead in the Delta is expected to increase the likelihood of survival of juveniles.

Objective STEE2.1: Increase the mean weight and length of juvenile Sacramento Basin steelhead rearing in and migrating through the Delta to Chipps Island.

Objective STEE2.2: Increase the mean weight and length of juvenile San Joaquin Basin steelhead, including the Mokelumne and Cosumnes River steelhead, rearing in and migrating through the Delta to Chipps Island.

Other biological objectives that contribute towards achieving this goal include: ECSY1.1, ECSY2.1, ECSY3.1-3.2, ECSY4.1, ECSY5.1, and NACO1.1-1.3.

Goal STEE3: Increase the life history diversity of Central Valley steelhead.

Problem Statement: The loss of life history diversity reduces the viability of Central Valley steelhead populations. Life history is defined as the lifetime patterns in growth, life stage differentiation, and reproduction. For steelhead, life history traits include the timing of downstream juvenile out-migration, the timing and patterns of ocean rearing and migrations, the timing of adult in-migrations upstream, and the age of returning spawners. Retention of life history diversity is important for steelhead because it helps buffer populations from increased environmental variability (e.g., changing hydrologic conditions) and catastrophic environmental events thus enabling the persistence of populations under a wide range of conditions.

Objective STEE3.1: Increase the survival of juvenile and adult steelhead in populations using the Delta across the temporal distributions for each run.

Other biological objectives that contribute towards achieving this goal include: ECSY1.4.

Goal STEE4: Increase the proportion of all adult Central Valley steelhead populations that migrate successfully through the Delta to upstream spawning habitats.

Problem Statement: All migrating adult steelhead in the Sacramento River and San Joaquin River watersheds must pass through the Delta on their way to upstream spawning grounds.

Increasing the proportion of adult migrants that successfully move through the Delta helps ensure a greater proportion of these adults reach these spawning habitats.

The following biological objectives achieve this goal: ECSY1.2 and NACO1.1.

Sacramento Splittail

Goal SASP1: Maintain and conserve a self-sustaining population of Sacramento splittail in the Delta.

Problem Statement: Sacramento splittail are a floodplain spawner and connectivity among habitats is critical to their population viability. Additionally, numerous physical and biological stressors threaten the viability of this species. Implementing actions to reduce the effects of these stressors are expected to maintain and increase the abundance, spatial distribution, life history diversity, and growth rate of the splittail population.

Objective SASP 1.1: Contribute towards increasing the abundance of Sacramento splittail within the Delta and Suisun Bay.

Objective SASP1.2: Maintain the distribution of Sacramento splittail within the Delta and Suisun Bay to achieve target distribution values.

Objective SASP1.3: Maintain connectivity between Central Valley and Napa/Petaluma Sacramento splittail populations.

Objective SASP1.4: Maintain multiple spawning cohorts of Sacramento splittail as part of the breeding population.

Other biological objectives that contribute towards achieving this goal include: ECSY1.1-1.5, ECSY2.1, ECSY3.1-3.2, ECSY4.1, ECSY5.1, NACO1.1-1.3, and GECF1.1-1.4.

Green Sturgeon

Goal GRST1: Increase the number of green sturgeon successfully migrating upstream and downstream through the Delta.

Problem Statement: Green sturgeon migrate upriver to spawning habitats in the late winter and spring when floodplains are inundated in the north delta. Floodplain flows are believed to attract green sturgeon and potentially misguide or strand them in bypasses. Actions to reduce stranding, remove impassable barriers, and alleviate potential attraction of green sturgeon towards floodplains are expected to increase the number of green sturgeon successfully migrating upstream through the Delta to upstream spawning habitats.

The following biological objectives achieve this goal: ECSY1.2 and NACO1.1.

Goal GRST2: Increase the spatial distribution of juvenile green sturgeon within the Delta.

Problem Statement: Habitat alteration limits the amount of habitat for foraging and rearing by juvenile green sturgeon. Increasing the distribution of available habitat for juvenile green sturgeon will improve the spatial distribution of juvenile green sturgeon populations in the Delta.

The following biological objectives achieve this goal: ECSY1.3-1.5 and NACO1.1-1.2.

White Sturgeon

Goal WHST1: Increase the number of white sturgeon successfully migrating upstream and downstream through the Delta.

Problem Statement: All migrating adult white sturgeon in the Sacramento River and San Joaquin River watersheds must pass through the Delta on their way to upstream spawning grounds. Increasing the number of adult migrants that successfully move through the Delta helps ensure a greater number of these adults reaching these spawning habitats. Actions to reduce stranding, remove impassable barriers, and alleviate potential attraction towards floodplains are expected to increase the number of white sturgeon successfully migrating upstream through the Delta to upstream spawning habitats.

The following biological objectives achieve this goal: ECSY1.2 and NACO1.1.

Goal WHST2: Increase the spatial distribution of white sturgeon within the Delta.

Problem Statement: White sturgeon are resident fish in the Delta and require habitats for foraging and rearing. Habitat alterations, invasive species, and contaminants are limiting white sturgeon populations. Actions to address these limiting factors will increase the abundance, life history diversity, and population growth rate of white sturgeon populations within the Delta.

The following biological objectives achieve this goal: ECSY1.3-1.5 and NACO1.1-1.2.

Goal WHST3: Maintain multiple age classes of spawning cohorts of white sturgeon.

Problem Statement: White sturgeon males spawn approximately every 1 to 2 years and females spawn every 2 to 4 years. Because these fish do not generally spawn every year, maintaining multiple age classes will increase the diversity in the timing of spawning among individuals and help protect the species from environmental variability and random environmental events.

The following biological objectives achieve this goal: ECSY1.3-1.5, ECSY5.1, and NACO1.1-1.2.

River Lamprey

Goal RILA1: Maintain the ecological functions of the Delta that support a self-sustaining population of river lamprey in the Central Valley.

Problem Statement: All river lamprey in the Sacramento River and San Joaquin River watersheds pass through the Delta on their way to either the ocean or to upstream habitat for spawning. Therefore, maintaining the ecological functions of the Delta will help ensure that lamprey can migrate successfully while in the Delta.

The following biological objectives achieve this goal: ECSY1.1-1.5, ECSY2.1, ECSY3.1-3.2, ECSY4.1, ECSY5.1, NACO1.1-1.3, and GECF1.1-1.3.

Pacific Lamprey

Goal PALA1: Maintain the ecological functions of the Delta that support a self-sustaining population of Pacific lamprey in the Central Valley.

Problem Statement: All Pacific lamprey in the Sacramento River and San Joaquin River watersheds pass through the Delta on their way to either the ocean or to upstream habitat for spawning. Therefore, maintaining the ecological functions of the Delta will help ensure that lamprey can migrate successfully while in the Delta.

The following biological objectives achieve this goal: ECSY1.1-1.5, ECSY2.1, ECSY3.1-3.2, ECSY4.1, ECSY5.1, NACO1.1-1.3, and GECF1.1-1.3.

3.3.7 Wildlife and Plant Species Goals and Objectives

[***Note to Reviewers****: Wildlife and plant species goals and objectives are in progress.*]

3.4 Conservation Measures

[***Note to Reviewers****: The text of this section of Chapter 3, including the conservation measures described, is subject to change and revision as the BDCP planning process progresses. This section, however, has been drafted and formatted to appear as it may in a draft HCP/NCCP. Although this section includes declarative statements (e.g., the Implementing Entity will…), it is nonetheless a "working draft" that will undergo further modification based on input from the BDCP Steering Committee, State and federal agencies, and the public.*]

This section presents the BDCP conservation measures that will be implemented by the BDCP Implementing Entity to avoid, minimize, and compensate for impacts on covered species associated with implementation of the covered activities and conservation measures; improve the ecological function of natural communities, and provide for the conservation of covered species. Conservation measures are those actions that collectively are expected to achieve the BDCP biological goals and objectives.[1] As described in Sections 3.2.2 through 3.2.5, conservation measures address conveyance and water operations, improvements in physical habitats that support covered species, and reductions in the effect of other stressors on covered species. Water operations conservation measures are presented in Section 3.4.1, physical habitat conservation measures are presented in Section 3.4.2, other stressors conservation measures are presented in Section 3.4.3, and avoidance and minimization measures for covered wildlife and plant species are presented in Section 3.4.4.

A summary list of BDCP conservation measures and the biological objectives they serve is provided in Table 3.3. The following information is provided with each conservation measure, as appropriate, in sections 3.4.1-3.4.3.

Letter/Number Code, Title, and Conservation Measure Description. This section provides the unique letter/number code for the measure for use in tracking BDCP implementation, a brief title for the measure, and a specific description of the conservation measure with specified metrics and targets as appropriate.

Defined Adaptive Range. The defined adaptive range applies only to water operations conservation measures and establishes quantified operating range limits within which parameters may be implemented to more effectively advance BDCP biological goals and objectives.

Problem Statement. This section describes the ecological problems that are intended to be addressed by the conservation measures.

Hypotheses. This section describes the hypotheses that justify the approach reflected in the conservation measure. Uncertainties and risks that could be associated with DRERIP-evaluated conservation measures are described in Appendix X, *DRERIP Evaluations*.

[1] Throughout Section 3.4 the terms "goal" and "target" are used to identify the values of metrics presented in the conservation measures. The completed plan will need to identify values of specific metrics that will be part of the terms and conditions of the permits. Some of the goals and targets presented in this section may evolve into permit terms.

Table 3.3. Summary Table of Conservation Measures and their Relationship to Biological Objectives

Conservation Measure	*Biological Objectives Addressed*
Water Operations Conservation Measures *(described in Section 3.4.1)*	
WOCMN12: Operate South Delta diversions to maintain sufficient Old and Middle River Flows during the near-term implementation period for environmental benefits.	ECSY1.1, ECSY1.2, ECSY1.3, ECSY1.4, ECSY1.5, ECSY2.1, ECSY5.1, DESM1.1, LOSM1.1, CHIN1.1, CHIN1.2, CHIN1.3, STEE1.1, STEE1.2, SASP1.1, SASP1.3, Goal WHST3, Goal RILA1, Goal PALA1
WOCMN5: Operate the Delta Cross Channel Gates during the near-term for environmental benefits.	ECSY1.1, ECSY1.3, ECSY1.5, ECSY5.1, DESM1.1, LOSM1.1, CHIN1.1, Goal CHIN4, STEE1.1, Goal STEE4, SASP1.1
WOCMN6: Maintain sufficient Rio Vista flows for environmental benefits during the near-term implementation period.	ECSY1.1, ECSY1.2, ECSY1.3, ECSY1.4, ECSY1.5, ECSY5.1, DESM1.1, DESM1.2, LOSM1.1, LOSM1.2, CHIN1.1, Goal CHIN4, STEE1.1, Goal RILA1, Goal PALA1
WOCMN8: Install and operate gates at Old River and Connection Slough ("Two Gates") to reduce the transport of covered species into the interior Delta and improve water quality in the south and central Delta.	ECSY1.1, ECSY1.3, DESM1.1, LOSM1.1, CHIN1.1, STEE1.1, SASP1.1
WOCMN9: Maintain sufficient Delta outflows during the near-term implementation period for environmental benefits.	ECSY1.1, ECSY1.2, ECSY1.3, ECSY1.4, ECSY1.5, ECSY5.1, DESM1.1, LOSM1.1, SASP1.1, SASP1.3, Goal RILA1, Goal PALA1
WOCMN14: Maintain agricultural, municipal, and industrial water quality requirements during the near-term implementation period.	ECSY1.3, SASP1.2
WOCMN11: Operate the Montezuma Slough Salinity Control Gate during the near-term implementation period for environmental benefits.	ECSY1.1, ECSY1.3, ECSY1.4, ECSY1.5, ECSY5.1, DESM1.1, DESM1.2, LOSM1.1, LOSM1.2, CHIN2.1, CHIN2.2, STEE2.1, STEE2.2, SASP1.2, Goal GRST1, Goal GRST2, Goal WHST1, Goal WHST2
WOCML1: Construct a new water diversion facility in the north Delta with multiple intakes and fish screens and an isolated conveyance facility and preferentially operate the facility while maintaining sufficient bypass flows for covered fish species.	ECSY1.1, ECSY1.2, ECSY1.3, ECSY1.4, ECSY 1.5, ECSY2.1, ECSY5.1, DESM1.1, DESM1.2, LOSM1.1, LOSM1.2, CHIN1.2, CHIN1.3, CHIN3.1, STEE1.2, STEE2.2, SASP1.1, Goal WHST3, Goal RILA1, Goal PALA1
WOCML12: Operate South Delta diversions to maintain sufficient Old and Middle River Flows during the long-term implementation period for environmental benefits.	ECSY1.1, ECSY1.2, ECSY1.3, ECSY1.4, ECSY1.5, ECSY2.1, ECSY5.1, DESM1.1, LOSM1.1, CHIN1.1, CHIN1.2, CHIN1.3, STEE1.1, STEE1.2, SASP1.1, SASP1.3, Goal WHST3, Goal RILA1, Goal PALA1
WOCML2: Modify the Fremont Weir and Yolo Bypass and operate the Fremont Weir to provide for a higher frequency and duration of inundation of the Yolo Bypass	ECSY1.2, ECSY1.4, ECSY1.5, ECSY2.1, ECSY5.1, NACO1.1, DESM1.1, DESM1.2, CHIN1.1, CHIN2.1, CHIN3.1, Goal CHIN4, STEE1.1, STEE2.1, Goal STEE4, SASP 1.1, SASP1.2, SASP1.4, Goal GRST1, Goal WHST1, Goal RILA1, Goal PALA1
WOCML5: Operate the Delta Cross Channel gates during the long-term for environmental benefits.	ECSY1.1, ECSY1.3, ECSY1.5, ECSY5.1, DESM1.1, LOSM1.1, CHIN1.1, Goal CHIN4, STEE1.1, Goal STEE4, SASP1.1
WOCML6: Maintain sufficient Rio Vista flows for environmental benefits during the long-term implementation period.	ECSY1.1, ECSY1.2, ECSY1.3, ECSY1.4, ECSY1.5, ECSY5.1, DESM1.1, DESM1.2, LOSM1.1, LOSM1.2, CHIN1.1, Goal CHIN4, STEE1.1, Goal RILA1, Goal PALA1
WOCML9: Maintain sufficient Delta outflows during the long-term implementation period for environmental benefits.	ECSY1.1, ECSY1.2, ECSY1.3, ECSY1.4, ECSY1.5, ECSY5.1, DESM1.1, LOSM1.1, SASP1.1, SASP1.3, Goal RILA1, Goal PALA1
WOCML#: Operate the Dual Conveyance Facilities to Maintain Delta Water Quality and Protect Covered Fish Species.	ECSY1.3, ECSY1.4, ECSY1.5, ECSY3.1, NACO1.1, GECF1.1
WOCML14: Maintain in-Delta agricultural, municipal, and industrial water quality requirements during the long-term implementation period.	ECSY 1.3, SASP1.2

Table 3.3. Summary Table of Conservation Measures and their Relationship to Biological Objectives

Conservation Measure	Biological Objectives Addressed
Water Operations Conservation Measures (described in Section 3.4.1) (continued)	
WOCML11: Operate the Montezuma Slough Salinity Control Gate during the long-term implementation period for environmental benefits.	ECSY1.1, ECSY1.3, ECSY1.4, ECSY1.5, ECSY5.1, DESM1.1, DESM1.2, LOSM1.1, LOSM1.2, CHIN2.1, CHIN2.2, STEE2.1, STEE2.2, SASP1.2, Goal GRST1, Goal GRST2, Goal WHST1, Goal WHST2
Habitat Restoration Conservation Measures (described in Section 3.4.2)	
HRCM 16. Restore 65,000 acres of freshwater and brackish tidal marsh within Restoration Opportunity Areas.	ECSY2.1, ECSY5.1, NACO1.2, DESM1.1, DESM1.2, LOSM1.1, LOSM1.2, CHIN2.1, CHIN2.2, CHIN3.1, STEE2.1, STEE2.2, STEE3.1, SASP1.2, SASP1.3, Goal GRST2, Goal WHST2
HRCM4: Restore at least 5,000 acres freshwater tidal marsh within the Cache Slough Complex ROA.	ECSY2.1, ECSY5.1, NACO1.2, DESM1.1, DESM1.2, LOSM1.2, CHIN2.1, CHIN3.1, STEE2.1, STEE3.1, SASP1.2, Goal GRST2, Goal WHST2
HRCM5: Restore at least 1,500 acres of freshwater tidal marsh within the Cosumnes/Mokelumne ROA.	ECSY2.1, ECSY5.1, NACO1.2, DESM1.2, LOSM1.2, CHIN2.2, CHIN3.1, STEE2.2, STEE3.1, SASP1.2, Goal WHST2
HRCM6: Restore at least 2,100 acres of tidal marsh within the West Delta ROA.	ECSY2.1, ECSY5.1, NACO1.2, DESM1.1, DESM1.2, LOSM1.1, LOSM1.2, CHIN2.1, CHIN2.2, CHIN3.1, STEE2.1, STEE2.2, STEE3.1, SASP1.2, SASP1.3, Goal GRST2, Goal WHST2
HRCM7: Restore at least 5,000 acres of tidal marsh within the South Delta ROA.	ECSY2.1, ECSY5.1, NACO1.2, DESM1.2, LOSM1.2, CHIN2.2, CHIN3.1, STEE2.2, STEE3.1, SASP1.2, Goal WHST2
HRCM8: Restore at least 1,400 acres tidal marsh within the East Delta ROA.	ECSY2.1, ECSY5.1, NACO1.2, DESM1.2, LOSM1.2, CHIN2.2, CHIN3.1, STEE2.2, STEE3.1, SASP1.2, Goal WHST2
HRCM9: Restore at least 7,000 acres of brackish tidal marsh within the Suisun Marsh Restoration Opportunity Area.	ECSY2.1, ECSY5.1, NACO1.2, DESM1.2, LOSM1.2, CHIN2.1, CHIN2.2, CHIN3.1, STEE2.1, STEE2.2, STEE3.1, SASP1.2, SASP1.3, Goal GRST2, Goal WHST2
HRCM##. Enhance channel margin habitats along at least 20 linear miles of Delta channel banks.	ECSY2.1, ECSY3.1, ECSY5.1, NACO1.3, DESM1.2, LOSM1.2, CHIN1.1, CHIN2.1, CHIN2.2, CHIN3.1, STEE1.1, STEE1.2, STEE2.1, STEE2.2, STEE3.1, SASP1.1, SASP1.2
HRCM15: Enhance channel margin habitats along non-Project levees in the Delta to improve habitat conditions for covered fish species.	ECSY2.1, ECSY3.1, ECSY5.1, NACO1.3, DESM1.2, LOSM1.2, CHIN1.1, CHIN2.1, CHIN2.2, CHIN3.1, STEE1.1, STEE1.2, STEE2.1, STEE2.2, STEE3.1, SASP1.1, SASP1.2
HRCM12: Enhance channel margin habitats along Steamboat and Sutter Sloughs to improve habitat conditions for covered fish species.	ECSY2.1, ECSY3.1, ECSY5.1, NACO1.3, DESM1.2, LOSM1.2, CHIN1.1, CHIN2.1, CHIN3.1, STEE1.1, STEE2.1, STEE3.1, SASP1.1, SASP1.2
HRCM13: Enhance channel margin habitats along the San Joaquin River between Vernalis and Mossdale to improve habitat conditions for covered fish species.	ECSY2.1, ECSY3.1, ECSY5.1, NACO1.3, DESM1.2, LOSM1.2, CHIN2.2, CHIN3.1, STEE1.2, STEE2.2, STEE3.1, SASP1.1, SASP1.2
HRCM11/HRCM14: Restore at least 5,000 acres of riparian forest and scrub in Restoration Opportunity Areas.	ECSY2.1, ECSY5.1, NACO1.3, DESM1.2, LOSM1.2, CHIN1.1, CHIN1.2, CHIN1.3, CHIN2.1, CHIN2.2, STEE1.1, STEE1.2, STEE2.1, STEE2.2
HRCM1/HRCM2: Restore seasonally inundated floodplain habitat along the San Joaquin River downstream of Vernalis.	ECSY2.1, ECSY5.1, NACO1.1, DESM1.2, LOSM1.2, CHIN2.2, CHIN3.1, STEE2.2, STEE3.1, SASP1.1, SASP1.2
HRCM3: Restore seasonally inundated floodplain habitat along Old and/or Middle Rivers.	ECSY2.1, ECSY5.1, NACO1.1, DESM1.2, LOSM1.2, CHIN2.2, CHIN3.1, STEE2.2, STEE3.1, SASP1.1, SASP1.2
HRCM17: Assess the feasibility of a new flood bypass east of the Sacramento Deep Water Ship Channel to restore seasonally inundated floodplain habitat.	ECSY1.4, ECSY2.1, ECSY5.1, NACO 1.1, DESM1.1, DESM1.2, CHIN1.1, CHIN2.1, CHIN3.1, STEE1.1, STEE2.1, SASP1.1, SASP1.2, SASP1.4

Table 3.3. Summary Table of Conservation Measures and their Relationship to Biological Objectives

Conservation Measure	*Biological Objectives Addressed*
***Other Stressors Conservation Measures** (described in Section 3.4.3)*	
OSCM1: Determine whether ammonia and ammonium have adverse direct and/or indirect effects on BDCP covered species and, if adverse effects are found, assist wastewater treatment plants in identifying funding sources to reduce the load of ammonia and ammonium in effluent discharges.	ECSY2.1, ECSY4.1, DESM1.1, DESM1.2, LOSM1.1, LOSM1.2, CHIN1.1, CHIN1.2, CHIN1.3, CHIN2.1, CHIN2.2, STEE1.1, STEE1.2, STEE2.1, STEE2.2, SASP1.1, SASP1.2, Goal RILA1, Goal PALA1
OSCM2: Determine whether endocrine disrupting compounds have adverse direct and/or indirect effects on BDCP covered species and, if adverse effects are found, assist wastewater treatment plants in identifying funding sources to reduce the load of endocrine disrupting compounds in effluent discharges.	ECSY4.1, DESM1.1, LOSM1.1, SASP1.1, SASP1.2, Goal GRST1, Goal WHST1, Goal RILA1, Goal PALA1
OSCM3: Reduce the load of methyl mercury entering Delta waterways.	ECSY4.1, SASP 1.1, Goal RILA1, Goal PALA1
OSCM4: Reduce the load of agricultural pesticides and herbicides entering Delta waterways from in-Delta sources that are believed to be toxic to covered fish species and the food organisms upon which they depend.	ECSY2.1, ECSY4.1, DESM1.1, DESM1.2, LOSM1.1, LOSM1.2, CHIN1.1, CHIN1.2, CHIN1.3, CHIN2.1, CHIN2.2, STEE1.1, STEE1.2, STEE2.1, STEE2.2, SASP1.1, Goal RILA1, Goal PALA1
OSCM5: Reduce the loads of toxic contaminants in stormwater and urban runoff by working with existing efforts in the Delta.	ECSY2.1, ECSY4.1, DESM1.1, DESM1.2, LOSM1.1, LOSM1.2, CHIN1.1, CHIN1.2, CHIN1.3, CHIN2.1, CHIN2.2, STEE1.1, STEE1.2, STEE2.1, STEE2.2, SASP 1.1, Goal RILA1, Goal PALA1
OSCM7: Maintain dissolved oxygen levels above levels that impair covered fish species in the Stockton Deep Water Ship Channel during periods when covered fish species are present.	ECSY5.1, CHIN1.2, CHIN1.3, Goal CHIN4, STEE1.2, Goal STEE4
OSCM8: Improve the quality of water discharged from managed seasonal wetlands into Suisun Bay and Delta waterways to prevent dissolved oxygen sags.	ECSY4.1, DESM1.1, LOSM1.1, CHIN1.1, CHIN1.2, CHIN1.3, STEE1.1, STEE1.2, SASP1.1
OSCM10: Reduce the risk for future introductions of non-native aquatic organisms from recreational watercraft.	ECSY3.2, DESM1.1, DESM1.2, LOSM1.1, LOSM1.2, CHIN1.1, CHIN1.2, CHIN1.3, CHIN2.1, CHIN2.2, STEE1.1, STEE1.2, STEE2.1, STEE2.2, SASP1.1, Goal RILA1, Goal PALA1
OSCM11: Improve the rapid detection of and rapid response to new non-native species introductions into Delta waterways.	ECSY3.2, DESM1.1, DESM1.2, LOSM1.1, LOSM1.2, CHIN1.1, CHIN1.2, CHIN1.3, CHIN2.1, CHIN2.2, STEE1.1, STEE1.2, STEE2.1, STEE2.2, SASP1.1, Goal RILA1, Goal PALA1
OSCM13: Remove non-native submerged and floating aquatic vegetation from Delta waterways.	ECSY3.1, DESM1.1, LOSM1.1, CHIN1.1, CHIN1.2, CHIN1.3, STEE1.1, STEE1.2, Goal STEE4, SASP1.1, SASP1.2
OSCM14: Increase the harvest of non-native predatory fish to decrease their abundance.	ECSY3.1, GECF1.2, CHIN1.1, CHIN1.2, CHIN1.3, STEE1.1, STEE1.2, SASP1.2
OSCM16: Reduce illegal harvest of Chinook salmon, Central Valley steelhead, green sturgeon, and white sturgeon in the Delta.	GECF1.2, LOSM1.1, CHIN1.1, CHIN1.2, CHIN1.3, STEE1.1, STEE1.2, Goal GRST1, Goal WHST3
OSCM17: Reduce adverse effects of harvest on Sacramento splittail abundance.	GECF1.2, SASP 1.1
OSCM18: Develop and implement hatchery and genetic management plans to minimize the potential for genetic and ecological impacts of hatchery reared salmonids on wild salmonid stocks.	GECF2.1, CHIN3.1, STEE3.1
OSCM19: Reduce losses of wild stocks of Chinook salmon to commercial fishing and recreational fishing through a mark-select fishery.	GECF1.2, GECF2.1, Goal CHIN4
OSCM20: Establish new and expand existing conservation propagation programs for Delta and longfin smelt.	GECF2.2, DESM1.1, LOSM1.1

Table 3.3. Summary Table of Conservation Measures and their Relationship to Biological Objectives

Conservation Measure	***Biological Objectives Addressed***
Other Stressors Conservation Measures *(described in Section 3.4.3) (continued)*	
OSCM21: Screen, remove, relocate, consolidate, modify and/or alter timing of non-project diversions to reduce entrainment of covered fish species in the Delta.	ECSY2.1, GECF1.1, DESM1.1, LOSM1.1, CHIN1.1, CHIN1.2, CHIN1.3, STEE1.1, STEE1.2, SASP1.1, SASP1.2, Goal RILA1, Goal PALA1
OSCM24: Reduce the effects of predators on covered fish species by conducting localized predator control of high predator density locations.	ECSY3.1, DESM1.1, LOSM1.1, CHIN1.1, CHIN1.2, CHIN1.3, STEE1.1, STEE1.2, SASP1.1
OSCM25: Improve the survival of outmigrating juvenile salmonids by using non-physical barriers to re-direct them away from channels in which survival is lower.	GECF1.1

Adaptive Management Considerations. This section describes adaptive management-related elements that are associated with each of the conservation measures.

[***Note to Reviewers:*** *The naming convention for conservation measures (e.g., codes "HRCM1," "HRCM2") is retained here to allow for tracking of conservation measures through various changes, additions, deletions, and reorganizations over the past 1½ years of plan development. This complex approach to naming and numbering conservation measures has served its purpose and will be simplified as conservation measures become more stable in their form going into the administrative draft HCP/NCCP*].

Process of Development

The BDCP conservation measures were developed on the basis of the best available scientific and commercial information, including input of a broad range of technical experts and an extensive body of scientific study and analysis compiled over the past several decades. The conservation measures further reflect the recommendations of independent scientists with extensive knowledge of Delta ecological issues.

The BDCP conservation measures were initially developed by groups of technical experts convened by the Steering Committee. To guide initial development of potential conservation measures, these experts, based on review of the body of relevant scientific information and input from the Fishery Agencies and topical experts, identified important environmental stressors affecting the covered fish species and aquatic ecosystem. The groups then identified the range of potential conservation measures that could reduce or remove the effects of these stressors on the covered fish species. The conservation measure development process was informed through application of several tools and processes described in the following paragraphs. Following development of a range of potential conservation measures, the groups iteratively screened and refined the conservation measures based on evaluations of their likely biological effectiveness and implementability.

[***Note to reviewers:*** *Conservation measures for wildlife and plant species and non-tidal natural communities are under development. This section will be revised in subsequent document versions to describe that process.*]

A large body of information on the Delta ecosystem and approaches to ecosystem and species conservation has been developed over many years that provided a starting point for the development of the BDCP conservation measures. Important sources of scientific information and conservation approach ideas included the CALFED Bay Delta Program, particularly the Science Program and Ecosystem Restoration Program; the Interagency Ecological Program; two reports on the Delta prepared by the California Public Policy Institute; the Delta Vision Program, various plan and technical documents; and the Delta Risk Management Strategy. Building on this knowledge base, the BDCP conservation measures were developed using additional investigations, state-of-the-art physical models, specially developed conceptual models, and expert input from a large number of scientists and resource managers.

On several occasions, the BDCP plan participants convened these scientists to provide guidance and insight on a range of issues important to the development of a comprehensive conservation strategy for the BDCP. The recommendations of these advisors are reflected in many of the conservation measures set out in this section (see *BDCP Independent Science Advisors Report,* *November 16, 2007* [Appendix X]; the *BDCP Independent Science Advisors Report Concerning Non-aquatic Species, November 2008* [Appendix X]; and the *BDCP Independent Science Advisors Report on Adaptive Management, February 2009* [Appendix X]).

At several stages in the development of the conservation measures, the plan participants conducted interim evaluations to assess the potential for measures under consideration to improve ecological conditions within the Delta. Central to this assessment were the conceptual ecological models and detailed evaluation processes that were developed under the CALFED Ecosystem Restoration Program to gauge the likely effect of potential actions on Delta fish and ecosystem processes. This process, known as the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) Scientific Evaluation Process, was used to evaluate draft BDCP conservation measures in December 2008-March 2009 (see Appendix X, *DRERIP Evaluations of BDCP Draft Conservation Measures Summary Report*). Under the DRERIP process, potential conservation measures were evaluated individually to assess their benefits and drawbacks without factoring in potential synergies with other actions. To account for interrelationships with other potential measures, the plan participants formed the BDCP Synthesis Team to review the results of the DRERIP process and identify instances in which combinations of measures would likely provide benefits greater than the sum of the individual measures. The Synthesis Team assessed potential synergies and conflicts between various measures and suggested modifications to the draft conservation measures to improve the overall effectiveness of measures. Based on input from the DRERIP Evaluation and the Synthesis Team, the conservation measures were revised to improve potential effectiveness.

3.4.1 Water Operations Conservation Measures

[***Note to Reviewers***: *The text of this section of Chapter 3, including the water operations conservation measures described, is subject to change and revision as the BDCP planning process progresses. This section, however, has been drafted and formatted to appear as it may in a draft HCP/NCCP. Although this section includes declarative statements (e.g., the Implementing Entity will…), it is nonetheless a "working draft" that will undergo further modification based on input from the BDCP Steering Committee, state and federal agencies, and the public.*]

The lower Sacramento River, Delta, and Suisun Bay and Marsh provide habitat for a diverse and complex assemblage of resident and migratory fish and other aquatic organisms. Section 3.2, *The BDCP Approach to Conservation: An Overview*, describes the BDCP approach to conservation, and 3.2.1 outlines seven of the basic principles governing the approach. Several of these principles apply directly to the design of the conservation measures proposed in this section and are, therefore, expanded upon here. Development of water operations conservation measures as part of the BDCP is based, in large part, on the balance of seasonal and interannual variation in hydrologic conditions occurring within the watershed, seasonal variation in the habitat requirements and geographic distribution of each of the lifestages of the covered fish within the estuary and tributary rivers, and a variety of other factors. These include the beneficial interactions between establishing new aquatic habitats and hydrodynamics, a variety of flow-based and other mechanisms affecting the habitat quality and availability for these species and their food supplies, growth, survival, reproduction, and overall population dynamics in response to near-term and long-term implementation of conservation measures. In addition, water operations conservation measures are designed to provide a reliable water supply in a manner that avoids and reduces adverse effects to covered species and their habitat. The water operations measures are based on a variety of considerations outlined above and with respect to each element of the conservation measures.

The proposed water operations also reflect the fact that the covered fish and other aquatic species have evolved in the Central Valley rivers and Delta. Their life histories are keyed to seasonal changes that naturally occur in flows, water temperatures, and other environmental cues that affect processes such as the seasonal timing of juvenile emigration downstream through the Delta, seasonal timing of reproduction, seasonal patterns in phytoplankton and zooplankton production that are food for covered fish and other aquatic species, seasonal inundation of floodplain habitat, and other important biological mechanisms.

One factor in developing the water operations measures is the consideration of unidirectional downstream sweeping flows across the new fish screens proposed for the lower Sacramento River as part of long-term dual facility operations. Another consideration is the downstream transport of planktonic fish eggs and larvae, organic material, phytoplankton, and zooplankton from the lower Sacramento River into the Delta and Suisun Bay. A third factor is the consideration of sufficient flows in the lower Sacramento River during the primary migration period for juvenile Chinook salmon, steelhead, and other species (December-June) to reduce the frequency of bidirectional tidal flows in areas like Sutter and Steamboat Sloughs that are thought to reduce migration rates and increase the risk of juvenile fish to mortality from sources such as predation. A further factor that is taken into account is the provision of operations to maintain and improve habitat quality and availability for aquatic species in areas such as the Cache Slough complex, the lower Sacramento River, Delta and the low salinity zone located in the western

Delta and Suisun Bay. The near-term and long-term water operations conservation measures described below were developed to meet these and other biological objectives, water supply objectives, and water quality objectives of the BDCP.

This section describes conservation measures that address changes to water operations in the Delta under the BDCP. The BDCP Conservation Strategy proposes two types of water operations conservation measures: (1) construction of new operational control facilities, and (2) operations of new operational control facilities or changes to the operations of existing operational control facilities. The evaluation of proposed new conveyance facilities (or changes to existing facilities) addresses two core issues that are separate and distinct, but are also closely interrelated. The first is the design issue associated with the new facility; that is, whether the new facility itself may enable improvements in flows and hydrodynamics if operated properly, and how to design the facility to achieve those improvements. The second issue is the operational issue. That is, what types of operational parameters would be most appropriate for the new facility to contribute to plan goals and objectives. It is important to recognize that these two aspects of proposed new water conveyance facilities are separate and distinct yet also closely joined, and they must be evaluated as such.

The proposed new isolated conveyance facility offers an instructive example of this distinction. The appropriateness of the isolated facility as a major new conservation measure for the BDCP demonstrates how both issues must be addressed together. There is a relatively broad agreement within the fisheries conservation community that a properly operated new isolated facility will provide substantial benefits for certain listed species over the existing system, for all of the reasons enumerated below. The far more energetic debate focuses on what constitutes the proper operating parameters for the new facility, and less on the design parameters of the new facility itself – although both are essential components of the proposal. Determining the appropriateness of the isolated facility, therefore, considers the operational parameters that will govern it as much as the reliability of the governance structures that will apply those parameters. Hence, distinguishing clearly the design features from the operational features is important for an accurate appraisal of the merits of the measure overall.

These facilities and operational conservation measures will be implemented in the near-term and long-term to address and respond to near-term and long-term risks, respectively, to covered species. Some facilities and operational measures will reduce entrainment mortality of covered fish in the near-term, such as construction and operation of gates on Old River and Connection Slough, whereas other facilities and operational measures will reduce entrainment of and improve habitat for covered fish in the long-term, such as construction and operation of north Delta diversion facilities and isolated conveyance facility.

In addition to reducing direct entrainment loss as a result of BDCP covered activities, these facilities and operational conservation measures are designed to reduce other sources of harm to listed species, both direct and indirect (e.g. stranding, loss of homing ability, and reduced predation). In addition, these measures will be adaptively managed to optimize benefits to covered species while maintaining water supply reliability (see Section 3.6, *Adaptive Management*). Uncertainties concerning these measures will be managed through ongoing monitoring and research under the BDCP monitoring and adaptive management programs.

Water operations in the Delta are an integrated collection of actions that affect flow and water quality. These facilities and operational conservation measures are closely intertwined with other components of the conservation strategy, including habitat restoration and measures addressing other stressors to covered species. For example, the ability of habitat restoration in the south Delta to increase the amount of biological productivity transported to the western Delta and Suisun Bays will be realized only after preferential operation of the north Delta diversion facility begins (i.e., long-term operations).

Where applicable, criteria (quantitative values) are identified for each parameter for specific times of year and specific water year types.

3.4.1.1 Operational Control Facilities

This section presents an introduction to and summary of all of the proposed operational control facilities found in Section 3.4.1. For purposes of the BDCP, operational control facilities are defined here as those structures in the SWP and CVP water management system within and near the BDCP Planning Area that physically control the flow of water (Figure 3.4). These facilities involve physical control structures such as gates, intakes, and pumps that can modify flows and affect Delta hydrodynamics in the immediate vicinity of the structure and often across large portions of the surrounding Delta. The physical construction and modification of these facilities are described and evaluated separately from the operations of the facilities by the BDCP.

The following is a list of operational control facilities and brief description of their functions:

1. North Delta Diversion Facilities and Isolated Conveyance Facility (long-term) – The north Delta diversion facilities will include five new intakes along the Sacramento River from north of Freeport (across the Sacramento River from the Pocket Area of the City of Sacramento) to just downstream of Hood. Intakes will be equipped with state-of-the-art positive barrier fish screens to reduce entrainment of fish and will connect to an isolated conveyance facility to carry water to the south Delta SWP and CVP export facilities.
2. Fremont Weir Operable Gates (long-term) – New operable gates on the Fremont Weir will allow for the control of the timing, duration, and frequency of inundation of the Yolo Bypass during non-flood stage periods of the Sacramento River.
3. Delta Cross Channel Gates (near-term and long-term) – Delta Cross Channel Gates are existing radial gates that control the flow of Sacramento River water through the Delta Cross Channel into the interior Delta.
4. Gates on Old River and Connection Slough ("2-Gates") (near-term) – These will be new gates installed on the east and west sides of Bacon Island on Old River and Connection Slough to control tidal flows, salinity concentrations, and fish in the south Delta.
5. Montezuma Slough Salinity Control Gate (near-term and long-term) – Existing gates at the eastern opening of Montezuma Slough that control the flow of fresh and salt water into Montezuma Slough.
6. South Delta Diversions (near-term and long-term) – Two existing diversion facilities, the CVP Jones Pumping Plant and the SWP Banks Pumping Plant, divert water from the south Delta to meet water supply demands outside the Delta.
7. Deep Water Ship Channel Bypass Operable Gates (long-term) – If constructed, these will be new operable gates off the Sacramento River that will allow for the control of the timing, duration, and frequency of inundation of a new Deep Water Ship Channel Bypass.

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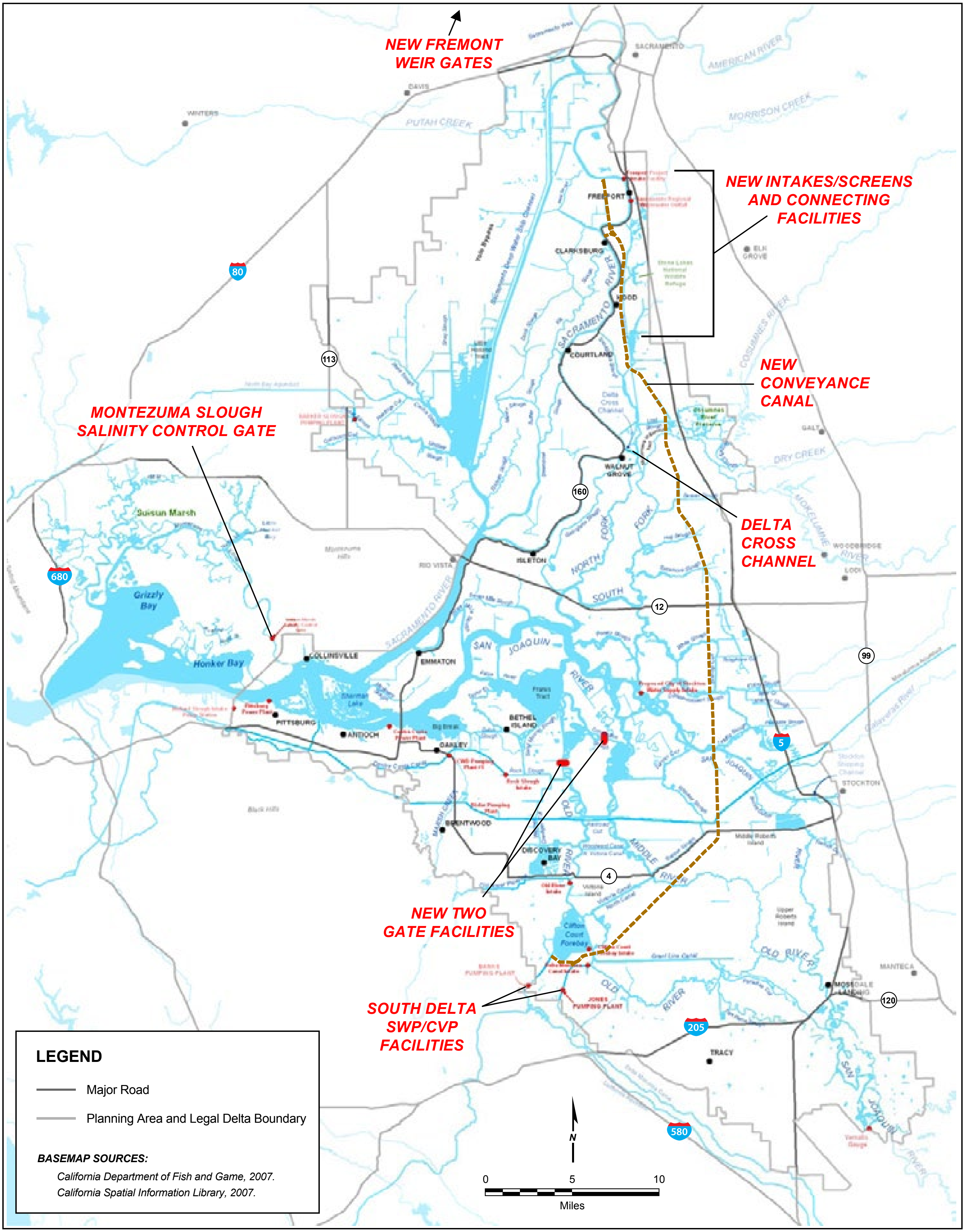

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Figure 3.4
Water Operations Control Facilities in the Delta (Existing and New)

3.4.1.2 Near-Term Water Operations Conservation Measures[1]

This section describes the near-term water operations for multiple parameters across the Delta. Each near-term water operations conservation measure (WOCMN) is provided a unique alpha-numeric label (e.g. WOCMN1, WOCMN2, etc.). Near-term operations include only through-Delta water conveyance and exports from the existing SWP/CVP facilities prior to completion of new north Delta diversions and the isolated conveyance facility. Construction of facilities necessary for long-term operations (e.g., new north Delta diversions, isolated conveyance facility, new gates at Fremont Weir) will be completed during the near-term.

WOCMN12: Operate South Delta diversions to maintain sufficient Old and Middle River Flows during the near-term implementation period for environmental benefits. Maximum Old and Middle River reverse flows during the near-term implementation period set under the BDCP will reduce the impacts of south Delta diversions on covered fish species and the Delta environment. These rivers are subject to reduced or reverse flows as a result of low San Joaquin River inflow, flood tides, and water exports at SWP and CVP facilities. These flow conditions can result in increased risk of entrainment of fish, invertebrates, and food. Near-term regulation of the seasonal rate of exports are intended to reduce the direct and indirect effects of south Delta exports on covered fish species and other aquatic organisms.

Operational Criteria and Adaptive Limits. The operational criteria for Old and Middle River flows during the BDCP near-term implementation periods are described in Table 3.4.

Table 3.4. Proposed Near-Term Operational Criteria and Adaptive Range Limits.

*[**Note to reviewers:** Near-term operational criteria are under development and will be included in table 3.4 when completed.]*

Water Operations Parameter (i.e., conservation measure)	*Proposed Initial Near-Term Water Operations Criteria*[2]	*Adaptive Range Limits*[3]
WOCMN12: South Delta Diversions/Old and Middle River flows	TBD	TBD
WOCMN5: Delta Cross Channel Gate Operations	TBD	TBD
WOCMN6: Rio Vista Flow Requirements	TBD	TBD
WOCMN8: Two-Gates Operations	TBD	TBD
WOCMN9: Delta Outflow/ Western Delta Salinity	TBD	TBD
WOCMN14: In-Delta Ag and M&I Water Quality Requirements	TBD	TBD
WOCMN11: Montezuma Slough Salinity Control Gate	TBD	TBD

Problem Statement: Export operations of the SWP and CVP diversion facilities in the South Delta, in combination with San Joaquin and Sacramento River flows, tidal effects, and substantially reduced inflows into the Delta, have been identified as primary factors in altering hydrodynamic conditions within Delta channels and associated fishery habitat (DWR 2006, Baxter et al. 2008). Export operation of the SWP and CVP pumping plants contributes to local changes in water current patterns, water quality, and direct

1 Section 3.1.2 defines and describes several important features of the term "conservation measure" as used in this chapter, including the need to assess the characterization of a measure as such on a species-by-species basis. These definitions carry over and apply throughout the BDCP, including the water conveyance facilities and measures described herein.

2 Parameter values with which the BDCP Implementing Entity will manage water operations through the governance structures described in Chapter __ *Governance*.

3 Range of parameter values around the operational criteria within which water operations may be conducted by the Implementing Entity through the BDCP adaptive management process.

entrainment and losses of fish, macroinvertebrates, nutrients, phytoplankton, and zooplankton from the Delta environment (DWR 2006).

Although the response of various lifestages of covered species to flows within Old and Middle Rivers is dynamic and variable within and among species, there is a positive relationship between the magnitude (average monthly) of reverse flows within Old and Middle Rivers and the occurrence of pre-spawning adult delta smelt in SWP and CVP fish salvage during the winter months (Kimmerer 2008, USFWS 2009). Further, particle tracking model simulations predict that there is a greater risk that planktonic early lifestages of covered fish species (e.g., larval delta smelt) will be vulnerable to entrainment at the SWP and CVP export facilities when reverse flows within Old and Middle Rivers increase. In addition, a number of the covered fish, including the juvenile and adult lifestages of Chinook salmon, steelhead, delta smelt, longfin smelt, sturgeon, and splittail are expected to use hydrodynamic cues (e.g., channel flow direction and magnitude) to help guide movement through the Delta. Reverse flows in Delta channels are thought to contribute to false attraction to migration cues, longer migration routes that may expose fish to sources of mortality such as predation, exposure to seasonally elevated water temperatures and other stressors, and increased vulnerability to entrainment at the SWP and CVP south Delta export facilities.

Reverse flows within the Old and Middle River channels are also hypothesized to affect local and regional habitat conditions for covered fish and other aquatic species. Changes in channel velocity and flow patterns affect hydraulic residence time in the area and the production of phytoplankton and zooplankton that are important to the diet of covered fish. Channel velocities and scour and deposition patterns affect habitat for benthic organisms and other macroinvertebrates. Changes in tidal hydrodynamics, especially channel velocity, affect habitat suitability for covered fish and other aquatic species in the area.

Relationships between the magnitude of reverse flows in Old and Middle Rivers and corresponding changes in salvage of various covered fish, such as juvenile Chinook salmon, steelhead, splittail, longfin smelt and sturgeon, are highly variable. Analyses and evaluations are ongoing to further assess the potential biological benefits of managing SWP and CVP south Delta exports based on direct diversion rates or changes in the magnitude of reverse flows in Old and Middle Rivers.

Hypotheses: Reducing diversions in the South Delta are hypothesized to:

- reduce the risk of entrainment mortality of salmonids, smelt, splittail, sturgeon and lamprey;
- reduce the risk of predation mortality of salmonids, smelt, and splittail in Clifton Court Forebay; and
- reduce the risk of entrainment of organic matter and food of salmonids, smelt, splittail, and sturgeon.

Adaptive Management Considerations: Adaptive operational changes of Old and Middle River flows will include modifications in export rates and reverse flows based on changes in water surface elevation or tidal conditions, changes in reverse flows in response to high or low flows within the channels, or the occurrence of covered fish in the SWP and/or CVP fish salvage

WOCMN5: Operate the Delta Cross Channel Gates during the near-term for environmental benefits. The Delta Cross Channel Gates will be operated during the near-term implementation period to improve fish migration, hydrodynamics (including hydraulic residence time), and food and organic material transport while minimizing changes to water quality for agriculture, municipal, and industrial uses in the interior and southern Delta. This parameter will affect WOCMN6, 8, and 14.

The Delta Cross Channel gates are located on the Sacramento River near Walnut Grove (Figure 3.4). The Delta Cross Channel serves as a conveyance facility for water to move from the Sacramento River into the interior Delta. Water quality in the central and south Delta can degrade during low San Joaquin River flows. The Delta Cross Channel was constructed to move higher quality Sacramento River towards the central and south Delta to improve water quality there. Juvenile Chinook salmon, and presumably a number of other fish species, move from the Sacramento River into the interior Delta when the gate is open (Brandes and McLean 2001). Results of survival studies using coded wire tagged and radio tagged fish suggest that survival juvenile Chinook salmon passing into the Delta through the Delta Cross Channel is lower than survival of those migrating down the mainstem Sacramento River (Brandes and McLean 2001, Burau pers. comm., USFWS unpubl. data). Based on results of these studies, closure of the Delta Cross Channel gates between February 1 and May 20 was established under D-1641 for fish benefits.

Operational Criteria and Adaptive Limits. The operational criteria for the Delta Cross Channel gates during the BDCP near-term implementation periods are described in Table 3.4.

Problem Statement: When the Delta Cross Channel is open, fish move into the interior Delta with Sacramento River water. Survival of juvenile Chinook salmon, and likely other fish species, within the interior Delta is lower than survival in the mainstem Sacramento River (Baker and Morhardt 2001, Brandes and McLain 2001, CALFED 2001, D. Vogel pers. comm., J. Burau pers. comm., USFWS unpubl. data),, although it is unknown whether this reduced survival has a population level effect on Chinook salmon (Manly 2002, 2008).

Current seasonal operations of the Delta Cross Channel gates designated by D-1641 are designed to prohibit the migration of juvenile fish from the Sacramento River into the interior Delta through the Delta Cross Channel during the spring. However, adverse effects of an open DCC operation to anadromous fish, and other fish, also occur outside of this closure period. Furthermore, open gates decrease velocities and increase bi-directional flows in the Sacramento River and its distributaries, slowing the migration of covered species and increasing their vulnerability to predation or mortality from poor habitat. Therefore, lengthening the closure period or operating on a tidal or daily cycle may improve survival of salmonids and other covered fish species.

Hypotheses: Revised operations of Delta Cross Channel gates are hypothesized to:

- increase the survival of juvenile Chinook salmon and possibly other covered fish species by: (1) improving downstream migration of fish in the Sacramento River and tributaries, which will reduce their risk to predation and other sources of mortality; and (2) reducing the proportion of fish entering the interior Delta, where survival of juvenile Chinook salmon is lower (Baker and Morhardt 2001, Brandes and McLain 2001, CALFED 2001, D. Vogel pers. comm., J. Burau pers. comm., USFWS unpubl. data). Several hypotheses have been suggested to explain reduced survival of juvenile Chinook salmon in the interior Delta relative to the mainstem Sacramento River, including, but not limited to: (1) increased exposure to unscreened water diversions within the Delta channels; (2) exposure to seasonally elevated water temperatures and potentially toxic contaminants; (3) increased residence time and longer migration routes leading to longer exposure to environmental conditions within the Delta and increased vulnerability to predation mortality; (4) delayed migration as a result of altered hydrologic conditions in Delta channels as a result of SWP and CVP export operations; and (5) direct losses as a result of entrainment, predation, or salvage mortality at the south Delta SWP and CVP export facilities (Baxter et al. 2008);

- improve the strength of migration cues and avoid false cues for adult migrating steelhead, Chinook salmon, and sturgeon on the Sacramento and San Joaquin Rivers. When the Delta Cross Channel is open, water from the Sacramento River mixes with water from the Mokelumne, Cosumnes, and San Joaquin Rivers, reducing the strength of migration cues to salmonids and sturgeon migrating upstream. Therefore, increasing the duration of Delta Cross Channel closure will allow anadromous fish to more directly sense migration cues to upstream habitat, thus increasing the ability to move upstream and reducing delays to spawning; and
- improve downstream flows and downstream transport of fish eggs, larvae, juveniles, food, and organic material within the Sacramento River into the Delta.

Adaptive Management Considerations: Results of biological monitoring could be used within the BDCP adaptive management framework to refine and modify seasonal operations of Delta Cross Channel gates.

WOCMN6: Maintain sufficient Rio Vista flows for environmental benefits during the near-term implementation period. The BDCP Implementing Entity will maintain sufficient Rio Vista flows for the benefit of covered fish species. The lower Sacramento River serves as an important part of the aquatic habitat within the Delta. Diversion of water from the mainstem river into side channels (e.g., Delta Cross Channel) or seasonally inundated floodplain habitat (e.g., Yolo Bypass), has a direct effect on flow rates in the Sacramento River at Rio Vista. Operations described under WOCMN5 will affect flow at Rio Vista. Identification of a minimum flow requirement at Rio Vista is intended to support fishery and aquatic habitat in the reach of the Sacramento River located between Sacramento and Rio Vista. Flow in the mainstem Sacramento River downstream of Rio Vista is augmented by the flow contribution from Cache Slough, the Yolo Bypass, Sutter and Steamboat Sloughs, and other local tributaries. Minimum river flows at Rio Vista in the fall are included in current regulations (D-1641).

Operational Criteria and Adaptive Limits. The operational criteria for Rio Vista flows during the BDCP near-term implementation periods are described in Table 3.4.

Problem Statement: The Sacramento River, in addition to its upstream tributaries, is the primary migration corridor and spawning/rearing habitat for Chinook salmon, Central

Valley steelhead, and sturgeon within the Central Valley. In addition, both delta and longfin smelt likely spawn in the lower river in the general vicinity of Rio Vista. Key fishery issues with respect to seasonal river flows at Rio Vista have primarily focused on adult Chinook salmon and steelhead attraction and upstream migration flows during the fall months. The importance of river flows to each of the species and lifestages of covered fish species varies seasonally depending on the life history and habitat requirements of the species. Given the importance of the Sacramento River as a migration route and habitat for covered fish species, seasonal flows within the Sacramento River may be important to support covered fish species.

Hypotheses: Maintaining sufficient flows past Rio Vista is hypothesized to:

- maintain sufficient attraction and upstream migration flows for adult salmonids and sturgeon in the Sacramento River;
- maintain sufficient downstream migration of juvenile Chinook salmon and steelhead;
- maintain sufficient downstream transport of planktonic fish eggs and larvae;
- maintain sufficient downstream transport of organic material, phytoplankton, and zooplankton; and
- provide high quality habitat for both resident and migratory species within the lower river.

Adaptive Management Considerations: Results of biological monitoring could be used within the BDCP adaptive management framework to refine and modify the seasonal river flow criteria at Rio Vista.

WOCMN8: Install and operate gates at Old River and Connection Slough ("Two Gates") to reduce the transport of covered species into the interior Delta and improve water quality in the south and central Delta. The BDCP Implementing Entity will install operable gates in Old River and Connection Slough on the west and east sides of Bacon Island, respectively, and operate the gates to reduce entrainment of fish, invertebrates, nutrients, and organic material into Old and Middle Rivers, which is an area of high entrainment risk by SWP and CVP facilities. The gates will be installed such that they could begin operation during BDCP near-term implementation. The gates will be closed when covered fish species are in the vicinity of the western Delta and during times of low water quality in the south Delta, such as during low flow periods. Operations under this parameter will affect WOCMN9 and 14.

Operational Criteria and Adaptive Limits. The operational criteria for the two gates during the BDCP near-term implementation periods are described in Table 3.4.

Problem Statement: The diversion of water from SWP and CVP facilities in the south Delta results in local and regional changes in hydrodynamics, particularly in south Delta channels such as Old and Middle Rivers, which can result in the direct entrainment of covered fish and other aquatic species. The influence of exports on south Delta hydrodynamics includes changing the magnitude (velocity and volume of flows) and the direction of tidal flows (creating negative or reversed net flows). Planktonic organisms, such as fish larvae, phytoplankton, and zooplankton, that move passively with water currents can be transported from areas within the Delta to the export facilities, as has been shown using particle tracking models. Many of the fish that migrate through the Delta, including juvenile and adult Chinook salmon, steelhead, delta smelt, longfin smelt, and sturgeon, use current patterns as migratory and navigational cues. Changes in the direction and magnitude of currents in response to exports have the potential to adversely affect the migration and movement of these and other Delta species, which can lead to false attraction, longer migration routes, delays in migration, and increased transport towards export facilities.

Hypotheses: Installation and operation of gates in Old River and Connection Slough are hypothesized to:

- avoid and minimize take of delta smelt by: (1) reducing the transport of these fish towards the CVP and SWP export facilities, and (2) keeping optimal rearing habitat west of the central Delta; and
- maintain drinking water quality in the south Delta by reducing salt water intrusion from downstream bays. Preliminary modeling indicates that water quality in the south Delta will improve with operations of the gates (D. Majors, pers. comm.)**.**

Adaptive Management Considerations: Because the two gates will allow flexible operations information collected through these monitoring programs could be used to refine gate operations and/or establish various physical or biological triggers for changes in gate operations. Adaptive operational changes may include leaving one or both gates open or closed for longer periods, modifying gate operations based on changes in water surface elevation or tidal conditions, changes in gate operations in response to high or low flows within the channels, or the occurrence of covered fish in the SWP and/or CVP fish salvage monitoring.

WOCMN9: Maintain sufficient Delta outflows during the near-term implementation period for environmental benefits. *[**Note to reviewers**: This conservation measure may be updated to include inflow, outflow, and/or proportional release operational criteria as determined by the BDCP Steering Committee]* The BDCP Implementing Entity will maintain sufficient Delta outflows during the near-term implementation period for the benefit of covered fish species. Delta outflows provide for downstream transport of fish and other aquatic organisms as well as organic material and prey for covered species into the lower reaches of the Delta and Suisun Bay. Delta outflows also control, in balance with upstream salinity intrusion from the bay, the location of the low salinity region of the estuary (Baxter et al. 1999, Kimmerer 2004). The abundance of life stages of a number of fish species, including some covered fish species (longfin smelt), has been positively correlated with the location of the low salinity zone (generally measured as X_2) within the estuary (Baxter et al. 1999, Kimmerer 2004). Suisun Bay and the western Delta represent important low salinity habitat areas within the estuary. Open water habitat in this region serves as larval and juvenile rearing, adult holding, and foraging habitat for resident and anadromous fish and a wide variety of other aquatic and wildlife species, and as a migration corridor for anadromous species such as salmon, steelhead, and sturgeon. Based on the information regarding the relationship between fish abundance and X_2 location, the State Water Quality Control Board's D-1641 includes requirements for maintaining the X_2 location during the late winter and spring within Suisun Bay. Operations under WOCMN11 and 12, as well as many habitat restoration conservation measures implemented in the near-term could affect the position of the low salinity zone in the estuary.

Operational Criteria and Adaptive Limits. The operational criteria for Delta outflow during the BDCP near-term implementation periods are described in Table 3.4.

Problem Statement: Fishery monitoring studies conducted by DFG (Baxter et al. 1999) suggest that abundances of juvenile lifestages of many fish (e.g., starry flounder, splittail, longfin smelt, and striped bass) and macroinvertebrates are correlated with the location of the low salinity zone during the late winter and spring (e.g., February through June [Kimmerer 2004]). For example, longfin smelt juvenile abundance indices increased as the location of X_2 moved further downstream (west) within Suisun Bay (Kimmerer 2004). Recent analyses have suggested that previous correlations between X_2 location and fish abundance indices have changed (Kimmerer 2004). The changes observed in these relationships have been hypothesized to be the result of the introduction and rapid colonization of Suisun Bay by the filter feeding Asian overbite clam (*Corbula*) and a subsequent reduction in phytoplankton and zooplankton as food supplies for juveniles within Suisun Bay (Kimmerer 2004). Another change in this relationship appears to have occurred since 2001 in conjunction with the pelagic organism decline, although the cause of this change is currently unknown (Baxter et al. 2008).

Factors that may to contribute to the relationship between Delta outflow (as well as X_2 location) and juvenile fish abundance are heavily debated, but may include increased productivity and availability of high quality habitat within Suisun Bay (although new research does not support this hypothesis [Kimmerer et al. 2009]), downstream transport of fish, food, and organic matter, reduced temperature and/or ammonia concentrations with lower X_2, inundation of backwater and floodplains with high flows, and the distribution of the earlier lifestages of fish into habitats that are located further downstream with decreased vulnerability to direct and indirect effects of south Delta SWP and CVP export operations.

Hypotheses: Allowing Delta outflow in the adaptable range above is hypothesized to:

- provide for downstream transport of fish and other aquatic organisms into the lower reaches of the Delta and Suisun Bay; and
- provide for downstream transport of organic material and prey for covered species into the lower reaches of the Delta and Suisun Bay.

Adaptive Management Considerations: Based on results and analysis of monitoring data, adaptive modifications to management of Delta outflow under the BDCP adaptive management framework could occur by modifying operational criteria by season or water-year type (hydrology) or by addressing other stressors and factors that may be affecting the survival or abundance of a covered fish species.

WOCMN14: Maintain in-Delta agricultural, municipal, and industrial water quality requirements during the near-term implementation period. The BDCP Implementing Entity will maintain existing D-1641 North and Western Delta agricultural and municipal and industrial (M&I) standards, except that the D-1641 compliance point will be moved from Emmaton to the Three Mile Slough juncture. All water quality requirements contained in the North Delta Water Agency/DWR Contract and other DWR contractual obligations will be maintained. Operations under WOCMN5, 11, and 12 could affect this parameter.

Operational Criteria and Adaptive Limits. The operational criteria for Delta salinity during the BDCP near-term implementation periods are described in Table 3.4.

Problem Statement: Salinity in the Delta is primarily a function of freshwater flowing from tributary rivers and saltwater intrusion from San Francisco Bay. Areas located downstream such as Suisun Bay and further west are characterized by increasing salinity gradients. The northern and eastern Delta is characterized by primarily freshwater aquatic habitats. The lower San Joaquin River and southern Delta are characterized by low salinity waters, primarily resulting from saline agricultural drainage returns with elevated salt concentrations discharging into the San Joaquin River (DWR et al. 2006). If salinity increases to levels above standards dictated in D-1641, agricultural and M&I use of exported water can be severely limited.

Hypotheses: Maintaining existing D-1641 North and Western Delta agricultural and municipal and industrial (M&I) standards and all water quality requirements contained in the North Delta Water Agency/DWR Contract and other DWR contractual obligations would permit existing agricultural and M&I uses of water in these areas.

Adaptive Management Considerations: Within the BDCP framework of adaptive management, the BDCP Implementing Entity will monitor and adaptively manage salinity in the Delta in response to any adverse impacts resulting from the operational criteria described above.

WOCMN11: Operate the Montezuma Slough Salinity Control Gate during the near-term implementation period for environmental benefits. The BDCP Implementing Entity will coordinate with the Suisun Marsh Charter Group over the term of the BDCP to seek amendments to the Suisun Marsh Habitat Management, Preservation, and Restoration Plan (in development) that will provide for relaxing or ceasing near-term operation of the Montezuma Slough Salinity Control Gate. This action will allow more water to flow past Chipps Island and will improve access of covered fish species to existing and future restored intertidal marsh habitats. This parameter will involve either changing gate operations or removing the gate and will affect WOCMN9 and 14. Suisun Marsh is currently managed largely to provide seasonal freshwater wetland habitat, primarily to support waterfowl habitat and recreation. The Montezuma Slough Salinity Control Gate was originally installed and operated as a tidal pump to reduce salinity within the marsh: gates were opened on the ebb tide to allow freshwater from upstream to enter the slough and closed on the flood tide to prohibit saline water from entering the slough. The salinity control structure has been shown to alter local hydrodynamics and water quality conditions and impede the migration and passage of various fish species.

Operational Criteria and Adaptive Limits. The operational criteria for the Montezuma Slough Salinity Control Gate during the BDCP near-term implementation periods are described in Table 3.4.

Problem Statement: The Montezuma Slough Salinity Control Gate has been identified as an impediment to migration and passage of species such as Chinook salmon, steelhead, and green sturgeon through Montezuma Slough (Fujimura et al. 2000). In addition, existing operations of the control structure alter local current patterns and tidal hydrodynamics within Montezuma Slough, in large regions of Suisun Marsh, and in the main river channel between the control gate and Suisun Bay (DWR 1999). For example, operation of the control structure during the late fall in dry years can cause a significant upstream shift in X_2 location, potentially increasing the risk of entrainment at the SWP/CVP export facilities of smelt and other species that are situated near X_2 location (D. Fullerton pers. comm. 1). These changes in environmental conditions are thought to have resulted in adverse effects on covered species and other aquatic resources within the area.

Hypotheses: A reduction in operation of the Montezuma Slough Salinity Control Gate is hypothesized to:

- reduce delays in outmigration of juvenile salmonids and sturgeon by allowing more water and fish to flow past Chipps Island; and
- improve access of splittail, salmonids, and sturgeon to existing and future restored intertidal marsh habitats in Suisun Marsh.

Adaptive Management Considerations: In the event that the control structure remains in place and the gates are opened, results of monitoring could be used in the future to adaptively manage the control gates (resume gate operations) if unexpected undesirable consequences are detected. If the control structure is removed, adaptive management of salinity regimes will require modifications of Delta outflow to manage salinity within the marsh.

3.4.1.3 Long-Term Water Operations Conservation Measures

This section provides descriptions of the long-term water operations for multiple parameters across the Delta. Each long-term water operations conservation measure (WOCML) is provided a unique alpha-numeric label (e.g. WOCML1, WOCML2, etc.) that is coordinated with the near-term, equivalent of the parameter. For example, WOCML1 is the long-term component of WOCMN1. Long-term operations are made possible by facilities constructed during the near-term (e.g., new north Delta diversions, isolated conveyance facility, and new gates at Fremont Weir). In the long-term implementation period, dual operations of the existing south Delta diversion facilities and the new north Delta diversion facilities will provide greater flexibility to benefit covered fish and water exports not possible during the near-term implementation period. Long-term operations under the dual facility will allow water to be diverted from the lower Sacramento River using state-of-the-art positive barrier fish screens that are expected to substantially reduce the risk of entrainment of covered fish and other aquatic organisms, but will also provide positive benefits resulting from a reduction in the rate of water diversions occurring from the south Delta when covered fish species are present (see WOCML#). Long-term water operations described in this section will replace certain near-term water operations described above once the new north Delta diversions and the new isolated conveyance facility are completed and functional.

Long-term water operations conservation measures suitable for evaluation have been evaluated through the DRERIP process. The potential benefits, uncertainties, and risks identified through the DRERIP evaluation process for each of the evaluated water operations conservation measures are presented in Appendix X, *DRERIP Evaluations.*

WOCML1: Construct a new water diversion facility in the north Delta with multiple intakes and fish screens and an isolated conveyance facility and preferentially operate the facility while maintaining sufficient bypass flows for covered fish species. Five new water diversion facilities with 3,000 cfs capacity each (combined 15,000 cfs capacity) will be constructed and operated on the Sacramento River in the north Delta to minimize impacts on fish at the SWP and CVP south Delta diversion facilities. An isolated conveyance facility with a 15,000 cfs capacity will be constructed to convey water from the new diversion facilities to the south Delta, where it will join existing SWP and CVP diversion facilities. The sizing of the proposed facility is proposed at 15,000 cfs, which is approximately the amount that will be needed to match existing export pumping capacity of the SWP and CVP facilities in the southern Delta.[4] The ultimate size of the facility will be determined during the BDCP development process. The new conveyance facility will follow a route along the eastern side of the Delta (Figure 3.4) (*the exact location of the isolated conveyance facility has not been determined at this time*). Each new intake will be screened with state-of-the-art positive barrier fish screens and have a pump station, power lines, access roads, and other associated infrastructure.

Five locations for intakes have been identified, from north of Freeport (across the Sacramento River from the Pocket Area of the City of Sacramento) to just downstream of Hood (Figure 3.4). Selection of locations is based on multiple considerations including, but not limited to, maximizing function and effectiveness of screens; minimizing impacts to in-channel, on-bank, and terrestrial resources; applicable navigational and flood conveyance regulations; channel geometry and bathymetry; location relative to tidal influence and ranges of covered fish; future climate change and sea level rise; and proximity to other infrastructure (e.g., Sacramento Regional Wastewater outfall, existing developed land, and other intakes). Each intake will be engineered to allow variable rate pumping to handle variation in the location of covered fish and tidally-induced flows, as well as sea level rise from climate change. The influence of tides, which could produce reverse or stagnant flows in channels, attenuates upstream such that the most northern intakes are expected to be less influenced by tides than downstream intakes, particularly during higher river flow.

Two types of intake/screens structures are currently being considered: (1) on-bank screens and (2) in-river screens. Each has different benefits, impacts, and costs that will be considered in the ultimate decision of which type to use. More than one screen type may be used depending on site conditions at each intake. Fish screens will be designed to include specific screen mesh sizes (____ inch open area), approach velocities (____ ft/sec), sweeping flows, screen cleaning mechanisms, and monitoring systems. Three types of screening materials are currently being investigated: stainless steel, copper-nickel, and plastic. The advantages and disadvantages of each will be considered in the ultimate decision of which material to use. Further, with the high risk of invasion into the Delta by quagga and zebra mussels in the future, the use of anti-fouling material or alternative cleaning systems is also being considered.

A 49 mile isolated conveyance facility will be routed along the eastern side of the Delta from the intakes to a new 730 acre forebay near Clifton Court Forebay (Figure 3.4). Five pump stations will lift water from the five intakes into the isolated conveyance facility. The conveyance facility will be primarily above ground but will have four short tunnels totaling two miles in length and eight siphons will take the conveyance facility under existing waterways. Because the conveyance facility will cross multiple roads and railroads, 19 new bridges will be constructed. The new forebay will tie directly to existing south Delta CVP and SWP facilities.

[4] Numerous comments have been received during the planning process on the optimal sizing of the new diversion and conveyance facilities and to the design of the facility as a pipeline or tunnel rather than as a canal. Alternatives to the sizing and design features of the conveyance facility proposed 15,000 cfs here will be thoroughly analyzed through the BDCP planning process.

Although construction of the new north Delta facility and associated infrastructure will be initiated in the near-term, operation of the new facility will not start until the long-term implementation period. The north Delta diversion facility will be operated in conjunction with, but preferentially to (except during summer months [see WOCML#] and at other times where necessary to meet the goals of fish conservation and water supply), existing south Delta SWP and CVP diversion facilities to minimize adverse effects on fish in the Delta while maintaining water supply reliability as described in Chapter 4 *Covered Activities*. The quantity and timing of diversions will be affected by specific parameters described in this chapter.

The new intake facilities will be operated to maintain flows in the Sacramento River to meet five primary objectives for flows at and downstream of the new north Delta facilities:

1. maintain fish screen sweeping velocities,
2. minimize upstream transport from downstream channels,
3. support salmonid and pelagic fish transport to regions of suitable habitat,
4. minimize predation effects downstream, and
5. maintain or improve rearing habitat in the north Delta.

These north Delta facilities "bypass flows" represent the rate of flow at which the Sacramento River must pass downstream of the new diversion points. Bypass flows are intended to serve as an operational parameters to limit or otherwise manage water diversions from the new north Delta diversion facilities to minimize and reduce the effects of those diversions on downstream hydrodynamics (e.g., reduce Sacramento River flow downstream of the point of diversion) needed to support functions within and downstream of the river. Bypass flows for the Sacramento River act as an operational criteria in which water diversions will only occur when flows are maintained above the minimum criteria. The minimum bypass flow rates act as restrictions on water diversions during those years and seasons when flow in the Sacramento River is low. To meet water supply goals (see Chapter 4 *Covered Activities*), constraints on the amount of water diverted from north Delta facilities may require commensurate increases in diversions from the south Delta SWP and CVP facilities. To maintain water quality in the South Delta during low flow periods on the San Joaquin River in summer months (July-September), existing South Delta pumps will be preferentially operated up to 3000 cfs (see WOCML##)

In addition to establishing the minimum bypass flow rates as one set of operating criteria, two additional operating criteria will be implemented response to low river flow conditions. The first operational condition is preferential operation of the new diversion facilities located the farthest upstream to reduce the effects of low Sacramento River flow on tidal reversal in the vicinity of the diversion (maintain positive downstream flows across the intake structures and reduce the likelihood that larval and juvenile fish will move upstream into the area of potential entrainment/impingement at the diversion). Results of hydrodynamic modeling indicate that a higher level of Sacramento River flow needs to be maintained to avoid tidal flow reversal downstream (e.g., near Walnut Grove) when compared to the flow needed to maintain downstream river flows at more upstream sites. A second operational response to low Sacramento River flow conditions is to implement preferential diversion operations in response to tidal conditions (e.g., divert water during ebb tide stage to maintain sweeping velocity and avoid tidal flow reversal) and then reduce or curtail diversion during the flood tide stage.

Factors considered in developing north Delta diversion bypass flows included:

- seasonal timing of various life stages of covered fish inhabiting the Sacramento River in the vicinity of the proposed water diversion locations;
- changes in the biological processes and relationship in response to river flow that occur seasonally (e.g., differences in the biological processes of phytoplankton and zooplankton production between winter-spring and summer-fall);
- the relationship between bypass flows and hydrologic synchrony of flows and environmental cues within the Sacramento River watershed;
- the relationship between river bypass flow rate and constraints on water diversions and water supplies;
- the relationship between downstream transport rate of planktonic particles (simulating larval delta and longfin smelt transport between the upstream spawning areas, such as Cache Slough, and the downstream estuarine habitat where first deeding and juvenile rearing occur) and river flow rate;
- the relationship between river flow and downstream transport of phytoplankton, zooplankton, and organic material;
- the relationship between fall river flows and attraction and migration flows in the mainstem river for adult upstream migration by fall-run and late fall-run Chinook salmon, steelhead, delta and longfin smelt, splittail, and other upstream migrating adults;
- relationships between river flow rate and juvenile transit time through the lower river (a factor thought to affect vulnerability to predation mortality), juvenile survival rates, and river flow;
- relationships between river flow and habitat conditions for predatory fish (e.g., largemouth bass, smallmouth bass, pikeminnow, and striped bass) in the river and sloughs;
- the relationship between river flow rate and tidal dynamics (e.g., changes in water velocity and direction in response to flood and ebb tide conditions) and the river flows at various potential diversion locations that maintain a net unidirectional downstream flow over all tidal conditions;
- the relationship between mainstem river flows and seasonal flows into a floodplain habitat such as the Yolo Bypass and the resultant effects on hydrodynamic conditions in the river at the points of diversion;
- the relationship between existing and expanded tidal marsh habitat within the Cache Slough complex and tidal hydrodynamics within the river at various potential points of diversion;
- the relationship between river flow, channel geometry, and resulting sweeping velocities across a positive barrier fish screen at each potential diversion location. Sweeping velocity is intended to help remove accumulated debris from the fish screen surface to maintain approach velocities and to help transport fish downstream and reduce their exposure to entrainment and impingement at the diversion.

New north Delta diversions will also affect WOCML6, 9, and 14.

Operational Criteria and Adaptive Limits. The north Delta facilities operations and bypass flow requirements will apply in the BDCP long-term implementation period following completion of facilities construction. Specifics on the operational criteria and adaptive range of north Delta facilities bypass flows are provided in Table 3.5.

Table 3.5. Proposed Long-Term Operational Criteria and Adaptive Range Limits.

*[**Note to reviewers:** Long-term operational criteria are under development and will be included in table 3.5 when completed. The table in brackets that follows table 3.5 provides a summary of proposed long-term Delta water operations for the purpose of conducting the BDCP impact and conservation assessment. Information in the bracketed table provides the basis for hydrologic and hydrodynamic modeling inputs for the assessment. The bracketed table does not state an agreed to proposal for operations.]*

Water Operations Parameter (i.e., conservation measure)	***Proposed Initial Long-Term Water Operations Criteria***	***Adaptive Range Limits***
WOCML1: Construct a new water diversion facility in the north Delta with multiple intakes and fish screens and an isolated conveyance facility and preferentially operate the facility while maintaining sufficient bypass flows for covered fish species.	TBD	TBD
WOCML12: Operate South Delta diversions to maintain sufficient Old and Middle River Flows during the long-term implementation period for environmental benefits.	TBD	TBD
WOCML2: Modify the Fremont Weir and Yolo Bypass and operate the Fremont Weir to provide for a higher frequency and duration of inundation of the Yolo Bypass	TBD	TBD
WOCML5: Operate the Delta Cross Channel gates during the long-term for environmental benefits.	TBD	TBD
WOCML6: Maintain sufficient Rio Vista flows for environmental benefits during the long-term implementation period.	TBD	TBD
WOCML9: Maintain sufficient Delta outflows during the long-term implementation period for environmental benefits.	TBD	TBD
WOCML#: Operate the Dual Conveyance Facilities to Maintain Delta Water Quality and Protect Covered Fish Species.	TBD	TBD

Table 3.5. Proposed Long-Term Operational Criteria and Adaptive Range Limits.

*[**Note to reviewers:** Long-term operational criteria are under development and will be included in table 3.5 when completed. The table in brackets that follows table 3.5 provides a summary of proposed long-term Delta water operations for the purpose of conducting the BDCP impact and conservation assessment. Information in the bracketed table provides the basis for hydrologic and hydrodynamic modeling inputs for the assessment. The bracketed table does not state an agreed to proposal for operations.]*

Water Operations Parameter (i.e., conservation measure)	*Proposed Initial Long-Term Water Operations Criteria*	*Adaptive Range Limits*
WOCML14: Maintain in-Delta agricultural, municipal, and industrial water quality requirements during the long-term implementation period.	TBD	TBD
WOCML11: Operate the Montezuma Slough Salinity Control Gate during the long-term implementation period for environmental benefits.	TBD	TBD
HRCM17: Assess feasibility of a new flood bypass east of the Sacramento Deep Water Ship Channel to restore seasonally inundated floodplain habitat.	TBD	TBD

Problem Statement: For decades, water has been diverted directly from the south Delta through SWP and CVP facilities to meet agricultural and urban water demands south of the Delta. These diversions both require and create an artificial north-to-south flow of water through the Delta (as opposed to the natural general east-to-west flow pattern) and have resulted in the development of reverse flows in major Delta channels that result in entrainment of fish, invertebrates, nutrients, and other organic material. Existing diversion facilities are equipped with louvers that guide juvenile and larger fish into salvage facilities. Salvaged fish are subsequently transported to release locations on the lower Sacramento and San Joaquin Rivers where they are believed to be subject to high predation pressure (DWR 2005). Planktonic eggs, larvae, and small juveniles are not effectively salvaged and do not survive when carried into conveyance facilities. Smelt and juvenile salmon that are drawn into Clifton Court Forebay are subject to predation from the large populations of predatory fish that are present there.

The Sacramento River, in addition to its upstream tributaries, is the primary migration corridor and spawning/rearing habitat for Chinook salmon, Central Valley steelhead, and green and white sturgeon within the Central Valley. Further, both delta smelt and longfin smelt are thought to spawn in the lower Sacramento River (Wang 1986, Bennett 2005). Important fishery issues with respect to seasonal river flows include: (1) adult Chinook salmon, steelhead, and green and white sturgeon attraction flows and upstream migration; (2) juvenile Chinook salmon and steelhead downstream migration and survival; (3) downstream transport of planktonic fish eggs and larvae; (4) downstream transport of food and other organic material; and (5) habitat for both resident and migratory covered

[DRAFT Proposed Long-Term BDCP Water Operations Range of Criteria for Effects Analysis

(revised at July 30, 2009 Steering Committee Meeting)

This table provides a summary of proposed long-term Delta water operations for the purpose of conducting the BDCP effects analysis. Information in this table provides the basis for hydrologic and hydrodynamic modeling inputs for the analysis. This table does not state an agreed to proposal for operations. More specifics regarding criteria and rationale for each water operational parameter will be provided in the text of water operations conservation measures in Chapter 3 Conservation Strategy.

1. North Delta Diversion Bypass Flows

Objectives include flows or the functional equivalent thereof to (1) maintain fish screen sweeping velocities, (2) minimize upstream transport from downstream channels, (3) support salmonid and pelagic fish transport to regions of suitable habitat, (4) minimize predation effects downstream, and (5) maintain or improve rearing habitat in the north Delta.

Range A

Based on the objectives stated above, it is recommended to implement the following operating criteria:

- *Bypass flows sufficient to minimize upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.*

Range A: Feb - Apr

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	9,000 cfs	100% of the amount over 0 cfs
9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000
15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs

Draft Proposed Operations for Analysis

Based on the objectives stated above, it is recommended to implement the following operating criteria:

- *Bypass flows sufficient to minimize upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.*

Proposed Operations: Feb - Apr

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	11,000 cfs	100% of the amount over 0 cfs
11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000
15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs
20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs

Range B

Based on the objectives stated above, it is recommended to implement the following operating criteria:

- *Bypass flows sufficient to minimize upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.*

Range B: Feb - Apr

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	15,000 cfs	100% of the amount over 0 cfs
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs
20,000 cfs	no limit	18,400 plus 30% of the amount over 20,000 cfs

Range A	Draft Proposed Operations for Analysis	Range B
1. North Delta Diversion Bypass Flows (continued)		

Range A: Jan & May

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	9,000 cfs	100% of the amount over 0 cfs
9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000
15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs

Range A: Dec & Jun

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	9,000 cfs	100% of the amount over 0 cfs
9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000
15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs

Jul-Sep: 5,000 cfs

Oct-Nov: 7,000 cfs

** Fremont Weir spill to the Yolo Bypass included as available for diversion as long as base bypass flow is satisfied.*

*** Percentage will vary linearly over a 10-day period when transitioning between months*

Proposed Operations: Jan & May

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	11,000 cfs	100% of the amount over 0 cfs
11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000
15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs
20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs

Proposed Operations: Dec & Jun

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	11,000 cfs	100% of the amount over 0 cfs
11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000
15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs

** Base flow value of 11,000 cfs is replaced with 9,000 cfs in Dry and Critical years as indicated by the 50% forecast*

Jul-Sep: 5,000 cfs

Oct-Nov: 7,000 cfs

*** Fremont Weir spill to the Yolo Bypass included as available for diversion as long as base bypass flow is satisfied.*

**** Percentage will vary linearly over a 10-day period when transitioning between months*

Range B: Jan & May

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	15,000 cfs	100% of the amount over 0 cfs
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs
20,000 cfs	no limit	17,900 plus 20% of the amount over 20,000 cfs

Range B: Dec & Jun

If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	15,000 cfs	100% of the amount over 0 cfs
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs
20,000 cfs	no limit	17,400 plus 20% of the amount over 20,000 cfs

Jul-Sep: 5,000 cfs

Oct-Nov: 7,000 cfs

** Fremont Weir spill to the Yolo Bypass included as available for diversion as long as base bypass flow is satisfied.*

*** Percentages will vary linearly over a 10-day period when transitioning between months*

**** Beginning Dec 1, the first storm event exceeding 20,000 cfs at Freeport will be bypassed for up to 7 days (first flush concept).*

Range A	Draft Proposed Operations for Analysis	Range B

2. South Delta Channel Flows

Minimize take at south Delta pumps by reducing incidence and magnitude of reverse flows during critical periods for pelagic species.

Range A

OMR Flows

Old and Middle River flows no less than the values below:

Combined Old and Middle River flows no less than values below* (cfs)					
Month	W	AN	BN	D	C
Jan	-5000	-5000	-5000	-5000	-5000
Feb	-5000	-5000	-5000	-5000	-5000
Mar	-5000	-5000	-5000	-5000	-5000
Apr	-5000	-5000	-5000	-5000	-5000
May	-5000	-5000	-5000	-5000	-5000
Jun	-5000	-5000	-5000	-5000	-5000
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A
Oct	N/A	N/A	N/A	N/A	N/A
Nov	N/A	N/A	N/A	N/A	N/A
Dec	-6800	-6800	-6800	-6800	-6800

** Values are monthly average for use in modeling. December 20-31 targets are -5000 cfs and are averaged with an assumed background of -8000 cfs for December 1-19.*

Draft Proposed Operations for Analysis

OMR Flows

- *FWS smelt BO model of adaptive restrictions (temperature, turbidity, salinity, smelt presence)*

Table below represents current estimate of "most likely" operation under FWS BO for modeling purposes

Combined Old and Middle River flows no less than values below* (cfs)					
Month	W	AN	BN	D	C
Jan	-4000	-4000	-4000	-5000	-5000
Feb	-5000	-4000	-4000	-4000	-4000
Mar	-5000	-4000	-4000	-3500	-3000
Apr	-5000	-4000	-4000	-3500	-2000
May	-5000	-4000	-4000	-3500	-2000
Jun	-5000	-5000	-5000	-5000	-2000
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A
Oct	N/A	N/A	N/A	N/A	N/A
Nov	N/A	N/A	N/A	N/A	N/A
Dec	-6800	-6800	-6300	-6300	-6100

** Values are monthly average for use in modeling. December 20-31 targets are -5000 cfs (W, AN), -3500 cfs (AN, D), and -3000 cfs (C), and are averaged with an assumed background of -8000 cfs for December 1-19. Values are reflective of the "most likely" operation under the FWS Delta Smelt Biological Opinion. Values for modeling may be updated based on review by fishery agencies.*

South Delta Export – San Joaquin Inflow Ratio

- *Sliding scale for flows above the established OMR to share additional SJR flows between export and environment; export share would increase at higher flows*
- *Time value of benefit; crediting outside of period in which flows are acquired*

[Note that Conveyance WG/HOTT recommends continuing to evaluate the concept of isolating Old River to address south Delta channel flows.]

Range B

Consider replacement of OMR with sliding scale SJR EI ratio that provides similar or greater protection than FWS smelt BO

South Delta Export – San Joaquin Inflow Ratio

- *50% Mar & Jun*
- *25% April & May*
- *75% Oct, 50% Nov*
- *100% Dec-Feb*

OMR Flows

- *Old and Middle River flows no less than -5,000 cfs during Jul-Sep.*

Range A	Draft Proposed Operations for Analysis	Range B
3. Fremont Weir/Yolo Bypass **Considerations include (1) increasing spawning and rearing habitat for splittail and rearing habitat for salmonids, (2) providing alternate migration corridor to the mainstem Sacramento River, and (3) increasing effectiveness of habitat and food transport in Cache Slough.**		
Same as "Proposed Operations"	***Modified Fremont Weir and Control Gate*** • *Spills into Yolo Bypass enabled at water surface elevation 17.5 ft NAVD88 (~15,000 cfs Sac R at Fremont flow) by notch and new gates, as compared to current weir elevation of 33.5 ft (~56,000 cfs Fremont flow).* • *Flows: 2,000-6,000 cfs* depending on hydrology* • *Duration: 30-45 days* • *Period: Gates operable December – April 15 (occasionally April 16-May 15 depending of hydrologic conditions)* ** Flows less than 3,000 cfs may require physical modifications to the Yolo Bypass and toe drain to achieve levels of desired floodplain habitat.* *** Physical modifications to Yolo Bypass and the toe drain may be required to achieve levels of desired floodplain habitat enhancement.*	*Same as "Proposed Operations"*
4. Delta Cross Channel Gate Operations **Considerations include (1) reduce transport of outmigrating Sacramento River fish into central Delta, (2) maintain flows downstream on Sacramento River, (3) and providing sufficient Sacramento River flow into interior Delta when water quality for M&I and AG may be of concern.**		
Same as "Proposed Operations"	*Oct-Nov: DCC gate closed if fish are present (assume 15 days per month; may be open longer depending on presence of fish)* *Dec-Jun: DCC gate closed* *Jul-Sep: DCC gate open*	*Same as "Proposed Operations"*
5. Rio Vista Minimum Instream Flows **Maintain minimum flows for outmigrating salmonids and smelt.**		
Sep-Dec: Per D-1641 *Jan-Aug: Minimum of 3,000 cfs*	*Sep-Dec: Per D-1641* *Jan-Aug: Minimum of 3,000 cfs*	*Sep-Dec: Per D-1641* *Jan-Aug: Minimum of 3,000 cfs*

Range A	Draft Proposed Operations for Analysis	Range B
6. Delta Inflow & Outflow ***Considerations include (1) Provide sufficient outflow to maintain desirable salinity regime downstream of Collinsville during the spring, (2) explore range of approaches toward providing additional variability to Delta inflow and outflow.***		
Delta Outflow: *Jul-Jan: Per D-1641* *Feb-Jun: Per D-1641*, except no Roe Island triggering* ** Current relaxation of Collinsville standard to 4,000 cfs in May and June revised to state when the Eight River Index is 10.0 or less as established on May 1.* *** Proportional Reservoir Release concept will continue to be evaluated to the extent that it provides similar response to outflow, inflow, and upstream storage conditions*	***Delta Outflow:*** *Jul-Jan: Per D-1641* *Feb-Jun: Per D-1641* ** Proportional Reservoir Release concept will continue to be evaluated to the extent that it provides similar response to outflow, inflow, and upstream storage conditions*	***Delta Outflow:*** *Jul-Aug & Jan: Per D-1641* *Sep-Nov: Fall X2 per FWS Smelt BO* *Feb-Jun: NGO X2-Eight River Index approach (storage off-ramps to be refined)* ** Proportional Reservoir Release concept will continue to be evaluated to the extent that it provides similar response to outflow, inflow, and upstream storage conditions* *** Continue analysis of NGO watershed unimpaired runoff approach as it relates to PREs and parties outside of BDCP. Carry into "related action" alternative.*
7. Operations for Delta Water Quality and Residence Time ***Considerations include (1) maintain a minimum level of pumping from the south Delta during summer to provide limited flushing for general water quality conditions (reduce residence times), (2) for M&I and AG salinity improvements, and (3) to allow operational flexibility during other periods to operate either north or south diversions based on real-time assessments of benefits to fish and water quality.***		
Same as "Proposed Operations"	***Assumptions for analysis:*** *Jul-Sep: Prefer south delta pumping up to 3,000 cfs before diverting from north* [1] *Oct-Jun: Prefer north delta pumping (real-time operational flexibility)*	*Same as "Proposed Operations"*
8. In-Delta Agricultural and Municipal & Industrial Water Quality Requirements ***Existing M&I and AG salinity requirements.***		
Same as "Proposed Operations"	*Existing D-1641 North and Western Delta AG and MI standards, except move D-1641 compliance point from Emmaton to Three Mile Slough juncture. Maintain all water quality requirements contained in the NDWA/ DWR Contract and other DWR contractual obligations.*[1]	*Same as "Proposed Operations"*
9. Habitat Restoration Targets		
Same as "Proposed Operations"	*65,000 acres Tidal Marsh (subtidal, sea level rise accommodation, mitigation credits)* *10,000 acres Floodplain* *5,000 acres Riparian* *80,000 acres Total*	*Same as "Proposed Operations"*

[1] *The results of the water quality modeling from the effects analysis will be used, to determine if other actions are needed to address water quality issues that may arise, including water quality in the southern and central Delta for both Agricultural and M&I due to the BDCP Long-term operations."*

Figure 3.5. Proposed North Delta Diversion Bypass Rule example for February-April.

[Figure to come].

fish species within the lower Sacramento River. The importance of river flows to each life stage of the covered fish species varies seasonally depending on each species' life history and habitat requirements. Because of the importance of the Sacramento River as a migration route and habitat for covered fish species, maintaining sufficient flows within the river to support this function is an important operational objective for covered fish species.

Hypotheses: Relocation and operation of the primary point of SWP and CVP water diversions from the south Delta to multiple facilities on the Sacramento River between Freeport and Hood and conveying water through an isolated conveyance facility are hypothesized to provide a broad range of benefits to covered fish species, the Delta ecosystem, and water supply if operated according to an appropriate set of operational parameters, which are described separately in this chapter. The following hypotheses provide the basis for this conservation measure:

1. Relocation and operation of the primary point of diversion to the north Delta will substantially reduce entrainment of the larvae of covered fish species by reducing the spatial overlap of diversion intakes and covered fish species. The location of the existing south Delta export facilities is within the influence of covered fish species for at least part of the year. However, the population centers of resident estuarine species, particularly delta and longfin smelt, are downstream of the reach of the Sacramento River where the north Delta intakes could be installed (Wang 1986, Bennett 2005).
2. Equipping facility intakes with state-of-the-art positive barrier fish screens will substantially reduce entrainment and impingement losses of juveniles and adults of covered fish species. These screens will be engineered to provide a maximum approach velocity to protect covered fish species when fish are within the vicinity of intakes.
3. Constructing multiple intakes (rather than one or few) along the Sacramento River between Walnut Grove and Freeport will substantially reduce entrainment and impingement losses of juveniles and adults of covered fish species. Multiple intakes will reduce the distance fish must travel past each fish screen, allowing individuals to rest between intake locations. Early estimates indicated that, if one 15,000 cfs intake were constructed, a single fish screen nearly a mile long will need to be constructed to meet approach and sweeping velocity criteria. This distance would expose fish to screens for longer periods, potentially exhausting them, reducing their swimming ability, and increasing their vulnerability to entrainment and impingement.
4. Reducing water diversions in the tidal region of the Delta will substantially reduce entrainment and impingement losses of juveniles and adults of covered fish species. Reverse flows associated with tidal oscillations increase the zone of influence of existing diversion facilities in many south Delta channels, potentially increasing the risk of entrainment of covered fish species. Relocating the primary point of diversion farther upstream will reduce the tidal influence on diversions, which will reduce entrainment of covered fish species. Further, for positive barrier fish screens to function properly to minimize fish entrainment risk, a minimum unidirectional sweeping velocity must be maintained. Opportunities for such velocity improve as tidal influence decreases farther upstream.

5. Relocation and operation of the primary point of diversion to the north Delta will reduce the export of nutrients, phytoplankton, zooplankton, macroinvertebrates, and other organic material from the estuary. The location of existing south Delta diversion facilities is thought to be in an area that exports higher concentrations of nutrients, phytoplankton, zooplankton, macroinvertebrates, and other organic material than will occur with the new proposed reach of the Sacramento River. As a result, the loss of Delta productivity will be lower if water is diverted at north Delta facilities compared to existing south Delta facilities.
6. Improving hydrodynamics within Delta channels will improve fishery and aquatic habitat within the Delta. Existing flow patterns in the Delta have been altered to maintain high water quality in the south Delta for project exports, as well as for local agricultural and other urban water uses. Such alterations include north to south flows through the man-made Delta Cross Channel and reverse flows in Old and Middle Rivers, generating substantial adverse effects on fish and aquatic processes.
7. Relocation and operation of the primary point of diversion to the north Delta will reduce or eliminate mortality of covered fish species associated with collection, handling, transport, and release of salvaged fish from the existing export facilities and predation within these facilities. A north Delta diversion facility will be designed to avoid altogether the need to salvage fish at this facility by constructing in-river or on-river facilities.
8. Relocation and operation of the primary point of diversion to the north Delta will improve water supply reliability and flexibility under conditions of future environmental change. Because of their location, new diversion facilities could withstand predicted future sea level rise in ways that existing diversion facilities will not. Multiple intakes will add flexibility in operations to handle variation in the location of covered fish and tidally-induced flows.
9. Reducing artificial north-to-south through-Delta flows when covered fish are present will increase hydraulic residence time and improve aquatic productivity in the interior Delta. Existing Delta operations promote north-to-south flow of water via the Delta Cross Channel to offset high salinities and lower inflows from the San Joaquin River. By reducing South Delta diversions, less water will move from north to south, resulting in increased residence time of nutrients and organic matter, allowing these materials to be assimilated into the Delta food web.
10. Reducing the reliance on through-Delta conveyance via the Delta Cross Channel and intakes in the south Delta will provide greater opportunity for effective physical habitat restoration and enhancement in the western, eastern, and southern Delta. Decreased south Delta pumping will reduce the export of primary and secondary ecological production that may result from restored habitat, which would other reduce or eliminate the expected benefits of the habitat restoration also proposed by the BDCP. Restoration in these parts of the Delta, as well as Delta-wide hydrodynamic changes expected from a north Delta diversion, will reestablish ecosystem complexity by improving aquatic ecosystem processes, distribution, connectivity, migration, transport, and residence time in ways that the current water conveyance system simply cannot accommodate.

11. Reducing the reliance on through-Delta conveyance via the Delta Cross Channel and intakes in the south Delta will substantially reduce the effects of existing water projects on salmonids in the San Joaquin River system and tributaries, Mokelumne River, and other east side tributaries. Such artificial flow patterns are thought to entrain outmigrating juvenile salmonids in these channels towards the pumps and confuse the upstream migration cues of adults. Although the potential for adverse effects on Sacramento River salmonids may increase, these effects are predicted to be avoided or minimized by the positive fish screen and sweeping and approach velocity criteria (see #2-4 above) and other operational parameters.

12. Relocation and operation of the primary point of diversion to the north Delta will facilitate the implementation of some other conservation measures focused on non-flow and non-habitat related stressors.

13. Relocation and operation of the primary point of diversion to the north Delta will allow for the emulation of more natural physical patterns (e.g., salinity regimes, flow patterns) and processes in the Delta under which native resident species evolved. For example, a change in the hydrograph could favor native species by providing proper timing of biological processes from physical cues, such as those needed to initiate upstream or downstream migration, and create conditions that disfavor non-native species, such as reduced summer inflows, which are currently higher than would occur naturally.

The following hypotheses provide the basis for maintaining bypass flows past north Delta diversions:

1. Maintaining bypass flows will maintain adequate flows in the mainstem Sacramento River and distributaries downstream of the points of diversion for covered fish species. Of particular interest are flow rates within Sutter and Steamboat Sloughs (see WOCMN4). These sloughs are existing channels that convey water from the Sacramento River in the general vicinity of Courtland downstream to approximately Rio Vista where they re-enter the lower Sacramento River. Both channels currently have a hydraulic capacity greater than 500 cfs. Benefits maintaining adequate flows in Sutter and Steamboat Sloughs include:

    - Providing an alternative migration route for salmonids (Perry and Skalski 2008) and possibly splittail and sturgeon that circumvents the Delta Cross Channel and Georgiana Slough, thereby reducing the likelihood of covered fish species moving into the interior Delta where they may be exposed to higher predation pressure and entrainment into the South Delta pumps.
    - Providing high quality juvenile rearing habitat and adult holding habitat for salmonids, sturgeon, and splittail. Both slough channels support substantially more woody riparian vegetation and greater habitat diversity (e.g., water depths, velocities, in-channel habitat, etc.) than is present along the mainstem Sacramento River between Courtland and Rio Vista.
    - Providing high quality spawning habitat for splittail during dry periods without floodplain inundation.

Despite these anticipated benefits, recent field work by Perry and Skalski (2008) indicates that survival rates of juvenile late fall-run Chinook salmon in these sloughs are currently similar to or lower than survival rates in the mainstem Sacramento River, likely due to high predation rates. However, recent hydrodynamic modeling indicates that substantial habitat restoration in the Cache Slough area (HRCM4), in combination with bypass flow requirements for the north Delta diversions, will enhance downstream flows in Sutter and Steamboat Sloughs substantially above those present under current conditions without an isolated facility (A. Munevar unpubl. data). Further, HRCM12 proposes to enhance channel margin habitat in Sutter and Steamboat Sloughs in part to control the number of non-native predators that may be reducing survival of Chinook salmon, and likely other covered species in these sloughs. Therefore, in combination with these other conservation measures, maintaining bypass flows is expected to improve survival of salmonids, sturgeon, and splittail in Sutter and Steamboat Sloughs.

2. Maintaining bypass flows will provide transport flows necessary for downstream movement of delta and longfin smelt. Newly hatched larval delta and longfin smelt, called yolk-sac larvae, have a yolk sac attached to them with an oil globule (Wang 1986). The yolk sac provides nourishment for delta smelt larvae for approximately 4 to 6 days (Bennett 2005) and is thought to be similar for longfin smelt. These larvae are very weak swimmers and drift downstream with flows from the Sacramento River to the low salinity zone, where they can find suitable prey. To avoid starvation, this downstream movement must take place before the entire yolk sac is absorbed. Because downstream movement is driven nearly entirely by downstream flows, a minimum bypass flow criteria that allows this movement to occur is necessary.

3. Maintaining minimum bypass flows will provide downstream transport of food and organic material. The Sacramento River is used as a major corridor through which food and other organic material from upstream are transported downstream to the Delta and bays. The Delta and bays acquire production from upstream habitats to support their ecosystems.

4. Maintaining minimum bypass flows will provide necessary attraction flows for upstream migration of adult Chinook salmon, steelhead, and green and white sturgeon, including attraction flows through Sutter and Steamboat Sloughs.

5. Maintaining minimum bypass flows will minimize tidally driven bidirectional flows near diversion intakes, reducing the exposure duration of covered fish species to predators that will likely reside near intake structures. Unidirectional flows past intakes may also affect local current patterns and hydrodynamics in the vicinity of the screen surface that may affect fish entrainment or impingement, debris loading, effectiveness of fish screen cleaning mechanisms in removing debris from the screen surface, and maintaining a uniform approach velocity within the screen design criterion.

Developing bypass flow criteria for the north Delta diversion facilities involves consideration of the seasonal timing of various life stages of covered fish species within the lower Sacramento River, relationships between river flow, water velocity, transport time, and residence time, and the growth, survival, and distribution of various life stages of the covered species.

Adaptive Management Considerations: Results of the biological monitoring could be used adaptively in a variety of ways that include, but are not limited to: (1) changes in diversion operations within a range of adopted diversion parameters that are based on "real-time" monitoring of the occurrence of eggs and larvae of covered fish in the area; (2) selectively operating diversions based on the geographic distribution of covered fish within the river; and (3) changing diversion operations based on tidal velocity and river flows to increase sweeping velocity and the rate of fish movement past fish screens.

Results of both biological and operational monitoring throughout the Delta could be used within the BDCP adaptive management framework to refine and modify river bypass flow rates. For example, additional information on the actual timing of fish migration downstream within the Sacramento River within a given year could result in modification to the river bypass flows to facilitate migration past the points of diversion and fish screens.

WOCML12: Operate South Delta diversions to maintain sufficient Old and Middle River Flows during the long-term implementation period for environmental benefits. Maximum Old and Middle River (OMR) reverse flows during the long-term implementation period set under the BDCP will reduce the impacts of south Delta diversions on covered fish species and the Delta environment.

Diversions from the south Delta SWP and CVP facilities will be reduced considerably during wetter periods with dual operation of new north Delta diversion facilities. During wetter periods in the BDCP long-term implementation period, water will be diverted from the south Delta to augment north Delta diversions and may be diverted in appropriate circumstances to improve circulation and maintain water quality conditions in the interior and southern Delta. This parameter will affect WOCML9 and 14 and will be affected by operations associated with WOCML1, 5, and 8. For more information about Old and Middle River flows, see WOCMN12.

Operational Criteria and Adaptive Limits. The operational criteria for Old and Middle River flows during the BDCP long-term implementation periods are described in Table 3.5.

With operation of north Delta diversion facilities in the long-term implementation period, the existing south Delta SWP and CVP export facilities will be operated as part of a dual conveyance facility and exports from the south Delta will be substantially reduced (the north Delta diversion facilities will be equipped with state-of-the-art positive barrier fish screens and will be the primary point of long-term diversion during wetter periods). The dual export system will be operated to meet water supplies.

Problem Statement: see WOCMN12

Hypotheses: see WOCMN12

Adaptive Management Considerations: see WOCMN12

WOCML2: Modify the Fremont Weir and Yolo Bypass and operate the Fremont Weir to provide for a higher frequency and duration of inundation of the Yolo Bypass. The Fremont Weir and Yolo Bypass will be physically modified to manage the timing, frequency, and duration of inundation of the Yolo Bypass (Figure 3.4) with Sacramento River flows via the Fremont Weir to support the physical and biological attributes described in Section 3.4.2.1, *Physical Habitat Conservation Concepts*. To increase the frequency and duration of inundation of floodplain habitat in the Yolo Bypass, a section of the Fremont Weir will be lowered to 17.5 feet (NAVD88) (other elevations may be considered if necessary to satisfy inundation targets) and fitted with an operable gate(s) that, when opened, will allow Sacramento River water to flow into the Yolo Bypass when the river stage at the weir exceeds 17.5 feet. The operable gate(s) will be designed and operated to provide for the efficient upstream and downstream passage of multiple fish species to and from the Yolo Bypass into the Sacramento River. Other design elements of this measure will include:

- excavation of a canal to convey water past the higher elevation natural levee of the Sacramento River upstream of the new gate at Fremont Weir and past accumulated sediment below the new gate at Fremont Weir to the Tule Canal;
- acquisition of lands, in fee-title and through conservation or flood easements to restore seasonally inundated aquatic habitats;
- removal and replacement of the existing Fremont Weir fish ladder with new fish passage facilities designed to effectively allow for the passage of adult salmonids and sturgeon from the Yolo Bypass past the Fremont Weir into the Sacramento River;
- grading, removal of existing berms or levees, and construction of berms or levees to the extent necessary to improve the distribution (e.g., wetted area) and hydrodynamic characteristics (e.g., residence times, flow ramping, and recession) of water moving through the Yolo Bypass, to prevent stranding of covered fish species and to protect property (e.g., existing wildlife, public, and agricultural use areas); and
- construction of a structure in the Sacramento River, if needed, in the vicinity of the new weir gate to encourage the passage of juvenile salmonids migrating down the Sacramento River into the Bypass.

[***Note to Reviewers:*** *Additional Yolo Bypass design elements under consideration include improving connectivity of the Toe Drain with Putah Creek to improve fish passage, modifying the Lisbon Weir to improve fish passage and water management for fish and wildlife benefits, improving fish passage in the Tule Canal, and changing water circulation to allow use of existing managed seasonal wetlands.*]

The modified Fremont Weir will be operated to manage the timing and increase the frequency and duration of inundation of the Yolo Bypass (Figure 3.4) with Sacramento River flows via the Fremont Weir to support the physical and biological attributes described in Section 3.4.2.1, *Physical Habitat Conservation Concepts*.

To implement this conservation measure, the BDCP Implementing Entity will coordinate with the U.S. Army Corps of Engineers and other flood control entities, as appropriate, to ensure that fish passage improvements, bypass improvements, and Fremont Weir operations are compatible with the flood control functions of the Yolo Bypass.

When water inundates the Yolo Bypass, flows are reduced in the Sacramento River between the weir and Rio Vista. Closing the weir gate will provide water to support environmental benefits in Sutter and Steamboat Sloughs (WOCML4), the mainstem Sacramento River between the weir and Rio Vista, the Central Delta via the Delta Cross Channel (WOCML5) and Georgiana Slough, and a potential new floodplain east of the Sacramento Deep Water Ship Channel (HRCM17). This conservation measure could also affect Delta salinity (WOCML14).

Operational Criteria and Adaptive Limits. The criteria for non-flood stage operation of a new Fremont Weir gate(s) and associated channels are described in Table 3.5.

According to preliminary limited HEC-RAS modeling (A. Munevar, pers. comm.), flow rates of 2,000-6,000 cfs will inundate between 5,700-21,500 acres of floodplain habitat to an average depth of 2.6-5.3 feet and a mean velocity of 1.3-1.9 ft/s. The frequency of Fremont Weir spills of at least 30 days at 2,000 cfs between 1984 and 2007 would have been over 100% greater with the modified weir height compared to the existing weir height (current weir height: 9 times in 24 years; proposed weir height: 19 times in 24 years) (A. Munevar pers. comm.). Once the targeted duration of inundation is achieved, the weir gate(s) could be operated to stop flows into the Bypass from the Sacramento River if the river is below flood stage. At flood stage, the weir will overtop as it does currently.

Problem Statement: The majority of historical floodplain in the Sacramento/San Joaquin River system has been lost. This has resulted in a reduction of highly productive rearing habitat for juvenile salmon and spawning and rearing habitat for other native species such as splittail. Loss of floodplain habitat has reduced the input of organic and inorganic material and food resources into adjoining riverine habitat and the downstream bay and estuary. Inundation of the Yolo Bypass from the Sacramento River is currently limited to times when the Fremont Weir is overtopped, further limiting the availability of habitat for covered fish species and inputs to the food web.

Hypotheses: Modifying the Fremont Weir and increasing the frequency and duration of floodplain inundation in the Yolo Bypass will reduce the adverse effects of stressors related to food availability, habitat availability, passage, harvest, stranding, predation, and entrainment for the covered fish species. Specifically, this conservation measure will:

- create additional spawning habitat for Sacramento splittail (Sommer et al. 2001a, 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006). Because splittail are primarily floodplain spawners, successful spawning is predicted to increase with increased floodplain inundation;
- create additional juvenile rearing habitat for Chinook salmon, Sacramento splittail, and possibly steelhead (Sommer et al. 2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006). Growth and survival of larval and juvenile fish is higher in the floodplain compared to those rearing in the mainstem Sacramento River (Sommer et al. 2001b);
- increase downstream juvenile passage of Chinook salmon, Sacramento splittail, river lamprey, white sturgeon, and possibly steelhead. An inundated Yolo Bypass is used as an alternative to the mainstem Sacramento River for downstream migration of salmonids, splittail, river lamprey, and sturgeon. Sommer et al. (2003, 2004a) found that all of these species except steelhead inhabit the Yolo Bypass during periods of inundation. Based on the timing and life history traits of steelhead relative to Chinook salmon, steelhead may benefit from inhabiting the Yolo Bypass;
- increase adult upstream passage of fall- winter- and spring-run Chinook salmon, steelhead, and green and white sturgeon. It is thought that an inundated Yolo Bypass is used as an alternative route for upstream migrating salmonids and sturgeon;

- increase food production for rearing salmonids, splittail, and other covered species on the floodplain (Sommer et al. 2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006). During periods when the bypass is flooded, there is relatively high production of zooplankton and macroinvertebrates that serve, in part, as the forage base for many of the covered fish species (Benigno and Sommer 2008);
- increase the availability and production of food in the Delta, Suisun Marsh, and bays downstream of the bypass, including restored habitat in Cache Slough, for delta smelt, longfin smelt, and other covered species by exporting organic material and phytoplankton, zooplankton, and other organisms produced from the inundated floodplain into the Delta (Schemel et al 1996, Jassby and Cloern 2000, Mitsch and Gosselink 2000, Moss 2007, Lehman et al. 2008). The co-occurrence of suitable food supplies (zooplankton) and various life stages of delta smelt (e.g., larval and juvenile life stages) has been identified as an important factor affecting delta smelt survival and abundance (Feyrer et al. 2007, Miller 2007), although it has not been demonstrated that food abundance affects overall population abundance of delta smelt. The relationship between longfin smelt abundance and Delta outflow has experience two step declines: one after the invasion of *Corbula* and one during the POD years, although the slope of the relationship has not changed, suggesting that longfin smelt are food-limited (Baxter et al. 2008). Hobbs et al. (2006) found evidence of food limitation in early-stage juvenile longfin smelt, although spatially and temporally variable;
- increase the duration that the floodplain is inundated during periods that the Yolo Bypass is receiving water from both the Fremont Weir and the westside tributaries (e.g., Cache and Putah Creeks);
- reduce losses of adult Chinook salmon, sturgeon, and other fish species to stranding and illegal harvest by improving upstream passage at the Fremont Weir. When flows in the Sacramento River recede, the Fremont Weir stops spilling, trapping fish downstream of the weir. Many of these fish remain in the shallow water near the weir, providing easy access to illegal harvesters. Under this conservation measure, the Fremont Weir will be modified to avoid stranding if Sacramento River flows recede;
- reduce the exposure and risk of outmigrating juvenile fish migrating from the Sacramento River into the interior Delta through the Delta Cross Channel and Georgiana Slough, thus decreasing the risk for predation losses (Brandes and McLean 2001); and
- reduce the exposure of outmigrating juvenile fish to entrainment at intakes of the proposed north Delta water diversion facilities by passing juvenile fish into the Yolo Bypass upstream of the proposed intake locations.

Increasing the frequency and duration of inundation within the Yolo Bypass is the largest opportunity for enhancing inundated floodplain habitat in the north Delta. The Yolo Bypass provides the only opportunity for increasing the frequency and duration of inundation of a floodplain in the Planning Area without restoration of historical floodplain surfaces presently in other land uses.

Adaptive Management Considerations: Results of both biological and operational monitoring in the Yolo Bypass versus the mainstem Sacramento River could be used within the BDCP adaptive management framework to refine and modify Fremont Weir operations and the timing, frequency, and duration of spills over the Fremont Weir into the Yolo Bypass.

WOCML5: Operate the Delta Cross Channel Gates during the long-term for environmental benefits. The Delta Cross Channel Gates will be operated during the long-term implementation period to improve fish migration, hydrodynamics (including hydraulic residence time), and food and organic material transport while minimizing changes to water quality for agriculture, municipal, and industrial uses in the interior and southern Delta. This parameter will affect WOCML6 and 14.

Operational Criteria and Adaptive Limits. The operational criteria for the Delta Cross Channel gates during the BDCP long-term implementation period are described in Table 3.5.

Problem Statement: See WOCMN5.

Hypotheses: In addition to potential benefits identified in WOCMN5, revised operations of Delta Cross Channel gates are hypothesized to:

- maintain sufficient water quality in the south Delta in combination with minimal year-round pumping in the south Delta (see WOCML12). Seasonally elevated water temperatures and an accumulation of toxics can occur in the central and south Delta, likely as a result of high residence times associated with low inflows from the San Joaquin River. These impairments can have lethal and sublethal effects on covered fish species inhabiting the south and central Delta. In addition, preliminary modeling indicates that drinking water quality standards for the south Delta under D-1641 would not be violated under this revised set of operational criteria (A. Munevar pers. comm.) [***Note to reviewers***: *this statement will need to be verified once criteria have been established*];

Adaptive Management Considerations: See WOCMN5.

WOCML6: Maintain sufficient Rio Vista flows for environmental benefits during the long-term implementation period. The BDCP Implementing Entity will maintain sufficient Rio Vista flows for the benefit of covered fish species. The lower Sacramento River serves as an important part of the aquatic habitat within the Delta. Diversion of water at new north Delta Diversion Facilities, as well as diversion of water from the mainstem river into side channels (e.g., Delta Cross Channel) or seasonally inundated floodplain habitat (e.g., Yolo Bypass), has a direct effect on flow rates in the Sacramento River at Rio Vista. Operations described under WOCML1, 2, and 5 will affect flow at Rio Vista. Identification of a minimum flow requirement at Rio Vista is intended to support fishery and aquatic habitat in the reach of the Sacramento River located between Sacramento and Rio Vista. Flow in the mainstem Sacramento River downstream of Rio Vista is augmented by the flow contribution from Cache Slough, the Yolo Bypass, Sutter and Steamboat Sloughs, and other local tributaries. Minimum river flows at Rio Vista in the fall are included in current regulations (D-1641).

Operational Criteria and Adaptive Limits. The operational criteria for Rio Vista flows during the BDCP long-term implementation periods are described in Table 3.5.

Problem Statement: See WOCMN6.

Hypotheses: See WOCMN6.

Adaptive Management Considerations: See WOCMN6.

WOCML9: Maintain sufficient Delta outflows during the long-term implementation period for environmental benefits. *[**Note to reviewers**: this conservation measure may be updated to include inflow, outflow, and/or proportional release operational criteria as determined by the BDCP Steering Committee]* The BDCP Implementing Entity will maintain sufficient Delta outflows during the long-term for the benefit of covered fish species. Operations under WOCML1, 11, and 12, as well as many habitat restoration conservation measures, could affect the position of the low salinity zone in the estuary. For a general description of Delta outflows, see WOCMN9.

Operational Criteria and Adaptive Limits. The operational criteria for Delta outflow during the BDCP long-term implementation period are described in Table 3.5.

Problem Statement: See WOCMN9

Hypotheses: See WOCMN9

Adaptive Management Considerations: See WOCMN9

WOCML#: Operate the Dual Conveyance Facilities to Maintain Delta Water Quality and Protect Covered Fish Species. The BDCP Implementing Entity will operate the dual conveyance facilities in the Delta during the long-term implementation period to balance flows and exports for fish protection and water quality for both fish and humans while maintaining water supply reliability. Preferential south Delta operations during summer months when flows in the San Joaquin River are lowest will provide flushing the south and central Delta water with fresh Sacramento River water, thus reducing hydraulic residence time and improving water quality for fish, agriculture, and M&I uses in the south and central Delta.

Considerations regarding dual operations of conveyance facilities include: (1) providing limited flushing for general water quality conditions (reduce residence times) during low San Joaquin River flow periods, (2) maintaining adequate M&I and agricultural salinity in the central and south Delta, and (3) allowing operational flexibility during other periods to operate either north or south Delta diversions based on real-time assessments of benefits to fish, water quality, and operational constraints.

Operational Criteria and Adaptive Limits. The operational criteria for dual conveyance operations during the BDCP long-term implementation periods are described in Table 3.5.

Problem Statement: The balance of fish protection, water supply reliability, and water quality for both fish and humans is dependant, in part, on hydrologic and water quality (e.g., salinity, dissolved oxygen, etc.) conditions occurring within the Delta channels, the densities of covered fish in the general region of the central and south Delta, and the magnitude of effect of south Delta exports on reverse flows in Old and Middle Rivers.

Hypotheses: Dual operation of conveyance facilities in the long-term implementation period according to the operational criteria in Table 3.5 is hypothesized to:

- reduce entrainment mortality of all covered fish species at south Delta facilities;

- reduce toxic-related mortality and sublethal effects to all covered fish species in the central and south Delta (see WOCM1, 2, 3, 4, and 5 for detail on how toxics may adversely affect covered fish species);
- reduce the effects of the proliferation of noxious algae, such as Microcystis, in the central and south Delta. Microcystis tends to grow in warm, slowly moving water (Lehman et al. 2008). Microcystis is known to disrupt the food web by being toxic to zooplankton and macroinvertebrates (Resources Agency 2007, Baxter et al. 2008); and
- reduce the effects of the proliferation of SAV, including Egeria, in shallow areas of the central and south Delta. Egeria tends to establish and grow at faster rates in warm, slowly moving water (Barko and Smart 1981, Gantes and Caro 2001) (see WOCM13 SAV/FAV Control for detail on effects to these covered species),

Adaptive Management Considerations: Monitoring of water quality parameters, including EC, temperature, selenium, and other toxics as deemed necessary by the BDCP Implementing Entity, in central and south Delta before and after preferential south Delta operations begin in July.

WOCML14: Maintain in-Delta agricultural, municipal, and industrial water quality requirements during the long-term implementation period. In the long-term implementation period the BDCP Implementing Entity will continue to maintain existing D-1641 North and Western Delta agricultural and municipal and industrial (M&I) standards, except that the D-1641 compliance point will be moved from Emmaton to the Three Mile Slough juncture. All water quality requirements contained in the North Delta Water Agency/DWR Contract and other DWR contractual obligations will be maintained. Operations under WOCML1, 2, 5, 11, and 12 could affect this parameter. For more information about Delta salinity, see WOCMN14.

Operational Criteria and Adaptive Limits. The operational criteria for Delta salinity during the BDCP long-term implementation period are described in Table 3.5.

Problem Statement. See WOCMN14

Hypotheses. See WOCMN14

Adaptive Management Considerations. See WOCMN14

WOCML11: Operate the Montezuma Slough Salinity Control Gate during the long-term implementation period for environmental benefits. The BDCP Implementing Entity will coordinate with the Suisun Marsh Charter Group over the term of the BDCP to seek amendments to the Suisun Marsh Habitat Management, Preservation, and Restoration Plan (in development) that will provide for relaxing or ceasing long-term operation of the Montezuma Slough Salinity Control Gate. For more information about the Montezuma Slough Salinity Control Gate, see WOCMN11.

Operational Criteria and Adaptive Limits. The operational criteria for the Montezuma Slough Salinity Control Gate during the BDCP long-term implementation period are described in Table 3.5.

Problem Statement. See WOCMN11

Hypotheses: See WOCMN11

Adaptive Management Considerations. See WOCMN11

3.4.2 Physical Habitat Conservation Measures

[***Note to Reviewers***: *The text of this section of Chapter 3, including the physical habitat restoration conservation measures described, is subject to change and revision as the BDCP planning process progresses. This section, however, has been drafted and formatted to appear as it may in a draft HCP/NCCP. Although this section includes declarative statements (e.g., the Implementing Entity will…), it is nonetheless a "working draft" that will undergo further modification based on input from the BDCP Steering Committee, state and federal agencies, and the public.*

This section presently is focused on conservation measures directed toward species that use freshwater and brackish tidal marsh, subtidal riparian forest and scrub, and seasonally inundated floodplains. Measures to address species that use upland habitats and non-tidal wetlands are still in development and are not included in this draft.]

This section sets out the physical habitat conservation measures for the BDCP. It describes the approach to protecting, enhancing, and restoring (collectively referred to as "conserving") physical covered species habitats and the natural communities that support those habitats to help achieve the biological goals and objectives, as described in Table 3.2. Under the BDCP, these habitat areas will be managed in perpetuity to ensure that their intended ecological functions are maintained over the long-term.

The actions described in this section to conserve natural communities and habitats identified in Table 3.6 are expected to benefit a number of covered species. Descriptions of the covered species habitat types that are supported by these natural communities and habitats are presented in Appendix A, *Covered Species Accounts.*

The scope of the physical habitat actions provided for under the BDCP is presented in Table 3.7. The extent of the habitat and natural communities conservation actions set out in this section reflects both an assessment of the long-term conservation needs of individual covered species (i.e., habitat function, quantity, connectivity, and distribution), and an analysis of existing and future constraints that could affect habitat conservation, including land surface subsidence, habitat values, and land use.

A primary conservation goal of the BDCP is to restore 80,000 acres of tidal marsh and associated aquatic estuarine habitats, riparian habitat, and new floodplain for the benefit of fish, wildlife, and plants and ecosystem processes in the Delta and Suisun Marsh. The BDCP physical habitat conservation program is organized geographically across the northern, eastern, southern and western regions of the Delta. It is also organized by habitat type, and temporally into near-term and a long-term implementation phases. The schedule for protection, enhancement, and restoration of physical habitat is described in Chapter 6, *Implementation Plan*. Protection, enhancement, and restoration of other natural communities and habitats would be undertaken in both the near-term and long-term implementation periods as described in Chapter 6, *Implementation Plan*. In the near-term, prior to completion of the isolated conveyance facility, the BDCP targets for habitat restoration include 14,000 acres of tidal marsh and associated aquatic estuarine habitat and 1,300 acres of riparian forest and scrub habitat. Within 15 years, the goal is for tidal marsh and associated aquatic estuarine habitat restoration to reach 25,000 acres and riparian restoration to reach 2,300 acres and the addition of 1,000 acres of new season floodplain habitat. By year 40, the BDCP goal is to have established 65,000 acres of tidal marsh and associated aquatic estuarine habitats, 5,000 acres of riparian habitat, and 10,000 acres of new floodplain.[1]

[1] The 10,000 acre target for new floodplain restoration does not include floodplain habitat enhanced in the Yolo Bypass under WOCML2.

Table 3.6. Relationship of BDCP Covered Species to BDCP Protected, Enhanced, and Restored Natural Communities Expected to Provide Habitat Benefits

Covered Species	***Protected, Enhanced, and Restored Natural Community and Habitat Types***										
	Seasonally Inundated Floodplain	**Freshwater Tidal Marsh**	**Brackish Tidal Marsh**	**Channel Margin**	**Riparian**	**Agricultural**	**Grassland**	**Natural Seasonal Wetland**	**Managed Seasonal Wetland**	**Nontidal Perennial Aquatic**	**Nontidal Permanent Emergent Marsh**
Mammals											
San Joaquin kit fox							X				
Riparian woodrat					X						
Salt marsh harvest mouse		X	X								
Riparian brush rabbit					X						
Townsend's western big-eared bat					X						
Suisun shrew		X	X								
Birds											
Tricolored blackbird		X	X		X	X	X	X	X		X
Suisun song sparrow		X	X								
Yellow breasted chat				X	X						
Western burrowing owl						X	X	X	X		
Greater sandhill crane		X				X	X	X	X		
California black rail		X	X								
California clapper rail		X	X								
White-tailed kite				X	X	X	X	X	X		
Swainson's hawk				X	X	X	X	X	X		
Reptiles											
Giant garter snake		X				X	X	X	X	X	X
Western pond turtle		X		X	X		X			X	X
Amphibians											
California red-legged frog							X			X	X
Western spadefoot toad							X	X			
California tiger salamander, CV DPS							X	X		X	X
Fish											
Steelhead, Central Valley DPS	X	X	X	X							
Chinook Sacramento R. winter-run	X	X	X	X							
Chinook Central V. spring-run	X	X	X	X							
Chinook Central V. fall-/late fall-run	X	X	X	X							
Longfin smelt		X	X								
Delta smelt	X	X	X								
Sacramento splittail	X	X	X	X							
White sturgeon		X	X								
Green sturgeon		X	X								

Table 3.6. Relationship of BDCP Covered Species to BDCP Protected, Enhanced, and Restored Natural Communities Expected to Provide Habitat Benefits

Covered Species	*Protected, Enhanced, and Restored Natural Community and Habitat Types*										
	Seasonally Inundated Floodplain	**Freshwater Tidal Marsh**	**Brackish Tidal Marsh**	**Channel Margin**	**Riparian**	**Agricultural**	**Grassland**	**Natural Seasonal Wetland**	**Managed Seasonal Wetland**	**Nontidal Perennial Aquatic**	**Nontidal Permanent Emergent Marsh**
Fish (continued)											
Pacific lamprey		X	X	X							
River lamprey		X	X	X							
Invertebrates											
Valley elderberry longhorn beetle				X	X						
Vernal pool tadpole shrimp								X			
Conservancy fairy shrimp								X			
Longhorn fairy shrimp								X			
Vernal pool fairy shrimp								X			
Mid Valley Fairy Shrimp								X			
Plants											
Suisun Marsh aster (*Aster lentus*)		X	X	X	X						
Alkali milk-vetch								X			
Heartscale							X	X			
Brittlescale							X	X			
San Joaquin spearscale							X	X			
Lesser saltscale							X	X			
Slough thistle					X						
Suisun thistle			X								
Soft bird's-beak			X								
Delta button celery					X			X			
Boggs Lake hedge-hyssop								X			
Carquinez goldenbush			X				X	X			
Delta tule pea		X	X	X	X						
Legenere								X			
Heckard's peppergrass								X			
Mason's lilaeopsis		X	X	X	X						
Delta mudwort		X		X	X						
Caper-fruited tropidocarpum							X				

Notes:

1. This species habitat is supported by brackish tidal marsh. Freshwater tidal marsh restored in the west Delta, however, is anticipated to become brackish tidal marsh in the future with sea level rise.

Table 3.7. Extent of BDCP Natural Communities and Habitat Types Conserved Over the Term of the BDCP

Conserved Natural Community/Habitat Type	*Extent of Each Natural Community and Habitat Type Conserved*			
	Protected	**Enhanced (acres except as noted in table)**	**Restored**	**Total**
Seasonally Inundated Floodplain	[To come.]	2,000-6,000 cfs[1]	10,000 acres	[To come.]
Freshwater Tidal Marsh and Brackish Tidal Marsh	[To come.]	[To come.]	65,000 acres	[To come.]
Channel Margin	[To come.]	20 linear miles	[To come.]	[To come.]
Riparian	[To come.]	[To come.]	5,000 acres	[To come.]
Agricultural	[To come.]	[To come.]	[To come.]	[To come.]
Grassland	[To come.]	[To come.]	[To come.]	[To come.]
Natural Seasonal Wetland	[To come.]	[To come.]	[To come.]	[To come.]
Managed Seasonal Wetland	[To come.]	[To come.]	[To come.]	[To come.]
Nontidal Perennial Aquatic	[To come.]	[To come.]	[To come.]	[To come.]
Nontidal Permanent Emergent Marsh	[To come.]	[To come.]	[To come.]	[To come.]
Total	[To come.]	[To come.]	[To come.]	[To come.]

Notes:

1. This represents the extent of increased inflow into the existing Yolo Bypass floodplain that would be provided with operation of a modified Fremont Weir to increase the duration and frequency of seasonally inundated floodplain habitat. The conditions under which this increased inflow would be provided are described in conservation measure WOCML2 in Section 3.4.1.

In the near-term BDCP implementation period, actions to restore tidal marsh and riparian habitats will likely be directed at the Cache Slough, West Delta, and Suisun Marsh Restoration Opportunity Areas (ROAs) (see Figure 3.1). The initial focus on these ROAs reflects the anticipated productivity benefits that may be achieved in the near-term prior to changes to the existing through Delta conveyance system. These near-term elements of the habitat program will parallel adjustments in water management and flow regimes that are designed together to realize substantial improvements in aquatic productivity and function for covered species while the structural long-term improvements are constructed. Following commencement of dual water conveyance operations (i.e., the long-term BDCP implementation period), restoration of tidal and riparian habitat would continue in these ROAs and would be expanded significantly into the remaining ROAs in the south and eastern Delta. The restoration of physical habitat in tidal and floodplain areas will not only benefit covered species by the expansion of rearing and spawning habitat, but will also improve adjacent aquatic habitat through inputs of organic material and nutrients and through influences on hydrodynamics of flow and tidal action in upstream and downstream channels.

3.4.2.1 Physical Habitat Conservation Concepts

This section describes concepts associated with the protection, enhancement and restoration of habitat and natural communities present in the Planning Area and Suisun Marsh that support covered species. Under the BDCP, habitat protection refers to actions to ensure that lands that are intended to provide conservation values be used only for those purposes in perpetuity. Habitat restoration measures in the context of the BDCP are defined as those actions that either result in the reestablishment of habitat in historical locations or in the creation of habitat in areas where no such habitat previously existed. Habitat enhancement measures refer to improvements in the ecological functions of existing habitat. All areas that undergo habitat restoration or enhancement will either be in, or brought under, protected status.

Preserve Design Concepts

Important implementation concepts that will guide the selection, distribution and design of habitat protection, enhancement, and restoration are described below.

1. During the BDCP near-term implementation period, focus restoration and enhancement of covered fish species habitats in north Delta locations to generate improvements in productivity consistent with continued operations of the SWP and CVP pumping facilities.
2. Identify restoration areas and design actions to accommodate and integrate improvements in water management strategies over both the near-term and the long-term to optimize primary and secondary productivity, spawning and rearing, and other aquatic functions to support covered species.
3. During the BDCP long-term implementation period, expand the restoration and enhancement of habitats to include the Sacramento, Mokelumne, and San Joaquin River deltas to provide benefits to covered fish species found in each of those watersheds.
4. Design conservation measures for terrestrial and non-tidal wetland communities and covered wildlife and plants to complement the conservation strategies of approved and developing conservation plans for areas adjacent to and overlapping the BDCP planning area. These conservation measures will be implemented in coordination with the local government entities charged with the development and implementation of those plans, or equivalent program, in a manner that furthers their plan goals and objectives
5. Restore habitat in large patches to increase the likelihood of providing the desired levels of ecological function and to support large numbers of covered species.
6. Distribute restored and enhanced habitats throughout the Delta to minimize the risk of loss of substantial habitat benefits to catastrophic events in one part of the Delta.
7. Distribute and design restored habitats to withstand potential changes in Delta conditions associated with future sea level rise and changes in stream hydrographs.
8. Design tidal marsh habitats to withstand effects that could be associated with Delta levee failures.
9. Restore habitat in patch sizes that are equal to or greater than the patch sizes required by the covered species that use the habitat.
10. Juxtapose restored habitats with existing habitats to improve and maintain habitat corridors and connectivity among covered species habitats.
11. Locate and design restored habitats to provide beneficial hydrodynamic affects on adjacent channel systems (e.g., increased tidal flows that may result in decreased bidirectional flow in upstream channels or provide greater mixing in adjacent channels).
12. Locate and design restored habitats to create natural gradients in the Delta that historically transitioned from shallow subtidal aquatic habitats, to riverine floodplain habitats, and to transitional upland habitats (seasonal wetland, riparian, grassland).
13. Design tidal marsh and seasonally inundated floodplain habitats to provide access and egress to covered fish species such that fish do not become stranded or trapped.

14. Locate and design restored habitats to minimize potential effects of other stressors that could substantially degrade intended covered species benefits (e.g., effects of nearby diversions, discharges of low quality water).
15. Coordinate the design and management of wetland and aquatic habitat restorations and enhancements with mosquito abatement officials to incorporate to the extent practicable measures to reduce the likelihood for problem numbers of mosquitoes.

Site Selection

The BDCP has identified six ROAs within which tidal marsh habitat restoration and enhancement conservation measures designed to conserve covered fish species will be implemented (see Figure 3.1). Over the term of the BDCP, tidal marsh habitat for covered fish species may also be restored or enhanced in other locations within the Delta or outside the Delta in coordination with other conservation programs to further advance the BDCP biological goals and objectives. Protection, restoration, and enhancement of seasonal inundated floodplain, riparian, channel margin, terrestrial, and non-tidal wetland habitats may occur anywhere within the Planning Area and Suisun Marsh, including the tidal marsh ROAs, or in adjacent areas where physical habitat actions will contribute to the biological goals and objectives of adjacent or overlapping regional conservation plans.

Tidal marsh ROAs have been identified based on their suitability to support actions to restore or enhance tidal marsh habitat targeted by the plan and provide conditions beneficial to the conservation of the covered species. The primary criteria used to identify ROAs included land surface elevation relative to elevations that could support restored tidal marsh habitat, beneficial conditions for each of the covered fish species, geographic distribution to address the range of species within the Delta, practicability (e.g., cost, and potential effects on existing land uses and regional infrastructure), and previous restoration suitability assessments (e.g., CALFED Ecosystem Restoration Program actions and existing habitat restoration plans). Consequently, areas within the central Delta that are deeply subsided have generally been excluded from ROAs. ROAs encompass a total area of __ acres.

Before acquiring lands for habitat restoration and enhancement, the BDCP Implementing Entity will develop site selection criteria to evaluate the suitability of sites for habitat protection, enhancement, and restoration, and will collect sufficient site-specific information to make determinations pursuant to the criteria. Site selection criteria will include consideration of:

- presence of and proximity to existing occupied covered species habitats;
- connectivity to existing habitat areas;
- ability to complement achieving the goals and objectives of adjacent and overlapping regional conservation plans;
- potential for synergistically increasing covered species benefits with implementation of water operations and other stressors conservation measures;
- suitability for development of desired ecological functions and habitat characteristics (e.g., tidal connectivity, soil conditions, extent of area that could be restored as habitat);

- sustainability of restored habitat functions over time with future climate change and sea level rise;
- existing species and habitat values associated with evaluated sites;
- existing land uses and potential effects on surrounding land uses relative to other Delta locations;
- likelihood for creating mosquito vector control problems or nuisances relative to other Delta locations;
- proximity to infrastructure that could degrade restored habitat values (e.g., proximity to contaminant sources toxic to covered species or diversions that pose substantial risk for entrainment of covered fish species);
- relative suitability for restoring a mosaic of habitat types that would achieve multiple biological objectives;
- land acquisition and habitat restoration and maintenance costs; and
- site availability relative to the implementation schedule for protecting, enhancing, and restoring habitat.

Habitat Restoration Management Plans

The BDCP Implementing Entity will develop and implement specific habitat management plans for each conserved habitat area or assemblage of multiple connected or otherwise related habitat areas to guide long-term management. Habitat management plans will include the following information:

- biological goals and objectives to be addressed by the habitat, and how these tie back to the underlying goals and objectives of the BDCP;
- site-specific monitoring requirements and monitoring metrics by which to evaluate the achievement of the objectives for the plan and lay a foundation for adaptive management;
- areas for integration of management activities to ensure compatibility and synergistically increase benefits for covered species with implementation of water operations and other stressors conservation measures;
- non-native invasive plant species control requirements;
- non-native species predator and competitor control requirements;
- vegetation management activities;
- means for implementing the adaptive management program;
- infrastructure maintenance activities; and
- allowable uses and public access.

The BDCP Implementing Entity will maintain records of management activities and the results of associated monitoring for each habitat area. Habitat restoration management plans will periodically be revised to reflect any changes in management that are undertaken in response to results of monitoring and research.

3.4.2.2 Tidal Wetland, Riparian and Floodplain Restoration Conservation Measures

This section describes the habitat restoration conservation measures for tidal marsh, channel margin, riparian, and seasonally inundated floodplain habitats. Restoration of these habitat types is expected to contribute to the conservation of the covered fish, wildlife, and plant species by improving aquatic and wetland ecosystem functions and habitat conditions. Conservation measures to restore and enhance aquatic and wetland habitats have been evaluated through the DRERIP process. The potential benefits, uncertainties, and risks identified through the DRERIP evaluation process for each of the habitat conservation measures are presented in Appendix X, *DRERIP Evaluations.* Results of the DRERIP evaluations may be used by the Implementing Entity to design and implement restoration and enhancement actions to address uncertainties and minimize risks identified through the DRERIP process.

[***Note to Reviewers:*** *The naming convention for conservation measures (e.g., codes "HRCM1," "HRCM2") is retained here to allow for tracking of conservation measures through various changes, additions, deletions, and reorganizations over the past 1½ years of plan development. This approach to naming and numbering conservation measures has served its purpose and will be simplified as conservation measures become more stable in their form going into the administrative draft HCP/NCCP*].

Conservation Measures for Tidal Marsh Habitat: HRCM 16. Restore 65,000 acres of freshwater and brackish tidal marsh within Restoration Opportunity Areas. The BDCP will provide for the restoration of 65,000 acres of freshwater and brackish tidal marsh within the BDCP ROAs (Figure 3.1). For the purpose of this conservation measure, the acreage target for restored tidal marsh includes areas of subtidal habitat and transition upland habitat that form in association with the tidal marsh restoration action. The restoration or creation of this associated subtidal and transition upland habitat will be credited toward the overall target as follows:

- In areas of substantial land subsidence, subtidal aquatic habitat will constitute no greater than __% of the 65,000 acre target; and
- The transition upland habitat will comprise no greater than __% of the 65,000-acre total. This upland habitat will accommodate approximately 3 feet of sea level rise such that it will function as tidal marsh habitat at some future time. Additional upland habitat, however, would be protected and enhanced to provide habitat for terrestrial species.

Of the 65,000-acre restoration target, 22,000 acres will be distributed among the ROAs as described below in *Minimum Restoration Targets for Freshwater Tidal Marsh Habitat in ROAs* and *Minimum Restoration Target for Brackish Tidal Marsh Habitat in Suisun ROA.* The remaining 43,000 acres within the target total will be distributed among the ROA's at the discretion of the Implementing Entity based on land availability, biological value, and practicability considerations. The freshwater and brackish tidal marsh restoration targets will be achieved on the following time schedule:

- 14,000 acres developed[2] within the first 10 years of plan implementation;

[2] In achieving these targets the term "developed" means the completion of reintroduction of tidal inundation to areas expected to develop as tidal marsh. These target values represent the habitat area developed at the points in time identified. Development of fully functioning restored habitat may take years subsequent to initial tidal inundation through the effects of natural processes on the constructed surface.

- 25,000 acres (cumulative) developed by year 15 of plan implementation; and
- 65,000 acres (cumulative) developed by year 40 of plan implementation.

Freshwater Tidal Marsh Habitat Restoration. Freshwater tidal marsh habitats will be restored and enhanced to provide the following ecological benefits for covered fish species (see Appendix X, *DRERIP Evaluations*):

- increased primary and secondary production within restored tidal marsh channels in support of food production for covered fish species;
- export of organic carbon and primary and secondary production from restored marsh into Delta waterways in support of food production for covered fish species within and downstream of the Delta;
- improved covered fish species habitat conditions within tidal marsh channels and adjacent open water by reducing summer and fall water temperatures through nocturnal tidal thermal exchanges on marsh plain surfaces and reintroduction of cooled water to delta waterways;
- reduction of contaminants through filtering contaminants from Delta waterways or chemical transformation of contaminants to less toxic or non-toxic substances;
- increase in Sacramento splittail spawning and rearing habitat and salmonid and sturgeon rearing habitat associated with restoration of new tidal channels and shallow subtidal habitats adjacent to vegetated marsh plains;
- improved delta smelt and longfin smelt spawning habitat conditions;
- increased foraging habitat for white-tailed kite;
- increased breeding and foraging habitat for tricolored blackbird, Suisun song sparrow, and California black rail;
- increased aquatic and cover habitat for giant garter snake and western pond turtle; and
- increased habitat for Suisun Marsh aster, soft-bird's beak, delta tule pea, Mason's lilaeopsis, delta button celery, and delta mudwort where tidal marsh is restored within the range of each of these species and within the potential future range of soft-bird's beak given estimates of sea level rise and salinity intrusion.

Freshwater tidal marsh habitats will be restored by breaching or removing levees along Delta waterways to reestablish tidal connectivity to reclaimed lands. Tidal marsh restored on deeply subsided Delta tracts and islands may require construction of cross levees or berms to isolate deeply subsided lands from inundation, avoiding the creation of large areas of subtidal habitats that could favor non-native predator/competitor species and disfavor covered fish species. Where required, levees or berms will be constructed to prevent inundation of adjacent lands. Where appropriate and feasible, portions of restoration sites will be raised to elevations that support tidal marsh vegetation. Depending on the degree of subsidence and location, lands may be elevated by grading higher elevations to fill subsided areas, importing dredged or fill material from other locations, or planting tules or other appropriate vegetation to raise elevations in shallowly subsided areas over time through organic material accumulation. Surface grading will provide for a shallow elevation gradient from the marsh plain to the upland transition habitat. Based on assessments of local hydrodynamic conditions, sediment transport, and topography, restoration activities may be designed and implemented in a manner that accelerates the development of tidal channels within restored marshes. Following reintroduction of tidal exchange, tidal marsh vegetation will likely become established naturally at suitable elevations relative to the tidal range. Tidal marsh restoration sites will be monitored to determine if enhancement of tidal marsh vegetation could occur through artificial installation of patches of native emergent vegetation (see specific monitoring requirements with each conservation measure).

Restoration variables that will be considered in the design of restored freshwater tidal marsh habitat include:

- spatial distribution of restored tidal marsh habitats within the Delta;
- extent, location, and configuration of restored tidal marsh habitat areas;
- predicted tidal range at tidal marsh restoration sites following reintroduction of tidal exchange;
- size and location of levee breaches;
- cross sectional profile of tidal marsh restoration sites (elevation of marsh plain, topographic diversity, depth, and slope); and
- density and size of tidal marsh channels appropriate to each restoration site.

Restored freshwater tidal habitats will be designed to support habitat for covered species listed in Table 3.6. Restoration design considerations for freshwater tidal marsh habitat will include the following.

Marsh Plain Vegetation. To provide for highly functioning habitat, restored tidal marsh plains will be vegetated primarily with tules and other native freshwater emergent vegetation to reflect the historical composition and densities of Delta tidal marshes.

Hydrodynamic Conditions. Tidal marsh restoration will be designed to produce sinuous, high density, dendritic networks of tidal channels that promote effective tidal exchange throughout the marsh plain. Effective tidal exchange will enhance ecological functions that support covered fish species, including:

- the export of productivity from the marsh plain into adjacent Delta waterways in support of aquatic food web processes;
- production and export of phytoplankton and zooplankton from tidal channels into adjacent Delta waterways in support of the aquatic food web;
- filtration and chemical transformation of contaminants from tidally exchanged water; and
- maintenance of cooler localized water temperatures preferred by covered fish species through nocturnal thermal exchange on marsh plains.

Marsh channels and levee breaches will also be designed to maintain flow velocities that minimize conditions favorable to the establishment of non-native submerged and floating aquatic vegetation and habitat for non-native predatory fish.

Environmental Gradients. To the extent practicable as determined by site-specific constraints, tidal marsh restoration actions will be designed to provide a natural ecological gradient among subtidal, tidal, riparian, and upland habitats to accommodate the movement of fish and wildlife species and provide flood refuge habitat for marsh-associated species during high water events. In addition, by protecting higher elevation lands adjacent to restored marsh plains, areas will later be available for marsh establishment that may occur as a result of sea level rise associated with climate change. Higher elevation lands protected in anticipation of changing distributions of habitats with sea level rise are referred to as "accommodation space."

Shallow subtidal aquatic habitat. Shallow freshwater subtidal aquatic habitat in some portions of the Delta support large numbers of non-native predatory fish and extensive beds of non-native submerged aquatic and floating vegetation that adversely affect covered fish species. Because it would generate habitat for non-native predators, the BDCP does not include measures to restore areas of shallow subtidal aquatic habitat; rather, shallow subtidal aquatic habitat may form as a result of the restoration of freshwater tidal marsh where land surface elevations within restoration sites are subsided below elevations that would support tidal marsh. Tidal marsh restoration projects will be designed to minimize the likelihood of establishment of non-native submerged aquatic and floating vegetation, which may serve as habitat for non-native predators. Early restoration projects will be monitored to assess the response of non-native species to restoration designs and local environmental conditions. This information will be used to modify restoration designs and implementation methods, if necessary, over time to further improve habitat conditions for covered fish species. As described in OSCM13 *Remove Non-Native Submerged and Floating Aquatic Vegetation from Delta Waterways*, the BDCP Implementing Entity will engage in active removal of submerged aquatic and float aquatic vegetation in subtidal portions of tidal restoration sites to reduce the levels of establishment of non-native predators.

Boat wake reduction. Boat wake-induced disturbance of restored marsh habitats may limit the establishment and sustainability of native freshwater emergent vegetation in restored habitat areas. The BDCP Implementing Entity will coordinate with and fund the Department of Boating and Waterways and local governing entities to establish low boat speed regulations (no wake zones) and post signs in Delta locations with restored tidal marsh and shallow subtidal habitat that has been. Low boat speed zones would only be established in locations where the ecological functions of restored tidal marsh and adjacent shallow subtidal aquatic habitats could be degraded by boat wakes.

Minimum Restoration Targets for Freshwater Tidal Marsh Habitat in ROAs. The BDCP Implementing Entity will restore a minimum of freshwater tidal marsh in each of the ROAs (see Figure 3.1) as follows:

- **HRCM4: Restore at least 5,000 acres freshwater tidal marsh within the Cache Slough Complex ROA**. The BDCP Implementing Entity will restore a minimum of 5,000 acres of freshwater tidal marsh in the Cache Slough Complex ROA. Areas suitable for restoration include, but are not limited to, Haas Slough, Hastings Cut, Lindsey Slough, Barker Slough, Calhoun Cut, Liberty Island, Little Holland, the Westlands property, Shag Slough, Little Egbert Tract, and Prospect Island. The Cache Slough Complex has been recognized as possibly the best functioning tidal habitat area of the Delta. The complex includes Liberty Island, which is likely the best model for freshwater tidal marsh restoration in the Delta for native fishes. The Complex supports multiple covered fish species and is presumably one of the last known areas where Delta smelt and longfin smelt spawn and rear successfully. Restoring the amount of freshwater tidal wetlands and subtidal habitat and protecting upland habitat could benefit multiple covered species and the Delta ecosystem. Additionally, the Cache Slough Complex encompasses a substantial area of land with elevations suitable for freshwater tidal marsh restoration that would involve few impacts on infrastructure or permanent crops relative to other areas of the north Delta. The Cache Slough Complex provides an excellent opportunity to expand habitat supporting multiple aquatic and terrestrial covered species. Restoration of freshwater intertidal marsh and shallow subtidal habitats would be designed to support the physical and biological attributes that benefit covered species. Based on existing land elevations, approximately 21,000 acres of public and private lands in the area are potentially suitable for restoration of tidal marsh. Areas for restoration would be identified by working with interested landowners.

- **HRCM5: Restore at least 1,500 acres of freshwater tidal marsh within the Cosumnes/Mokelumne ROA**. The BDCP Implementing Entity will restore a minimum of 1,500 acres of freshwater tidal marsh in the Cosumnes/Mokelumne ROA. Areas suitable for restoration within the Cosumnes/Mokelumne ROA (see Figure 3.1) include McCormack-Williamson Tract, New Hope Tract, Canal Ranch Tract, Bract Tract, Terminous Tract north of State Highway 12, and lands adjoining Snodgrass Slough, South Stone Lake, and Lost Slough. If an eastern alignment around-Delta canal conveyance facility is constructed, the canal levees may be incorporated into the design of tidal marsh restoration. For example, in locations where the conveyance canal is located at elevations at or below elevations suitable for restoration of tidal marsh, marsh may be restored to the east of the canal levee, with the canal levee forming the western boundary of the restored tidal marsh.
- **HRCM6: Restore at least 2,100 acres of tidal marsh within the West Delta ROA.** The BDCP Implementing Entity will restore a minimum of 2,100 acres of freshwater tidal marsh in the West Delta ROA. The west Delta includes multiple small areas where tidal marsh, can be restored. Areas suitable for restoration include Dutch Slough, Decker Island, portions of Sherman Island, Jersey Island, Bradford Island, Twitchell Island, Brannon Island, Grand Island, and along portions of the north bank of the Sacramento River where elevations and substrates are suitable. The purpose of restoring tidal marsh in the west Delta is to provide a continuous reach of tidal marsh and aquatic habitat associated with food productivity between current and future restored habitats in the Cache Slough Complex and Suisun Marsh and Bay and to provide tidal marsh habitat within the anticipated future eastward position of the low salinity zone with sea level rise.
- **HRCM7: Restore at least 5,000 acres of tidal marsh within the South Delta ROA.** The BDCP Implementing Entity will restore a minimum of 5,000 acres of freshwater tidal marsh in the South Delta ROA. Potential sites for restoring freshwater tidal marsh include Fabian Tract, Union Island, Middle Roberts Island, and Lower Roberts Island. Sites selected for restoration would be dependent on the location and design of the selected conveyance pathway and operations for the through-Delta component of the dual conveyance facility. Selected sites would be those that would provide substantial species

and ecosystem benefits with the selected through-Delta conveyance configuration and most effectively avoid adverse affects of south Delta SWP/CVP operations.

- **HRCM8: Restore at least 1,400 acres tidal marsh within the East Delta ROA.** The BDCP Implementing Entity will restore a minimum of 1,400 acres of freshwater tidal marsh in the East Delta ROA. Areas suitable for restoration in the East Delta ROA (see Figure 3.1) include Terminous Tract south of State Highway 12, Shin Kee Tract, Rio Blanco Tract, and Bishop Bract. If an eastern alignment of an around-Delta canal conveyance facility is constructed, the canal levees may be incorporated into the design of intertidal emergent wetland restoration. For example, in locations where the conveyance canal is located at elevations at or below elevations suitable for restoration of intertidal marsh, marsh may be restored to the east of canal levee, with the canal levee forming the western boundary of the restored marsh.

Restored freshwater tidal marsh will be designed to support the physical and biological attributes described in above in *Freshwater Tidal Marsh Habitat Restoration*. Restored tidal marshes will be designed to support a mosaic of tidal marsh, tide flat, shallow subtidal aquatic, and transitional upland and riparian habitats as appropriate to specific restoration sites to mimic the historical ecological gradients of the Delta.

Design elements of freshwater tidal marsh restoration will include:

- acquiring lands, in fee-title or through conservation easements, suitable for restoration of intertidal and subtidal habitats and protecting adjacent uplands to accommodate future sea level rise;
- acquiring lands, in fee-title or through conservation easements, with transition habitat and upland habitat adjacent to restored tidelands sufficient to accommodate future sea level rise;
- breaching levees to reintroduce tidal exchange and restore tidal marsh to currently leveed former tidelands;
- constructing new or enhancing existing levees to provide flood protection for adjacent landowners and protecting existing land use against seepage and erosion of existing levees;
- constructing new levees to isolate deeply subsided lands for tidal flooding;
- excavating channels and creating berms to encourage the development of dendritic channel networks within restored marshes;
- modifying ditches, cuts, and levees to encourage more natural tidal circulation and better flood conveyance based on local hydrology;
- restoring tributary stream functions to establish more natural patterns of sediment transport to improve spawning conditions for delta smelt and other fish and macroinvertebrates;
- prior to breaching, scalping higher elevation land to provide fill for placement on subsided lands to raise surface elevations suitable for establishment of marsh plain in the intertidal zone;

- prior to breaching, importing dredge or fill in shallowly subsided areas to raise ground surface elevations to a level suitable for establishment of marsh plain in the intertidal zone;
- prior to breaching, planting tules in shallowly subsided areas to provide established marsh patches to accelerate marsh expansion and surface accretion following flooding;
- prior to breaching, farming tules for long periods to raise subsided ground surface to elevations suitable to support intertidal marsh and breaching levees when target elevations are achieved; and
- designing levee breaches to maximize the development of intertidal marsh and minimize hydrodynamic conditions that favor non-native predatory fish.

Problem Statement: The majority of historical freshwater and brackish tidal marsh in the Sacramento/San Joaquin Delta and Suisun Bay system has been lost. Historically, approximately 350,000 acres of tidal marsh was present in the Delta and 67,000 acres in Suisun Marsh. Approximately 10,000 acres of tidal marsh remain in the Delta (freshwater) and 8,300 acres in Suisun Marsh (brackish). This loss of tidal marsh has greatly reduced the availability and quality of spawning and rearing habitat for many native species, by reducing the input of organic and inorganic material and food resources into adjoining deep water habitats (sloughs and channels) and the downstream bay and estuary.

Hypotheses: Restoration of freshwater tidal marsh and shallow subtidal aquatic habitats are hypothesized to provide a range of ecosystem and covered species benefits. These anticipated benefits are described below for the freshwater tidal marsh restoration proposed in each of the ROAs. As described in Appendix X, *DRERIP Evaluations*, however, there are a number of uncertainties regarding the level of benefits that may be provided by marsh restored in each of the ROAs as well as risks for adverse consequences.

Restoring freshwater intertidal marsh and shallow subtidal aquatic habitats within the Cache Slough ROA will:

- increase rearing habitat area for Chinook salmon, Sacramento splittail, white sturgeon, and green sturgeon (Healey 1991, Brown 2003, Appendix X, *DRERIP Evaluations*);
- increase the local production of food for rearing salmonids, splittail, delta smelt, green and white sturgeon (Kjelson et al. 1982, Siegel 2007);
- increase the export of food in the Delta downstream of Rio Vista available to juvenile salmonids, splittail, delta smelt, white sturgeon, and green sturgeon by exporting organic material from the marsh plain and phytoplankton, zooplankton, and other organisms produced in intertidal channels into the Delta and Suisun Marsh (Siegel 2007);
- expand areas of cool water refugia for delta smelt (C. Enright pers. comm.);
- expand habitat available for colonization by Mason's lilaeopsis; and
- expand habitat for giant garter snake, California black rail, and tricolored blackbird.

In conjunction with floodplain enhancement in the Yolo Bypass, the habitat restoration in the Cache Slough ROA will re-establish the ecological gradient from river to floodplain to tidal estuary and to provide intertidal wetland adjacent to open channel habitat that is characteristic of less altered estuaries. Preliminary hydrodynamic modeling indicates that increased tidal exchange in the Cache Slough area resulting from 5,000-10,000 acres of tidal marsh restoration will reduce bidirectional flows in Steamboat and Sutter Sloughs and the mainstem Sacramento River associated with tidal action under present conditions, thus significantly enhancing movement of juvenile salmonids through these waterways and potentially reducing their exposure to predators.

Restoring freshwater intertidal marsh and shallow subtidal aquatic habitats within the Cosumnes/Mokelumne River ROA is also believed to reduce the adverse effects of stressors on the availability of food and habitat for the covered fish species by:

- increasing rearing habitat area for Cosumnes/Mokelumne fall-run Chinook salmon, steelhead, delta smelt, and Sacramento splittail (Healey 1991, Brown 2003);
- increasing the local production of food for Cosumnes/Mokelumne fall-run Chinook salmon, steelhead, delta smelt, and Sacramento splittail migrating to and from the Cosumnes and Mokelumne Rivers (Kjelson et al. 1982, Siegel 2007);
- increasing the availability and production of food in the east and central Delta available to juvenile salmonids, splittail, delta smelt, white sturgeon, and green sturgeon by exporting organic material from the marsh plain and phytoplankton, zooplankton, and other organisms produced in intertidal channels into the Delta (Siegel 2007);
- locally providing areas of cool water refugia for delta smelt (C. Enright pers. comm.);
- increasing the extent of habitat available for colonization by Mason's lilaeopsis, and
- increasing the extent of habitat for giant garter snake, California black rail, and tricolored blackbird.
- Restoring freshwater intertidal marsh and shallow subtidal aquatic habitats in the West Delta ROA is also believed to reduce the adverse effects of stressors related to food and habitat availability for the covered species by:
- increasing rearing habitat area for Chinook salmon, Sacramento splittail, and possibly steelhead (Healey 1991, Brown 2003);
- improving future rearing habitat areas for delta smelt and longfin smelt within the anticipated eastward movement of the low salinity zone with sea level rise. Lands within the West Delta ROA (see Figure 3.1) represent the only location to implement intertidal marsh restoration within the anticipated future location of the low salinity zone with sea level rise;
- increasing the local production of food for rearing salmonids, splittail, and other covered species (Kjelson et al. 1982; Siegel 2007);
- increasing the availability and production of food in the western Delta and Suisun Bay by exporting organic material via tidal flow from the marsh plain and organic

carbon, phytoplankton, zooplankton, and other organisms produced in intertidal channels into adjacent open water areas (Siegel 2007);

- providing an important linkage between current and future upstream restored habitat with downstream habitat in Suisun Marsh and Bay. This area's location at the confluence of the Sacramento and San Joaquin Rivers make it uniquely important to improving connectivity among the communities and species of the Delta;
- providing additional refugial habitat for migrating and resident covered species;
- locally providing areas of cool water refugia for delta smelt (C. Enright pers. comm.);
- increasing the extent of habitat available for colonization by Mason's lilaeopsis; and
- increasing the extent of habitat for California black rail and tricolored blackbird.
- Restoring freshwater intertidal marsh and shallow subtidal aquatic habitats in the South Delta ROA will reduce the adverse effects of stressors related to the availability of food and habitat for the covered species by:
- increasing rearing habitat area for Sacramento splittail, Chinook salmon produced in the San Joaquin River and other eastside tributaries, and possibly steelhead (Healey 1991, Brown 2003);
- increasing the local production of food for rearing salmonids, splittail, and other covered species (Kjelson et al. 1982; Siegel 2007);
- increasing the availability and production of food in the Delta and Suisun Bay by export from the south Delta of organic material via tidal flow from the new marsh plain and organic carbon, phytoplankton, zooplankton, and other organisms produced in new intertidal channels (Siegel 2007);
- locally providing areas of cool water refugia for delta smelt (C. Enright pers. comm.);
- increasing the extent of habitat available for colonization by Mason's lilaeopsis; and
- increasing the extent of habitat for California black rail and tricolored blackbird.

Additionally, in conjunction with dual conveyance operations, marsh restoration in the South Delta ROA may support the expansion of the current distribution of delta smelt into formerly occupied habitat areas.

Restoring freshwater intertidal marsh and shallow subtidal aquatic habitats within the East Delta ROA is also believed to reduce the adverse effects of stressors related to food and habitat availability for the covered fish species by:

- increasing rearing habitat area for Sacramento splittail and San Joaquin Chinook salmon and possibly steelhead (Healey 1991, Brown 2003);
- increasing the local production of food for rearing salmonids, splittail, and other covered species (Kjelson et al. 1982, Siegel 2007);
- increasing the availability and production of food in the east and central Delta by exporting organic material from the marsh plain and phytoplankton, zooplankton, and other organisms produced in intertidal channels into the Delta (Siegel 2007);

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

Adaptive management considerations: The adaptive management program will assess the value of restored marshes and adjacent shallow subtidal habitats to covered species habitat, including the capacity of the restored areas to produce food and organic carbon to support food web processes. Results of monitoring the development of early marsh restorations will help inform the design and management of subsequent marsh restoration projects. In addition, monitoring results will also support the development of more cost effective management techniques, if needed, to control the establishment of non-native species in restored marshes.

Brackish Tidal Marsh Habitat Restoration. Brackish tidal marsh will be restored within Suisun Marsh in coordination with the Suisun Marsh Habitat Restoration and Management Plan, currently under development. Brackish tidal marsh habitats will be restored and enhanced to provide the following ecological benefits for covered species (see Appendix X, *DRERIP Evaluations*):

- increased primary and secondary production within restored tidal marsh channels in support of food production for covered fish species;
- export of production from brackish tidal marsh into open water of Suisun Marsh sloughs and Suisun Bay in support of food for covered fish species, including delta and longfin smelt;
- improved covered fish species habitat conditions within tidal marsh channels and adjacent open water by reducing summer/fall water temperature through nocturnal tidal thermal exchange on marsh plain surfaces and reintroduction of cooled water to Suisun Marsh sloughs and Suisun Bay;
- reduction of contaminants through filtering contaminants from Suisun Bay or chemical transformation of contaminants to less toxic/non-toxic substances;
- increase in Sacramento splittail spawning and rearing habitat and salmonid and sturgeon rearing habitat associated with restoration of new tidal channels and shallow subtidal habitats adjacent to vegetated marsh plains;
- improved delta smelt and longfin smelt habitat conditions in Suisun Marsh sloughs and Suisun Bay;
- increased habitat for salt marsh harvest mouse, Suisun shrew, California black rail, and California clapper rail;
- increased foraging habitat for white-tailed kite;
- increased breeding habitat for tricolored blackbird, Suisun song sparrow;
- increased aquatic and cover habitat for western pond turtle; and
- increased habitat for Suisun Marsh aster, soft bird's-beak, Delta tule pea, and Mason's lilaeopsis where brackish tidal marsh is restored within the range of each of these species.

Brackish tidal marsh habitats will be restored by breaching or removing dikes along Montezuma and other Suisun Marsh sloughs and channels and Suisun Bay to reestablish tidal connectivity to reclaimed lands. Tidal marsh restored adjacent to farmed lands or lands managed as freshwater seasonal wetlands may require construction of dikes to maintain those land uses. Where appropriate, portions of restoration sites will be graded to elevations that would support tidal marsh vegetation. Depending on the degree of subsidence, location, and likelihood for natural accretion through sedimentation, lands may be elevated by grading higher elevations to fill subsided areas, importing dredged or fill material from other locations, or planting tules or other appropriate vegetation to raise elevations in shallowly subsided areas over time through organic material accumulation. Surface grading will be designed to result in a shallow elevation gradient from the marsh plain to the upland transition habitat. Remnant disconnected tidal channels would be restored if present within restoration sites to accelerate development of marsh functions. Based on assessments of local hydrodynamic conditions, sediment transport, and topography, restoration sites may be graded to accelerate the development of tidal channels within restored marshes. Following reintroduction of tidal exchange, tidal marsh vegetation would be expected to naturally establish at suitable elevations relative to the tidal range. Tidal marsh restoration sites will be monitored to determine if development of tidal marsh vegetation and functions would be enhanced with plantings of native emergent vegetation (see specific monitoring requirements with each conservation measure).

- Variables that will be considered in the design of restorations actions for brackish tidal marsh habitat include the:
- extent, location, and configuration of restored tidal marsh habitat areas,
- distribution of restored marshes along salinity gradients to optimize the range of habitat conditions for covered species and food production;
- predicted tidal range at tidal marsh restoration sites following reintroduction of tidal exchange;
- size and location of dike breaches;
- cross sectional profile of tidal marsh restoration sites (elevation of marsh plain, topographic diversity, depth, and slope); and
- density and size of tidal marsh channels appropriate to each restoration site.

Restoration actions for brackish tidal habitats will be designed to support habitat for covered species listed in Table 3.6. Restoration design considerations for brackish tidal marsh habitat include the following.

Marsh Plain Vegetation. To provide high functioning habitat, restored tidal marsh plains will be dominated by native brackish marsh vegetation (e.g., pickleweed, saltgrass) appropriate to marsh plain elevations, mimicking the composition and densities of historical Suisun Bay brackish tidal marshes. Vegetated marsh plains will also be expected to filter non-point source pollution from surface or subsurface infiltration that otherwise would flow into Suisun Bay.

Hydrodynamic Conditions. Restored brackish tidal marshes will be designed to provide hydrodynamic conditions similar to those described for freshwater tidal marsh.

Environmental Gradients. To the extent practicable as determined by site-specific constraints, restored tidal marshes will be designed to provide a natural ecological gradient among subtidal, tidal, and upland habitats to accommodate movement of fish and wildlife species and provide flood refuge habitat for marsh-associated species during high water events. Because land surface elevations within Suisun Marsh are relatively homogenous, opportunities to provide linkages to upland habitats are limited to restoration sites that are located along the fringe of Suisun Marsh. Dikes constructed to restore marshes in the interior of Suisun Marsh will be designed with low gradient slopes supporting high marsh and upland vegetation to provide flood refuge habitat. Where appropriate, higher elevation islands of upland habitat within restored marshes may also be created to provide flood refuge for marsh wildlife.

Minimum Restoration Targets for Brackish Tidal Marsh Habitat in Suisun ROA. The BDCP Implementing Entity will restore a minimum of freshwater tidal marsh in the Suisun Marsh ROA as follows:

- **HRCM9: Restore at least 7,000 acres of brackish tidal marsh within the Suisun Marsh Restoration Opportunity Area.** The BDCP Implementing Entity will restore a minimum of 7,000 acres of brackish tidal marsh in the Suisun Marsh ROA. Restored brackish tidal marsh will be designed to support the physical and biological attributes described in above in *Brackish Tidal Marsh Habitat Restoration*. Restored tidal marshes will be designed to support a mosaic of tidal marsh, tide flat, shallow subtidal aquatic, and transitional upland habitats as appropriate to specific restoration sites to mimic the historical ecological gradients of Suisun Marsh and Bay. The Suisun Marsh ROA (Figure 3.1) encompasses a substantial area with elevations suitable for intertidal marsh restoration that would have minimal effect on infrastructure or permanent crops relative to other suitable lands within the Delta.

The Suisun Marsh Habitat Management, Preservation, and Restoration Plan (currently under development) will include an evaluation of alternatives, including options that contemplate the restoration of up to 7,000 acres of brackish tidal marsh. Much of Suisun Marsh is currently at elevations that could be restored to tidal habitat.

Anticipated actions to restore brackish intertidal marsh habitat include:

- acquisition of lands, in fee-title or through conservation easements, suitable for restoration of intertidal and subtidal habitats and for accommodating future sea level rise from willing landowners;
- reconnecting disconnected remnant sloughs to Suisun Bay and removing remnant slough dikes to reintroduce tidal connectivity to slough watersheds to restore tidal marsh; and
- breaching dikes to reintroduce tidal exchange to diked lands.
- excavating channels and creating berms to encourage the development of dendritic channel networks within restored marshes;
- modifying ditches, cuts, and levees to encourage more natural tidal circulation and better flood conveyance based on local hydrology;

- prior to breaching, scalping higher elevation portions of islands to provide fill for placement on subsided lands to raise surface elevations suitable for establishment of marsh plain in the intertidal zone;
- prior to breaching, importing dredge or fill in shallowly subsided areas to raise ground surface elevations to a level suitable for establishment of marsh plain in the intertidal zone;

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

As described in WOCML11, future reoperation or removal of the Montezuma Slough Salinity Control Gate will increase the benefits of restoring brackish intertidal marsh in Suisun Marsh by increasing access for covered fish species to existing and restored tidal aquatic habitat within a large area of Suisun Marsh.

Problem Statement: Suisun Marsh is the largest brackish water marsh complex in the Western United States. It supports many listed and sensitive terrestrial and aquatic species. Much of the marsh currently is diked to prevent tidal influence and is managed as seasonal wetlands for waterfowl (approximately 52,000 acres). The majority of the Suisun Marsh is owned privately or by the Department of Fish and Game and is protected under the Suisun Marsh Preservation Act. Restoration of a portion of these diked marshes to tidal influence is being planned under the Suisun Marsh Restoration and Management Plan.

Hypotheses: Restoration of brackish tidal marsh and shallow subtidal aquatic habitats in Suisun Marsh are hypothesized to provide a range of ecosystem and covered species benefits. As described in Appendix X, *DRERIP Evaluations*, however, there are a number of uncertainties regarding the level of benefits that may be provided by marsh restored as well as risks for adverse consequences. Restoring brackish intertidal marsh within Suisun Marsh is expected to reduce the adverse effects of stressors related to food and habitat availability for the covered species by:

- increasing rearing habitat area for Chinook salmon, Sacramento splittail, and possibly steelhead (Healey 1991, Siegel 2007);
- increasing the local production of food for rearing salmonids, splittail, and other covered species (Kjelson et al. 1982). Suisun Marsh is located in an area of the estuary that has high production of phytoplankton, zooplankton, and macroinvertebrates;
- providing an important linkage between current and future upstream restored habitat, such as Yolo Bypass/Cache Slough, with downstream habitat, such as Suisun Bay. Suisun Marsh is located in the low salinity zone of the estuary, which serves as a corridor for upstream and downstream passage by migratory fish such as sturgeon and salmonids;

- increasing the availability and production of food in Suisun Bay for delta and longfin smelt by exporting organic material via tidal flow from the marsh plain and phytoplankton, zooplankton, and other organisms produced in intertidal channels into the Bay;
- locally providing areas of cool water refugia for delta smelt (C. Enright pers. comm.);
- reducing periodic low dissolved oxygen events associated with the discharge of waters from lands managed as seasonal freshwater wetlands that would be restored as brackish intertidal marsh (Siegel 2007, C. Enright pers. comm.);
- increasing the extent of habitat available for colonization by Suisun marsh aster and soft-bird's beak; and
- enhancing and increasing the extent of salt marsh harvest mouse and Suisun shrew habitat.

Adaptive management considerations: The adaptive management program will assess the value of restored marshes and adjacent shallow subtidal habitats to covered species habitat, including the capacity of the restored areas to produce food and organic carbon to support food web processes. Results of monitoring the development of early marsh restorations will help inform the design and management of subsequent marsh restoration projects. In addition, monitoring results will also support the development of more cost effective management techniques, if needed, to control the establishment of non-native species in restored marshes.

Conservation Measures for Channel Margin Habitat: HRCM##. Enhance channel margin habitats along not more than 20 linear miles of Delta channel banks. The BDCP will provide for the enhancement of 20 linear miles of channel margin habitat in the Delta. This conservation measure is directed at improving habitat conditions for covered fish species along Delta channel banks (as measured along one bank line of channels) by improving channel geometry and restoring riparian, marsh, and mudflat habitats along levees. Channel margin will be improved only along channels that serve as important rearing habitat and movement corridors for salmonids. Although channel margin enhancements are primarily intended to provide specific benefits to salmonids, enhancement of these habitat is also expected to improve spawning and rearing habitat conditions for Sacramento splittail. This measure will be implemented along non-Project levees within the BDCP Planning Area and along Project levees along the San Joaquin River from Vernalis and Mossdale and along Steamboat and Sutter Sloughs. Actions on Project levees will be carried out in coordination with USACE, consistent with floodplain restoration measures.

Channel Margin Habitat Enhancement Concepts. Channel margin habitats are located adjacent to the bank lines of Delta channels and sloughs at elevations from the mean higher high water tide elevation to 6 feet below the mean lower low water tide elevation. Channel margin habitats will be enhanced to provide the following ecological benefits for covered fish species (see Appendix X, *DRERIP evaluations*):

- increased production of phytoplankton, zooplankton, and macroinvertebrates that serve as or support production food for covered fish species;

- increased availability of Sacramento splittail spawning habitat and splittail and salmonid rearing habitat;
- increased inputs of allochthonous material (e.g., twigs, leaf litter) into Delta waterways in support food web processes;
- improved instream fish habitat structure and associated hydrodynamic complexity;
- improved diurnal water temperatures at a local scale; and
- increased habitat for Delta mudwort and Mason's lilaeopsis where channel margin habitat is restored within the range of each of these species.

Riparian and emergent vegetation that is restored as a component of channel margin habitat enhancements will support habitat for riparian-associated covered wildlife and plant species including (see Appendix X, *DRERIP evaluations*):

- Willow-dominated riparian scrub to increase habitat for riparian brush rabbit, riparian woodrat, and nesting habitat for white-tailed kite;
- Riparian woodland and scrub to increase nesting habitat for Swainson's hawk, white-tailed kite, and yellow-breasted chat;
- Increased habitat for elderberry longhorn beetle; and
- Increased habitat for Suisun Marsh aster where riparian and emergent vegetation is restored within the range the species.

In suitable locations, enhanced channel margin habitats will be designed to provide substrate conditions that support habitat for tidal mudflat-associated covered plant species.

Methods used to enhance channel margin habitats will vary, depending on site conditions. Channel geometry may be modified, where such actions would be consistent with flood control requirements, to improve subtidal aquatic habitat and hydrodynamic conditions by creating low benches that support emergent vegetation and higher elevation benches that support riparian vegetation. Designs with varying width and surface elevations along constructed benches would create hydrodynamic complexity and provide an ecological gradient of habitat conditions. Large woody material (e.g., tree trunks and stumps) could be anchored into constructed low benches or into existing riprapped levees to provide similar habitat functions.

Restoration variables that will be considered in the design of enhanced channel margin habitat include the:

- spatial distribution and extent within the Delta;
- length of habitat restored along channel margins;
- cross sectional profile of enhanced channels (elevation of habitat, topographic diversity, width, variability in edge and bench surfaces, depth, and slope);
- amount and distribution of installed woody debris along enhanced channel margins; and
- extent of shaded riverine aquatic overstory and understory vegetative cover needed to provide future input of large woody debris.

Enhanced channel margin habitats would be designed to support habitat for the covered species listed in Table 3.6. Enhancement design considerations for channel margin habitat include:

- enhancing channel margin habitats in important rearing areas and movement corridors for covered fish species;
- locating and configuring enhanced habitat areas to connect to existing patches of high value covered fish species habitats and to connect disconnected patches of high value habitats.
- incorporating large woody debris into channel banks to improve the structural complexity of existing channel margin habitats;
- providing a gradient of habitat and hydrodynamic conditions to benefit natives and minimize the colonization of non-native submerged aquatic vegetation and use by predatory fish; and
- restoring native woody riparian vegetation to create overhead cover and instream cover to reduce predation risk for vulnerable life stages of covered fish species and to provide nesting and cover habitat for riparian-associated wildlife species.

Distribution of Channel Margin Enhancement. Channel margin enhancement actions will be conducted along both Project levees and non-Project levees in the Planning Area.

- **HRCM15: Enhance channel margin habitats along non-Project levees in the Delta to improve habitat conditions for covered fish species.** The BDCP Implementing Entity will enhance channel margin habitat along non-Project levees in the Delta. This conservation measure is directed at improving habitat conditions for covered fish species along channel banks (as measured along one bank line of channels). Channel margin will be improved only along channels that serve as important rearing habitat and movement corridors for salmonids. Although channel margin enhancements would be located to provide specific benefits to salmonids, enhanced habitats are also expected to improve spawning and rearing habitat conditions for Sacramento splittail.
- **HRCM12: Enhance channel margin habitats along Steamboat and Sutter Sloughs to improve habitat conditions for covered fish species.** Steamboat and Sutter Sloughs are thought to serve as important rearing habitat and movement corridors for juvenile salmonids outmigrating from the Sacramento River (J. Burau pers. comm.). The purpose of this measure is to improve the growth and survival of juvenile salmonids that use these habitat areas. The BDCP Implementing Entity would coordinate planning with the U.S. Army Corps of Engineers to assess the feasibility of making modifications to the slough channels and adjacent Project levees while maintaining the flood control functions of these channels. This measure would be implemented by BDCP if results of planning studies indicate that restoring channel margin habitats along these sloughs is desirable and feasible.
- **HRCM13: Enhance channel margin habitats along the San Joaquin River between Vernalis and Mossdale to improve habitat conditions for covered fish species.** Habitat conditions for covered fish species would be enhanced along the San Joaquin River from Vernalis to Mossdale. The purpose of this measure is to improve rearing habitat conditions for juvenile salmonids and to improve spawning habitat and rearing

habitat conditions for Sacramento splittail. The BDCP Implementing Entity would coordinate planning with the U.S. Army Corps of Engineers to assess the feasibility of making modifications to the slough channels and adjacent Project levees while maintaining the flood control functions of these channels. This measure would be implemented by BDCP if results of planning studies indicate that restoring channel margin habitats along these sloughs is desirable and feasible.

Design elements for channel margin enhancement could include:

- modifying channel geometry to improve hydrodynamic and structural complexity (e.g., construction of low in-channel benches) and to create low velocity habitat areas designed to provide spawning habitat for splittail and rearing habitat for splittail and salmonids;
- establishing emergent and woody riparian vegetation along modified banks that do not support emergent and woody riparian vegetation to provide shaded riverine aquatic and instream cover for covered fish species;
- installing large woody material in banks to improve instream structure and hydrodynamic diversity; and
- controlling the abundance of non-native fish predators and competitors.

To enhance channel margin habitats, the BDCP Implementing Entity would coordinate with and receive approvals as appropriate from the Central Valley Flood Protection Board, California Department of Water Resources, and U.S. Army Corps of Engineers to modify channel characteristics along leveed waterways.

Problem Statement - General: Primary Delta channels serve as movement corridors for the covered fish species and support splittail spawning and salmonid and splittail rearing habitat. These channels are now leveed and, as such, channel margin habitats lack the diversity and complexity of habitat conditions associated with unmodified channels.

Hypotheses: Enhancement of channel margin habitats along important salmonid use areas is expected to reduce the adverse effects of stressors related to habitat and food availability by (see Appendix X, *DRERIP Evaluations*):

- increasing the extent of shaded riverine aquatic cover and increasing instream cover by through contributions of instream woody material (U.S. Fish and Wildlife Service 2004);
- providing inputs of organic material (e.g., leave and twig drop) in support of aquatic foodweb processes;
- increased production and export of terrestrial invertebrates into the aquatic ecosystem (Nakano S. and M. Murakami 2001);
- creating additional spawning habitat for Sacramento splittail by creating low velocity backwater habitats (Sommer et al. 2001a, 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006); and
- depending on location, increasing the quality of rearing habitat area for Sacramento River salmonids (J. Burau pers. comm., Siegel 2007) and for San Joaquin Basin runs

of Chinook salmon and possibly steelhead (Sommer et al.2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006).

Problem Statement – Steamboat and Sutter Sloughs: Steamboat and Sutter Sloughs are thought to serve as important rearing habitat and movement corridors for juvenile salmonids outmigrating from the Sacramento River (J. Burau pers. comm.). Preliminary evidence indicates that juvenile salmonids enter these sloughs in proposition to the amount of water entering these sloughs (Perry and Skalski 2008). Hydrodynamic modeling indicates that, depending on multiple factors (e.g., total flows and DCC gate position), up to 80% of Sacramento River water can move through these two sloughs (A. Munevar pers. comm.). If verified with future research, this indicates that up to 80% of outmigrating juvenile salmonids may enter these sloughs. Preliminary evidence suggests that survival of salmonids in these sloughs is lower or equal to that of the mainstem river (Perry and Skalski 2008), likely due to greater predation populations relative to the mainstem Sacramento River. Therefore, improving the habitat conditions in Sutter and Steamboat Sloughs could improve survival, and possibly growth, of outmigrating juvenile salmonids that use these habitat areas.

Hypotheses: Enhancing Steamboat and Sutter Sloughs as fish migration corridors is expected to increase the survival and growth of outmigrating Sacramento River salmonids by:

- increasing the quality of rearing habitat area for Sacramento River salmonids (Siegel 2007, J. Burau pers. comm.);
- reducing the risk for predation on covered fish species by non-native fish predators (J. Burau pers. comm.);
- providing inputs of organic material (e.g., leave and twig drop) in support of aquatic foodweb processes; and
- reducing the risk for entrainment of juvenile salmonids by providing a migration corridor that bypasses the intakes of a new north Delta diversion point, the Delta Cross Channel, and Georgiana Slough.

Problem Statement – San Joaquin River: The San Joaquin River from Vernalis to Mossdale is an important movement corridor for juvenile salmonids outmigrating from the San Joaquin River. This reach of river is also thought to be an important spawning habitat for San Joaquin River salmonids during drier years when floodplains do not inundate. However, much of the channel margin habitat in this reach has been eliminated.

Hypotheses: Enhancing channel margin habitat conditions along the San Joaquin River from Vernalis to Mossdale is expected to reduce the adverse effects of stressors related to food and habitat availability for the covered fish species by:

- creating additional rearing habitat for San Joaquin Basin runs of Chinook salmon, Sacramento splittail, and possibly steelhead (Sommer et al.2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006);

- creating additional spawning habitat for Sacramento splittail by creating low velocity backwater habitats (Sommer et al. 2001a, 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006);
- increasing the extent of shaded riverine aquatic cover and increasing instream cover by through contributions of instream woody material (U.S. Fish and Wildlife Service 2004);
- providing inputs of organic material (e.g., leave and twig drop) in support of aquatic foodweb processes;
- increasing production and export of terrestrial invertebrates into the aquatic ecosystem (Nakano and Murakami 2001);
- improving connectivity with upstream habitat areas, including existing and future restored habitats; and
- increasing habitat for Swainson's hawk, riparian brush rabbit, valley elderberry longhorn beetle, delta button celery, and delta tule pea.

Adaptive management considerations: Opportunities for adaptive management include adjusting the design of subsequent channel margin restoration actions to improve habitat functions for covered fish species if indicated by monitoring data. Implementation of this conservation measure would also afford the opportunity to test fish predator control techniques to identify the most efficacious methods for controlling predator populations.

Conservation Measures for Riparian Habitat: HRCM11/HRCM14: Restore at least 5,000 acres of riparian forest and scrub. The BDCP Implementing Entity will restore a minimum of 5,000 acres of riparian forest and scrub associated with the restoration of tidal and floodplain habitats and channel margin improvements. The following are the temporal targets for riparian restoration:

- 1,300 acres restored within 10 years of plan implementation
- 2,300 acres (cumulative) restored by year 15 of plan implementation
- 5,000 acres (cumulative) restored by year 40 of plan implementation

Riparian Restoration in Restored Floodplains. To the extent consistent with flood control requirements, restored floodplain habitat areas (see WOCML2, HRCM1/HRCM2, HRCM3) will allow for the natural establishment and growth of woody riparian vegetation on portions of restored floodplains that support appropriate soils and hydrology. In bypasses co-managed for habitat and flood control benefits, locations where riparian vegetation is allowed to establish would be limited to areas where the presence of riparian vegetation would not compromise flood control standards or hydraulic capacity of the flood control bypass. The locations of such restored vegetation will be determined in coordination with USACE, DWR, and appropriate local flood control agencies. Riparian habitat would be allowed to naturally establish in floodplain habitat areas that are restored by setting back levees to expand the extent of the floodplain subject to overbank flow. The development of riparian vegetation would be monitored to determine the need for control of non-native vegetation to facilitate the establishment of native riparian vegetation or if restoration success could be improved by plantings of native riparian vegetation.

Riparian Restoration in Restored Tidal Marsh. Woody riparian vegetation will be allowed to naturally reestablish along the upper elevation margins of restored intertidal marsh habitats within ROAs (see HRCM4-8 and 16) where soils and hydrology are suitable, including segments of stream channels that drain into restored marshes. Woody riparian vegetation will be actively established on new levees constructed the BDCP Implementing Entity within ROAs and along channel margins of existing levees (see HRCM12-13 and 15). The BDCP Implementing Entity would design these new levees to incorporate features that would provide for the active and passive establishment of riparian vegetation along low elevation surfaces (e.g., levee benches).

Riparian Restoration on Channel Margins. Woody riparian vegetation will be actively established along channel margins of existing levees (see HRCM12-13 and 15) to enhance covered fish species habitat.

Riparian Habitat Restoration Concepts. Riparian habitats would be restored to provide a range of habitat conditions that provide the following ecological benefits in support of covered species:

- increased availability of Swainson's hawk and white-tailed kite nesting and roosting habitat;
- increased availability of potential future breeding habitat for yellow-breasted chat;
- increased availability of riparian brush rabbit and riparian woodrat habitat;
- increased availability of valley elderberry longhorn beetle habitat;
- increased inputs of organic material and macroinvertebrates into Delta waterways in support of aquatic food web processes;
- enhanced shaded riverine aquatic and instream habitat conditions for covered fish species;
- improved diurnal water temperatures at a local scale along channel margins; and
- improved food production and habitat conditions for covered fish species where restored on BDCP restored floodplain habitats.

Woody riparian vegetation would be expected to naturally establish in areas within restored inundated floodplain habitats and along upper elevation margins of restored freshwater tidal marsh habitats that support suitable hydrology and soils. Riparian vegetation would also be restored through plantings of native riparian trees and shrubs in association with restoration of channel margin habitats. Restored riparian habitats would be designed and managed to provide a range of structural and vegetative conditions to meet the habitat requirements of associated covered species, including:

- riparian woodland with cottonwood, willow, and/or valley oak overstory to provide nesting habitat for Swainson's hawk and white-tailed kite;
- willow-dominated riparian or other riparian scrub with little or no overstory vegetation to provide habitat for yellow-breasted chat; and
- riparian scrub with dense brush and thickets of wild rose, wild grape, blackberry, and open overstory to provide habitat for riparian brush rabbit, riparian woodrat, and Suisun Marsh aster.

Restored inundated floodplain and tidal marsh habitats would be monitored to evaluate the progress of the establishment of riparian vegetation. If necessary, the establishment of non-native invasive plant species would be controlled and native riparian vegetation (e.g., seeds, seedlings, cuttings) would be planted to ensure the establishment of the desired species and structural characteristics. Once established, it is expected that the riparian habitats would be self-sustaining but would be monitored to determine if subsequent management actions may be required to ensure successful regeneration of native species.

Problem Statement: Most existing levees were not designed (e.g., steep banks, rip-rap) to incorporate riparian habitat and have created increased habitat for non-native predatory fish and thus contribute to increased predation losses of covered fish species. A lack of riparian habitat associated with existing and restored tidal aquatic and marsh habitats limits the ecological benefits to fish and wildlife by limiting important ecological gradients and ecosystem functions that a full suite of these habitats would provide.

Hypotheses: Restoration of riparian habitat on existing and new levees and in upland transition zones in association with aquatic and marsh habitats is expected to provide the following ecosystem and covered species benefits (see Appendix X, *DRERIP Evaluations*):

- providing inputs of organic material (e.g., leave and twig drop) resulting in increased production of phytoplankton, zooplankton, and macroinvertebrates that serve as or support production food for covered fish species;
- increasing the extent of shaded riverine aquatic cover and increasing instream cover by through contributions of instream woody material (U.S. Fish and Wildlife Service 2004);
- increased production and export of terrestrial invertebrates into the aquatic ecosystem (Nakano S. and M. Murakami 2001); and
- increasing the extent of valley elderberry longhorn beetle habitat and nesting habitat for Swainson's hawk and yellow breasted chat.

Adaptive management considerations: Opportunities for adaptive management include improving the design and management of restoration actions to provide for the successful establishment, growth, and habitat benefits of restored riparian habitats based on monitoring of the development of previously restored riparian habitats. For example, if the natural establishment and growth of native riparian vegetation is substantially impaired by competition with non-native plants, restoration projects may need to provide for the control of non-native plants or require that riparian plantings be installed to improve restoration success.

Conservation Measures for Floodplain Habitat: HRCM1/HRCM2: Restore 10,000 acres of seasonally inundated floodplain habitat. The BDCP will provide for the restoration at least 10,000 acres of seasonally inundated floodplain habitat within the Planning Area. Because of the long-lead time needed to implement floodplain restoration it is not expected that new floodplain would be restored in the first 10 years of plan implementation. The following are the temporal targets for seasonally inundated floodplain restoration:

- 1,000 acres restored by year 15 of plan implementation.

- 10,000 acres (cumulative) restored by year 40 of plan implementation.

Seasonally Inundated Floodplain Habitat Restoration Concepts. Inundated floodplain habitat would be restored and enhanced to provide the following ecological benefits in support of the covered species (see Appendix X, *DRERIP Evaluations*):

- increased primary and secondary production within inundated floodplains in support of food production for salmonid and Sacramento splittail rearing;
- export of organic carbon and primary and secondary production from floodplains into delta waterways in support of food production for covered species within and downstream of the delta;
- export of allochthonous material into delta waterways in support of food production for covered species within and downstream of the delta;
- substantial increase in high quality splittail spawning and rearing habitat and Chinook salmon (all runs) and steelhead rearing habitat relative to existing in-delta habitat conditions;
- reduction in stranding/poaching losses of adult sturgeon and salmonids by improving movement of adult fish past Fremont weir;
- improved habitat connectivity between upstream and downstream habitats;
- improved survival/escapement of juvenile salmonids by reducing the risk for predation by non-native predatory fish; and
- increasing sources of particulate matter to improve turbidity conditions for delta smelt and longfin smelt in delta waterways.

Floodplain habitats would be restored by setting back levees along existing river channels to reestablish connectivity of historical floodplains with river channels from which connectivity was severed with construction of levees and creating new flood bypasses and water control structures to provide for inundation of bypass floodplains (see conservation measure HRCM17 for a description of the Deep Water Ship Channel Bypass floodplain habitat measure).

Restoration variables that would be considered in the design of restored seasonally inundated floodplain habitat include:

- seasonal timing of inundation,
- interannual frequency of inundation,
- duration of inundation,
- spatial extent of inundation,
- depth of inundation,
- flow 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), and
- topography and slope.

Restored seasonally inundated floodplain habitats would be designed to support habitat for the covered species indicated in Table 3.6. Restoration design considerations for seasonally inundated floodplain habitat include the following.

Hydrodynamic Conditions. To provide preferred habitat conditions in support of Sacramento splittail spawning and juvenile salmonid and Sacramento splittail rearing and food production, restored floodplain habitats would be designed to provide the following attributes:

- shallow water with highly variable depth (approximately 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); and
- velocities that average about 1.5 feet/sec that are highly variable spatially and temporally.

Floodplain Topography. Where appropriate, the topography of restored and enhanced floodplains would be sculpted to reduce the risk for fish stranding by improving drainage and to provide topographic variability to increase hydrodynamic complexity. Berms may also be constructed to direct flows such that important existing habitat areas for sensitive wildlife and plant species are not inundated during periods the Weir is operated.

Connectivity. To the extent practicable, restored and enhanced inundated floodplains would be located and designed such that flows exiting the floodplain would flow through existing and restored tidal marsh to recreate historical landscape relationships and to provide for connectivity with adjacent uplands that result in transitional habitats and accommodate species movement.

Dry Floodplain Conditions. Restored and enhanced floodplains would be managed for ongoing agricultural uses or to support native wildlife habitats. Farmed floodplains would be managed to minimize the use of persistent herbicides and pesticides that are toxic to aquatic organisms and to provide structure and types of residual crop biomass to provide cover and hydrodynamic complexity for fish and provide sources of organic carbon in support of aquatic food web processes during inundation periods. To the extent consistent with floodplain land uses and flood control requirements, if applicable, woody riparian vegetation would be allowed to naturally establish. Established woody riparian vegetation would support habitat for riparian-associated covered species and provide cover and hydrodynamic complexity for covered fish species during inundation periods. Riparian vegetation would also serve as sources of instream woody material for fish habitat, organic carbon in support of the aquatic food web, and macroinvertebrates (e.g., insects) that provide food for covered fish species.

Distribution of Floodplain Restoration. Seasonal floodplain restoration actions could be conducted along any suitable channels in the north, east, and south Delta. Specific conservation actions could include restoration along the San Joaquin mainstem, Old River, Middle River, and east of the Deep Water Ship Channel affecting both Project and non-Project levees in the Planning Area.

- **HRCM1/HRCM2: Restore seasonally inundated floodplain habitat along the San Joaquin River downstream of Vernalis.** The BDCP Implementing Entity will coordinate floodplain restoration planning and flood control planning with the Central Valley Flood Protection Board, DWR, and USACE to assess the desirability and feasibility for setting back levees along the San Joaquin River downstream of Vernalis to restore seasonally inundated floodplain habitats for covered fish species and provide flood control benefits. If results of planning studies indicate that setting back levees along this reach of the San Joaquin River is desirable and feasible, the BDCP Implementing Entity would enter into a cost sharing agreement with the USACE for project planning and construction and would assist with securing authorization and funding for the project. If authorized and funded, the BDCP Implementing Entity would enter into subsequent agreements with the U.S. Army Corps of Engineers and other appropriate agencies governing levee and floodway maintenance responsibilities. This conservation action would expand the capacity of the existing constricted San Joaquin River downstream of Vernalis by setting back levees, improving access of juvenile fish, such as Chinook salmon and steelhead, to seasonally inundated floodplain habitat. Restored floodplain habitat would be designed and operated to support the physical and biological attributes described above in *Seasonally Inundated Floodplain Habitat Restoration Concepts.*

- **HRCM3: Restore seasonally inundated floodplain habitat along Old and/or Middle Rivers.** The BDCP Implementing Entity will restore seasonally inundated floodplain habitat by setting back non-Project levees along Old River and/or Middle River. Seasonally inundated floodplain habitat would be restored either on Fabian Tract along Old River or on Union Island and Upper Roberts Island along Middle River. The location of restored floodplain habitat would depend on the location and design of the selected conveyance pathway and operations of the through-Delta component of dual conveyance. Floodplain habitat would be restored along section of river that would provide the most species and ecosystem benefits. Restored floodplain habitat would be designed and operated to support the physical and biological attributes described above in *Seasonally Inundated Floodplain Habitat Restoration Concepts.*

- **HRCM17: Assess feasibility of a new flood bypass east of the Sacramento Deep Water Ship Channel to restore seasonally inundated floodplain habitat.** The BDCP Implementing Entity will coordinate flood control planning with the Central Valley Flood Protection Board, Sacramento Area Flood Control Agency, California Department of Water Resources (DWR), and U.S. Army Corps of Engineers to assess the desirability and feasibility for creating a new flood bypass east of the Sacramento Deep Water Ship Channel (see Figure 3.1) adjacent to the east levee of the Sacramento River Deep Water Ship Channel. This new flood bypass (hereafter referred to as the Deep Water Ship Channel Bypass) will restore seasonally inundated floodplain habitats for covered fish species and provide flood control benefits. If results of planning studies indicate that construction of a Deep Water Ship Channel Bypass is desirable and feasible, the BDCP Implementing Entity will enter into a cost sharing agreement with the U.S. Army Corps of Engineers for project planning and construction and will assist with securing Congressional authorization and funding for the project. If authorized and funded, the BDCP Implementing Entity will enter into subsequent agreements with the U.S. Army Corps of Engineers and other appropriate agencies governing bypass operations for providing joint flood control and ecosystem benefits and maintenance responsibilities. Restored floodplain habitat within the bypass will be designed and operated to support the physical and biological attributes described in Section 3.4.2.1, *Physical Habitat Conservation Concepts*. The operational criteria and adaptive range for a new weir and gates associated with the Deep Water Ship Channel Bypass during the BDCP long-term implementation periods are described in Table 3.5.

Design elements of this conservation measure could include:

- acquisition of lands, in fee-title or through conservation easements, suitable construction of set-back levees and restoration of floodplain habitat and for accommodating future sea level rise;
- setting back levees along the selected river corridor and removing the existing levees or large sections of the existing levees;
- discontinuing farming within the setback levees and allowing riparian vegetation to naturally establish on the floodplain;
- actively establishing riparian habitat where necessary to accelerate formation of habitat for specific covered species;
- re-contouring the restored floodplain surface, if needed, to avoid potential for stranding of juvenile and adult fish following inundation events;
- modifying the channel within the new floodplain reach where practicable to create low velocity areas designed to provide spawning habitat for splittail and rearing habitat for splittail and salmonids; and
- allowing the river channel to meander between the set-back levees through the natural processes of erosion and sedimentation.

Problem Statement: The vast majority of floodplain habitat in the Sacramento/San Joaquin River system has been lost through the construction of levees that have separated the major rivers from their natural floodplains. There is currently no functional floodplain habitat in the lower San Joaquin, Old, or Middle Rivers. Flood control agencies are currently planning modifications to the existing Central Valley flood control system, which provides an opportunity for the BDCP Implementing Entity to coordinate with these agencies to explore the desirability and feasibility for setting back levees along these river reaches for dual purposes: flood management and floodplain restoration.

Hypotheses: Increasing the extent of floodplain habitat by setting back levees along the San Joaquin River downstream of Vernalis and Old and Middle rivers is expected to reduce the adverse effects of stressors related to food and habitat availability for the covered fish species by (see Appendix X, *DRERIP Evaluations*):

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

- creating additional rearing habitat for Sacramento and San Joaquin Basin runs of Chinook salmon, Sacramento splittail, and possibly steelhead (Sommer et al. 2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006);
- increasing the production of food for rearing salmonids, splittail, and other covered species (Sommer et al. 2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006);
- increasing the availability and production of food in Delta channels downstream of restored floodplain habitat for delta smelt, longfin smelt, and other covered species by exporting organic material and phytoplankton, zooplankton, and other organisms produced from the inundated floodplain into Delta channels (Mitsch and Gosselink 2000, Moss 2007);
- reduce the risk and exposure to mortality associated with the interior Delta and the Delta Cross Channel and Georgiana Slough of outmigrating juvenile fish (Brandes and McLain 2001, USFWS unpubl. data, J. Burau pers. com.) (HRCM17 only);
- reducing the exposure of outmigrating juvenile fish to entrainment at intakes of the proposed north Delta water diversion facilities by passing juvenile fish into the new bypass upstream of the proposed intake locations (HRCM17 only);
- increasing habitat complexity by allowing the natural establishment and growth of woody riparian vegetation that will provide inputs of large woody debris into the river channel and provide overhead cover;
- improving in-channel habitat complexity along the Old or Middle River corridors would be expected to reduce the predation risk to covered fish species and improve connectivity between San Joaquin River habitats and Delta habitats for passage of juvenile salmonids outmigrating from the San Joaquin River and eastside tributaries; and
- riparian habitats within the new floodplain habitat would be expected increase habitat for Swainson's hawk, riparian brush rabbit, valley elderberry longhorn beetle, delta button celery, and delta tule pea.

Adaptive management considerations: Opportunities for adaptive management include adjusting the design of subsequent in-channel backwater and seasonal floodplain habitat restorations to improve their effectiveness in developing as functional habitat for covered species and to produce food and organic material in support of food web processes. Monitoring the establishment of riparian vegetation would provide information necessary for determining the need to control the establishment of non-native vegetation or plant native vegetation to promote development of native riparian forest and scrub habitats.

3.4.2.3 Terrestrial and Non-tidal Wetland Habitat Conservation Measures

[***Note to Reviewers:*** *Protection, enhancement, and restoration conservation measures for agricultural lands, natural seasonal wetlands, managed seasonal wetlands, non-tidal perennial aquatic, and non-tidal freshwater marsh natural communities are currently being developed by SAIC and the BDCP Terrestrial Resources Subgroup.*]

3.4.3 Other Stressors Conservation Measures

[***Note to Reviewers**: The text of this section of Chapter 3, including the other stressors conservation measures described, is subject to change and revision as the BDCP planning process progresses. This section, however, has been drafted and formatted to appear as it may in a draft HCP/NCCP. Although this section includes declarative statements (e.g., the Implementing Entity will…), it is nonetheless a "working draft" that will undergo further modification based on input from the BDCP Steering Committee, state and federal agencies, and the public.*

This section provides cost estimates for individual actions wherever possible as informational to help in the decision making process. These cost estimates are not BDCP commitments, which are currently indicated in the text as placeholders. A full economic analysis will be conducted later in 2009, after which some of these measures may be withdrawn from the BDCP or modified due to low cost-effectiveness.]

This section describes BDCP conservation measures that address other factors potentially affecting covered fish species. These factors, collectively titled "Other Stressors," go beyond issues associated with water operations and physical habitats to address toxic contaminants, other water quality issues (e.g., dissolved oxygen), non-native species, hatcheries, harvest, and non-project diversions that are individually and collectively affecting the productivity of the Delta. As discussed more fully in the Introduction (section 3.1) and the Conservation Strategy Overview (section 3.2), the inclusion of these measures into the BDCP reflects the comprehensive nature of the approach to conservation that underlies the BDCP.

A number of these conservation measures address activities that are not currently within the direct control of the BDCP Implementing Entity and therefore are proposed to be implemented through agreements with third parties. These agreements will establish reliable mechanisms for the execution and success of these measures by those third parties. In instances where a third party is proposed to implement the conservation measure funded by the BDCP, the BDCP Implementing Entity will enter into binding Memoranda of Agreement (MOA) or similarly binding instruments with the third party. These MOAs will describe respective roles and obligations for funding and implementing conservation measures as identified through the process described in each conservation measure. Specific elements of the MOA will describe:

- the specific activities or improvements that would be funded by BDCP;
- the preparation of annual work plans for these activities and improvements;
- the expected benefits of the action for covered species and the aquatic ecosystem;
- the performance metrics that will be measured to verify that the action being implemented has the expected benefit;
- provisions for monitoring, reporting, and documenting work performed; and
- provisions for modifying or terminating MOAs.

The third party will develop annual work plans, acceptable to the BDCP Implementing Entity and the Fishery Agencies, that describe activities or capital improvements to be funded by BDCP over the course of that year. The third party will be responsible for implementing the scope of work and submitting reports as specified in the MOA that demonstrate that work plans have been successfully implemented. The third party will also be responsible for demonstrating the effectiveness of the funded activities to meet objectives as specified in the MOA.

The BDCP Implementing Entity and the Fishery Agencies will review progress or other relevant reports prepared by the third party to assess program effectiveness and to identify adjustments to funding levels, management practices, or other related aspects of the program that will improve the biological effectiveness of the program. Such changes will be effected through the BDCP adaptive management process and will be included in the subsequent annual work plans.

If program assessments indicate that a particular conservation measure is not effective in achieving its stated objectives of providing benefits to listed species or their habitats, the BDCP Implementing Entity, in consultation with the Fishery Agencies, may terminate the conservation measure. A conservation measure will also be terminated if participation of a third party is required for its implementation and that party declines to enter into an agreement with the BDCP Implementing Entity. If terminated, remaining funding will be deobligated from that conservation measure and reallocated to augment funding for other more effective conservation measures in accordance with the BDCP adaptive management process (see Section 3.6, *Adaptive Management*). For conservation measures with MOAs that are different from this approach, a brief description of those differences is provided in the description of those conservation measures.

While the large majority of these other stressors conservation measures will provide tangible, reliable benefits to listed species both in the near term and the long term, there are a limited number of measures that may lack the desired level of certainty regarding expected benefits, due either to the need for additional information to target the best remedial approach or other factors. Notwithstanding these limitations, the BDCP includes these measures for the purpose of reflecting the comprehensive nature of its underlying approach, as described in the Overview of the Conservation Strategy dated January 19, 2009, the BDCP Planning Agreement dated October 6, 2006, and as encouraged by the conservation planning programs of the ESA and the NCCPA. These measures are included in the BDCP because they hold the prospect of addressing several other stressors on the system that are suspected (such as pollutant loadings) or known (invasive species) to compromise the productivity of the system and because they therefore may provide benefits over the long-term to ecosystem function and species conservation in the Delta. These measures may or may not be considered part of the basis of a determination about the sufficiency of the plan in achieving the goals and objectives of the BDCP or meeting regulatory requirements under the ESA or the NCCPA. However, they reflect the ongoing, active commitment to a broad-based conservation program that will yield substantial additional benefits to listed species and their habitats over the long-term.

Suitable other stressors conservation measures have been evaluated through the DRERIP process. The potential benefits, uncertainties, and risks identified through the DRERIP evaluation process for each of the evaluated other stressors conservation measures are presented in Attachment X, *DRERIP Evaluations.* Results of the DRERIP evaluations will be used by the Implementing Entity to design and implement other stressor reduction actions to address uncertainties and minimize risks identified through the DRERIP process.

OSCM1. Determine whether ammonia and ammonium have adverse direct and/or indirect effects on BDCP covered species and, if adverse effects are found, assist wastewater

treatment plants in identifying funding sources to reduce the load of ammonia and ammonium in effluent discharges. In coordination with sanitation districts that discharge wastewater into waterways within or just upstream of the Delta and Suisun Bay (hereafter, "local sanitation districts") and the Central Valley and San Francisco Regional Water Quality Control Boards (RWQCBs), evaluate the need and, if demonstrated to be necessary to protect covered fish species, reduce the levels of effluent-derived ammonia/um entering the Delta and Suisun Bay. The BDCP Implementing Entity would work closely with local sanitation districts and RWQCBs in evaluating ongoing research and funding additional research to determine the effects of effluent-derived ammonia and ammonium ion on covered species. If scientific findings identify adverse effects on covered species, the BDCP Implementing Entity, local sanitation districts, and RWQCBs would work together to determine the appropriate conservation measures to reduce the load of ammonia/um in the discharge to below levels necessary to protect covered species. The BDCP Implementing Entity would assist local sanitation districts in identifying sources of funding for these conservation measures.

This conservation measure would be comprised of three phases; implementation of Phases 2 and 3 would be contingent upon the outcome of the previous phase. During Phase 1, the BDCP Implementing Entity would convene ammonia/um and water quality experts to review current research on whether or not the discharges of ammonia/um effluent from local sanitation districts have adverse direct or indirect effects on covered fish species. At a CALFED Science Program workshop on March 10-11, 2009, a panel of national experts evaluated existing knowledge, identified data and science gaps, and developed a research framework to further determine the role of ammonia/um in the Delta and Suisun Bay. A follow up workshop, organized by the CVRWQCB, is scheduled for mid-August 2009, to present results of Delta specific research on ammonia/um. Building on this initial effort, a similar workshop would be organized and run by the BDCP Implementing Entity within 2 years of BDCP implementation to evaluate the newest information, identify data and science gaps, and determine what, if any, research is necessary to determine the effects of ammonia/um on covered fish species. The workshop would include individuals from the BDCP Implementing Entity, Fishery Agencies, local sanitation districts, RWQCBs, and other ammonia/um and water quality experts.

During Phase 2, if workshop results in Phase 1 indicate that additional research is warranted, the BDCP Implementing Entity, in coordination with Fishery Agencies, RWQCBs, and local sanitation districts, would identify additional research needs and fund or identify funding sources to evaluate the types and levels of effects of discharged ammonia/um effluent from local sanitation districts on covered fish species at a funding level of up to $_____ over 3 years. If workshop results from Phase 1 indicate that there is insufficient evidence that discharges of ammonia/um effluent from local sanitation districts adversely affect covered fish species, the BDCP will discontinue efforts with local sanitation districts to develop and funding or identify funding for additional research and develop ammonia/um reduction actions. In this case, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

During Phase 3, if research results indicate that discharges of ammonia/um effluent from local sanitation districts have adverse effects on covered fish species (Phase 1 or 2), the BDCP Implementing Entity would work with each local sanitation district and appropriate state and federal entities to identify sources of funding to develop and implement actions that would eliminate or minimize adverse effects of the effluent on covered fish species. Priority would be given to local sanitation districts whose effluent has the greatest impact to covered fish species. If research results indicate that discharges of ammonia/um effluent from local sanitation districts do not adversely affect covered fish species, the BDCP would discontinue efforts with local sanitation districts to develop conservation measures and funding would be deobligated from this conservation measure and reallocated to augment funding for other effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process. If actions to address the discharge of ammonia/um effluent are implemented, the BDCP Implementing Entity would work with local sanitation districts in reviewing covered fish species-response monitoring to assess the effectiveness of actions to eliminate or minimize effects of ammonia/um on covered fish species.

The BDCP Implementing Entity would enter into binding Memoranda of Agreement (MOA) or similar instruments with local sanitation districts that would describe respective roles and obligations for funding, conducting any additional research, finding additional sources of funding, and developing and implementing conservation measures as identified through the process described above. Elements of the MOA would include:

- a description of specific activities that would be funded by BDCP;
- preparation of annual research work plans for BDCP funded activities;
- provisions for documenting work performed; and
- provisions for modifying or terminating MOAs.

Problem Statement. Ammonia (NH_3) and ammonium (NH_4^+) are common constituents of effluent from wastewater treatment plants having only primary and secondary treatment processes (Jassby 2008). There are 23 wastewater treatment plants that discharge their effluent in or just upstream of the Delta and Suisun Bay (Table 3.8). Of these, 11 employ only primary and secondary treatments, currently releasing on average approximately 252 million gallons of effluent into the Delta and Suisun Bay waterways each day. Four of the 11 facilities have plans to upgrade to advanced treatment facilities in the near future, with a total average daily flow of 29 million gallons per day. The largest wastewater treatment plant in the Delta, the Sacramento Regional County Sanitation District (SRCSD) Wastewater Treatment Plant, released an average of 158 million gallons of treated effluent into the Sacramento River per day during 2001-2005 (Jassby 2008). The SRCSD Wastewater Treatment Plant and other treatment plants employ primary and secondary treatment processes to meet current waste discharge specifications in their NPDES permits, which are designed to protect beneficial uses and meets the US EPA aquatic criteria for ammonia/um. However, secondary treatment processes may not remove levels of ammonia/um to levels below which they may directly or indirectly affect covered fish species in the Delta. Advanced treatment processes, such as bacterial nitrification or constructed wetlands, can be up to 90% efficient at reducing ammonia/um loads in effluent (Wallace et al. 2006, Chan et al. 2008). If current ammonia/um concentrations in the Delta cause adverse effects to fish, these advanced processes may reduce concentrations of ammonia/um to levels below which they have adverse effects.

Table 3.8. Wastewater treatment plants that discharge treated wastewater into or just upstream of Delta and Suisun Bay waterways.
Wastewater treatment plants are sorted by level of treatment and capacity. Wastewater treatment plants/facilities located at a site beyond which effluent could potentially affect BDCP covered fish species and natural communities are not included. (mgd = million gallons per day)

Wastewater Treatment Plant	*Receiving Water Location*	*Level of Treatment*	*Average Flow (mgd)*	*Design Flow (mgd)*	*Source*	*Comments*
Sacramento Regional County Sanitation District	Sacramento River	Secondary	158	207	California State Water Project 2006; Jassby 2008	Plans to expand to 218 mgd by 2020.
Central Contra Costa Sanitary District	Suisun Bay 38° 2' 44" N 122° 5' 55" W	Secondary	42.2	53.8	Order No. R2-2003-0072 NPDES Permit No. CA0038024	445,000 residents in Alamo, Danville, parts of Dublin, Lafayette, parts of Martinez, Moraga, Orinda, Pleasant Hill, San Ramon and Walnut Creek; it also treats the wastewater from Concord and Clayton.
Vallejo Sanitation and Flood Control District Wastewater Treatment Plant	Carquinez Strait 38º 3' 53" N 122º 13' 42" W Mare Island Strait 38º 5' 23" N 122º 15' 12" W	Secondary	12.3	15.5	Order No. R2-2006-0056 NPDES Permit No. CA0037699	Population served: 117,000
Tracy Wastewater Treatment Plant	Old River	Secondary, but upgrading to tertiary	7.1	9	California State Water Project 2006	Plans to expand to 10.8 mgd in the future
Vacaville Easterly Wastewater Treatment Plant	Old Alamo Creek to Alamo Creek, to Cache Slough, to Sacramento River	Secondary, but upgrading to tertiary	10	15	Vacaville Easterly Wastewater Treatment Plant website	Plans to expand in the future
Delta Diablo Sanitation District	New York Slough, to San Joaquin River 38° 01' 40"N 121° 50' 14" W	6.7 mgd secondary only; 7.5 mgd tertiary and recycled	14.2	16.5	Order No. R2-2003-0114 NPDES Permit No. CA0038547	Services Antioch & Pittsburg Population served 180,000 in 2003 Planned expansion to 22.7 mgd by 2015
Manteca Wastewater Quality Control Facility	San Joaquin River	Secondary, but upgrading to tertiary	6.5	9.877	Manteca Wastewater Quality Control Facility website	Services Manteca & Lathrop Currently 2 mgd is applied to land and the rest is discharged to the San Joaquin River

Table 3.8. Wastewater treatment plants that discharge treated wastewater into or just upstream of Delta and Suisun Bay waterways.
Wastewater treatment plants are sorted by level of treatment and capacity. Wastewater treatment plants/facilities located at a site beyond which effluent could potentially affect BDCP covered fish species and natural communities are not included. (mgd = million gallons per day)

Wastewater Treatment Plant	Receiving Water Location	Level of Treatment	Average Flow (mgd)	Design Flow (mgd)	Source	Comments
City of Davis Wastewater Treatment Plant	Willow Slough or Restoration wetlands, and then to Conaway Ranch Toe Drain	Secondary, but upgrading to tertiary	5.4	7.5	Order no. R5-2007-0132-01 NPDES No. CA0079049	
City of Benicia Wastewater Treatment Plant	Carquinez Strait 38º 02' 30" N 122º 09' 03" W	Secondary	2.96	4.5	Order No. R2-2008-0014 NPDES Permit No. CA0038091	
Discovery Bay Wastewater Treatment Facility	Old River	Secondary	1.1	2.1	California State Water Project 2006	
Port Costa Wastewater Treatment Plant	Carquinez Strait 38º 02' 55" N 122º 10' 56" W	Secondary	0.02	0.033	Order No. R2-2008-0005 NPDES Permit No. CA0037885	
City of Stockton Wastewater Treatment Plant	San Joaquin River	Tertiary	34	55	City of Stockton Website; California State Water Project	
Fairfield-Suisun Sewer District	Boynton Slough outfall in Suisun Marsh 38° 12' 33" N 122° 03' 24" W	Tertiary	16.1	17.5	Order No R2-2003-0072 NPDES Permit No. CA0038024	Population served in 2003: 130,000. Plans to expand to 21.5 mgd
Mountain House Community Services District Wastewater Treatment Facility	Old River, 3 miles west of Tracy	Tertiary	0.3	3.0	Mountain House Community Services District Wastewater Treatment Facility website	Plans to expand to 5.4 mgd in the future
Dry Creek Wastewater Treatment Plant	Dry Creek tributary to Sacramento River	Tertiary	13	18	California State Water Project 2006	Services Roseville and unincorporated areas of Placer County
Woodland Water Pollution Control Facility	Tule Canal, tributary to Yolo Bypass	Tertiary	6	7.8	California State Water Project 2006	Plans to expand in the future
Lodi – White Slough Pollution Control Plant	Dredger Cut, tributary to White Slough – Sept-May	Tertiary	5.9	7.0	California State Water Project 2006	Plans to expand in the future

Table 3.8. Wastewater treatment plants that discharge treated wastewater into or just upstream of Delta and Suisun Bay waterways.
Wastewater treatment plants are sorted by level of treatment and capacity. Wastewater treatment plants/facilities located at a site beyond which effluent could potentially affect BDCP covered fish species and natural communities are not included. (mgd = million gallons per day)

Wastewater Treatment Plant	Receiving Water Location	Level of Treatment	Average Flow (mgd)	Design Flow (mgd)	Source	Comments
American Canyon Wastewater Treatment Facility	North Slough, 38º 11’ 03.7” N 122º 16’ 39.0” W Constructed freshwater wetlands, 38º 11’ 05.7” N 122º 16’ 44.8” W	Tertiary		2.5	Order No. R2-2006-0036 NPDES Permit No. CA0038768	
Lincoln Wastewater Treatment and Reclamation Facility	Auburn Ravine, tributary to Sacramento River	Tertiary	2.4	3.3	California State Water Project 2006	Plans to expand in the future
Brentwood Wastewater Treatment Plant	Marsh Creek, tributary to Dutch Slough	Tertiary	2.2	4.5	California State Water Project 2006	
University of California Davis Wastewater Treatment Plant	South and North Forks of Putah Creek, tributary to Yolo Bypass	Tertiary	1.5	2.7	California State Water Project 2006	Plans to expand in the future
Auburn Wastewater Treatment Plant	Auburn Ravine, tributary to Sacramento River	Tertiary	1.34	1.67	California State Water Project 2006	

Hypotheses. *[**Note to reviewers**: Because this conservation measure is contingent upon a necessary research component, it is not possible to identify clear hypothesized benefits of the conservation measure. Instead, a summary of potential effects of ammonia/um to covered fish species in the context of proposed research topics are described here.]*

Ammonia/um may affect covered fish species both directly and indirectly. Directly, ammonia/um can be toxic to fish at elevated concentrations (Randall and Tsui 2002), although concentrations currently measured in the Delta are well below levels at which the US EPA (1999) considers to be acutely or chronically toxic (SWRCB 2008). For example, SRCSD has conducted multiple modeling and experimental efforts and concluded that the residual impacts of ammonia/um in their effluent on aquatic organisms are "less than significant" (SRCSD 2003). However, recent mean unionized ammonia concentrations in some parts of the Delta have been above levels that have been shown to cause histopathological effects in sensitive fish species (US EPA 1999), although it is unclear whether these effects impact growth, reproduction, or survival of the species. Appendix 5 of US EPA (1999) reported that some data indicate that unionized ammonia can have adverse effects on aquatic life at concentrations as low as 0.001-0.006 mg/L. Mean unionized ammonia concentrations from 2000-2008 at the two monitoring locations in the Sacramento River immediately downstream of SRCSD's discharge point exceeded the lower end of this range (River Mile 44: 0.0021 mg/L, SRCSD unpubl. data; Hood: 0.0032 mg/L, DWR unpubl. data). In addition, there is some evidence that delta smelt and other covered fish species may be considerably more sensitive than US EPA aquatic criteria indicate when they are exposed to ammonia/um in combination with other stressors including elevated water temperature, food limitation, and exposure to other contaminants or when actively swimming (Eddy 2005).

Ammonia and ammonium exist in equilibrium in water according to the equation: $NH_4^+ \leftrightarrow NH_3 + H^+$. Ammonia is more acutely toxic to fish and invertebrates than ammonium. High concentrations of ammonia in water reduce or reverse diffusive gradients and cause a buildup of ammonia on the gills of fish and invertebrates, which, under normal ambient conditions, act to diffuse endogenously-produced ammonia (US EPA 1999). Ammonium is also toxic to fish and invertebrates under certain conditions. As a result, the 1999 US EPA criteria for ammonia/um concentrations were established in terms of total ammonia (NH_3+NH_4^+). The ammonia/um equilibrium and, therefore, the toxicity of ammonia/um, depend heavily on pH (Warren 1964) and temperature (US EPA 1999); when pH is higher or temperature is lower, ammonia/um toxicity is greater. The effect of pH on toxicity is higher than that of temperature. The ionic composition of water can also be a determinant of toxicity, but these effects are poorly understood and, therefore, were not included in the 1999 EPA criteria. Toxicity varies by species. Fathead minnows are used by the SRCSD and other dischargers in accordance with their NPDES permits due to their high sensitivity to ammonia/um. However, delta smelt and salmonids can be >5 times more acutely sensitive to ammonia/um than fathead minnows (Werner et al. 2009). Werner et al. (2008b) found that water samples near the Sacramento WWTP effluent reduced 4-day larval delta smelt survival in 2006, but did not affect survival even after 7 days in 2007, and concentrations of ammonia/um in water samples were below US EPA effect concentrations (e.g., LC_{50}). A comprehensive monitoring and research plan is needed to determine acute and chronic toxicity to all covered fish species of ammonia/um and other constituents in the water column.

Ammonia/um is hypothesized to indirectly affect covered fish species by disrupting the food web via at least three mechanisms. First, elevated concentrations of ammonium ion can limit the quantity of food to covered species by disrupting the uptake of nitrate (NO_3) by phytoplankton, leading to suppression of plant growth (Conway 1977, Cochlan and Harrison 1991, Dugdale et al. 2007, Appendix X, *DRERIP Evaluations*). Phytoplankton form the base of the food web from which much of the food energy for the Delta ecosystem is derived (Jassby and Cloern 2000). The phytoplankton community in the Delta and Suisun Bay has shifted over the past few decades from dominated by diatoms to dominated by green algae, blue-green algae (cyanobacteria), and flagellates (Lehman 2000). Diatoms are larger phytoplankton with higher growth rates that thrive in high nitrate conditions in San Francisco Bay (Wilkerson et al. 2006) and are believed to be an important pathway of productivity to higher levels of the food web (Jassby and Cloern 2000). As a result, a reduction in diatoms could lead to lower zooplankton abundance or a shift in zooplankton community composition, although changes in productivity could be masked by concomitant changes in Corbula grazing depending on the location in the Delta and Suisun Bay. Decreased zooplankton abundance could lead to a lower food base for covered pelagic fish species, particularly delta and longfin smelt. Juvenile salmonids may also be affected by limited zooplankton abundance, although they primarily consume other organisms. The suppression of nitrate uptake by ammonium has been demonstrated previously in diatoms in oceanic waters (Dugdale and MacIsaac 1971, Dugdale and Hopkins 1978, Dugdale et al. 2006) and recently in San Francisco, San Pablo, and Suisun Bays during spring months (Wilkerson et al. 2006, Dugdale et al. 2007). Current studies are evaluating whether ammonium, in combination with other unknown factors, inhibits the uptake of nitrate by phytoplankton in the Delta (Dugdale 2008, Parker and Dugdale 2008). Pilot studies in 2007 and 2008 in the lower Sacramento at Rio Vista and San Joaquin Rivers found suppression of phytoplankton growth (Ballard et al. 2009). However, preliminary tests in 2008 using Sacramento River water from River Mile 44 (immediately downstream of the SRCSD discharge point) to Isleton did not find suppressed uptake of nitrate in phytoplankton despite high ammonium concentrations, although nitrate concentrations were low during the testing period (Parker and Dugdale 2008). More research is needed to determine whether and to what extent ammonium-driven suppression of diatom nitrate uptake and growth is occurring in the Delta.

Second, ammonia/um may have toxic effects to invertebrates that are prey items for covered fish species that are similar to those that fish may experience (see Appendix X, *DRERIP Evaluations*). If food is limiting to delta and/or longfin smelt, a reduction in the abundance of prey could reduce the abundance of these fish species. *Hyalella azteca*, a resident amphipod in the Delta, was the most sensitive invertebrate species to ammonia/um evaluated for the 1999 US EPA criteria. However, aside from a family of mussels that are not found in the San Francisco Estuary, invertebrates are generally less acutely sensitive to ammonia/um than fish. A recent pilot study suggests that, in combination with other chemicals (i.e., pesticides), ammonia at elevated levels may reduce the survival of prey species for delta smelt and longfin smelt, *Eurytemora affinis,* although no conclusive evidence was found to support this (Teh et al. 2008). Clearly, more research is needed to determine whether this mechanism may be occurring in the Delta and Suisun Bay. Juvenile salmonids may also be affected by limited zooplankton abundance, although they primarily consume other organisms.

Third, high concentrations of ammonium ion may promote blooms of harmful cyanobacteria, *Microcystis aeruginosa*, which produce microcystins that are toxic to covered fish species (see Appendix X, *DRERIP Evaluations*). High ammonium concentrations relative to phosphorus concentrations have been demonstrated to promote cyanobacteria blooms in other parts of the world (Michigan lakes: Ward & Wetzel 1980; Sweden: Gahnström et al. 1993). Lehman (2008) found that Microcystis cell density in the Delta correlated best with low flows and high water temperature and secondarily with nutrient concentrations and ratios; however, nutrient concentrations throughout the water column during the study were always at least an order of magnitude higher than limiting levels. Further, Lehman (2008) indicated that the Microcystis bloom she documented in 2004 "probably did not cause acute toxicity to aquatic food web organisms in the San Francisco Estuary" (p. 201), although no conclusive evidence was found to support this. However, laboratory studies do indicate that *Pseudodiaptomus forbesi* is particularly sensitive to *M. aeruginosa* even when it accounts for only a small percent of the food available and even when there is no toxin present (Ger and Teh 2008). Because microcystins were found in low concentrations in Corbula tissue, Lehman (2008) concluded that the clam may have the ability to selectively reject Microcystis colonies during feeding, similar to zebra mussels in the Great Lakes (Vanderploeg et al. 2001). If true, Corbula may release Microcystis from competition with other phytoplankton that are consumed by Corbula. Further research is needed to verify or reject these potential mechanisms that could negatively affect covered fish species.

Adaptive Management Considerations. If effluent-derived ammonia and ammonium ion are found to have adverse effects on covered fish species and Phase 3 of the conservation measure is implemented, the BDCP Implementing Entity would coordinate with local sanitation districts needing modification to develop adaptive management and monitoring plans for assessing effectiveness of the proposed conservation measures. The adaptive management plan would identify the range of adaptive management responses appropriate to proposed ammonia/um-reduction conservation measures and the process for adaptively adjusting implementation based on monitoring results. If results of monitoring of ammonia/um effects on the covered fish species and their food base indicate that ammonia/um reduction efforts have not been sufficient to significantly reduce adverse effects, treatment actions would be modified to be more effective through the adaptive management process. This effort would not substitute for any of the requirements prescribed by the RWQCBs through permits or other regulatory authorities.

OSCM2. Determine whether endocrine disrupting compounds have adverse direct and/or indirect effects on BDCP covered species and, if adverse effects are found, assist wastewater treatment plants in identifying funding sources to reduce the load of endocrine disrupting compounds in effluent discharges. In coordination with sanitation districts that discharge wastewater into or just upstream of waterways within the Delta and Suisun Bay (hereafter, "local sanitation districts") and the Central Valley Regional Water Quality Control Board (CVRWQCB), evaluate the need and, if demonstrated to be necessary to protect covered fish species, improve treatment processes at wastewater treatment facilities to reduce loads of endocrine disrupting compounds (EDCs) into the Delta and Suisun Bay.[1] The BDCP

[1] Other likely sources of EDCs to Delta waterways include pesticides and other contaminants in agricultural and urban runoff. These sources are addressed in OSCM4 and OSCM5.

Implementing Entity will work closely with local sanitation districts and the CVRWQCB in evaluating ongoing research and funding additional research to determine the effects of effluent-derived EDCs on covered species. If scientific findings identify adverse effects on covered species, the BDCP Implementing Entity, local sanitation districts, and the CVRWQCB will work together to determine the appropriate conservation measures to reduce the load of EDCs in the discharge to below levels necessary to protect covered species. The BDCP Implementing Entity will assist local sanitation districts in identifying sources of funding for these conservation measures.

This conservation measure will be comprised of three phases; implementation of Phases 2 and 3 would be contingent upon the outcome of the previous phase. During Phase 1, the BDCP Implementing Entity would convene EDC and water quality experts to review current research on whether or not the discharges of EDCs from local sanitation districts have adverse direct or indirect effects on covered fish species. A workshop with these participants will be conducted within 2 years of BDCP Implementation to evaluate existing information on EDCs, identify data and science gaps, evaluate the contribution of sources of EDCs in the Delta that come from wastewater effluent, and determine what, if any, research is necessary to determine the effects of discharged EDCs from local sanitation districts on covered fish species. The workshop would include individuals from the BDCP Implementing Entity, Fishery Agencies, local sanitation districts, RWQCBs, and other ECC and water quality experts.

During Phase 2, if workshop results in Phase 1 indicate that additional research is warranted, the BDCP Implementing Entity, in coordination with Fishery Agencies, CVRWQCB, and local sanitation districts, will develop additional research needs and fund or identify funding sources to evaluate the types and levels of effects of discharged EDCs from local sanitation districts on covered fish species at a funding level of up to $_____ over 3 years. If workshop results from Phase 1 indicate that there is insufficient evidence that discharges of EDC effluent from local sanitation districts adversely affect covered fish species, the BDCP will discontinue efforts with local sanitation districts to develop and funding or identify funding for additional research and develop EDC reduction actions. In this case, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

During Phase 3, if research results indicate that discharges of EDCs from local sanitation districts have adverse effects on covered fish species (Phase 2), the BDCP Implementing Entity will work jointly with each local sanitation district and appropriate state and federal entities to identify sources of funding to develop and implement actions that would eliminate or minimize adverse effects of EDCs on covered fish species. Priority will be given to local sanitation districts whose effluent has the greatest impact to covered fish species. If research results from Phase 2 indicate that discharges of EDC effluent from local sanitation districts do not adversely affect covered fish species, the BDCP will discontinue efforts with local sanitation districts to develop EDC reduction actions and funding would be deobligated from this conservation measure and reallocated to augment funding for other effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process. If actions to address the discharge of EDCs are implemented, the BDCP Implementing Entity will also work jointly with local sanitation districts in reviewing covered fish species-response monitoring to assess the effectiveness of actions to eliminate or minimize the effects of EDCs on covered fish species.

The BDCP Implementing Entity will enter into binding Memoranda of Agreement (MOAs) or similar instruments with local sanitation districts that will describe respective roles and obligations for funding, conducting any additional research, finding additional sources of funding, and developing and implementing conservation measures as identified through the process described above. Elements of the MOAs will include:

- a description of specific activities that would be funded by BDCP;
- preparation of annual research work plans for BDCP funded activities;
- provisions for documenting work performed; and
- provisions for modifying or terminating the MOAs.

Problem Statement. Endocrine disrupting compounds are exogenous substances that can interfere with or eliminate natural endogenous hormones in body (Kavlock et al. 1996). There are currently no criteria defined by the US EPA for discharges of EDCs, although work is currently occurring to establish a set of policies for initial screening of EDCs (72 FR 70842).

Wastewater treatment plants can be large sources of EDCs (Sumpter and Jobling 1995, Chambers and Leiker 2006, Barber et al. 2007), although other sources exist, including pesticides (see OSCM4 for pesticide reduction actions). There are 23 wastewater treatment plants that discharge their effluent in or just upstream of the Delta and Suisun Bay (Table 3.8). Of these, 11 employ only primary and secondary treatments, currently releasing on average approximately 252 million gallons of effluent into the Delta and Suisun Bay waterways each day. If EDCs have adverse effects on fish in the Delta, these treatment processes may not be sufficient to remove EDCs to levels below which they have adverse effects on fish (Huang and Sedlak 2001, Campbell et al. 2006). Advanced treatment facilities have been shown to reduce EDCs by 30-85%, although reduction levels and efficiencies vary widely by treatment type and specific EDC (Hemming et al. 2004, Drewes et al. 2005, Gray and Sedlak 2005) and it is not currently known to what levels specific EDCs would need to be reduced to avoid effects to covered fish species.

Because natural endogenous endocrine chemicals (hormones) occur in extremely low concentrations in fish, it is thought that extremely low concentrations of exogenous endocrine disruptors could affect fish; however, the potency of exogenous EDCs is typically orders of magnitude lower than endogenous hormones (Pait and Nelson 2002).

Hypotheses. *[**Note to reviewers**: Because this conservation measure is contingent upon a necessary research component, it is not possible to identify clear hypothesized benefits of the conservation measure. Instead, a summary of potential effects of EDCs to covered fish species in the context of proposed research topics are described here.]*

Endocrine disruption has been observed in fish exposed to wastewater effluents throughout the world (Sumpter and Jobling 1995, Jobling et al. 1998, Pait and Nelson 2002, Chambers and Leiker 2006, Barber et al. 2007, Kidd et al. 2007). Because EDCs interfere or eliminate hormones receptors in fish, they may have significant effects on the development and health of fish, as well as on the ability of fish to reproduce successfully and have their progeny survive to reproduction (Pait and Nelson 2002, Falconer et al. 2006). Examples of effects of EDCs on fish include intersex fish (gonadal characteristics of both males and females, or "ovatestes") (Jobling et al. 1998), inhibition of gonadal growth and development (Jobling et al 1996), degeneration of gonadal tissue (Lye et al. 1998), presence of the egg yolk precursor, vitellogenin, in male fish (Panter et al. 1998), and behavioral modifications associated with reproductive competency (Barber et al 2007). Kidd et al. (2007) demonstrated that levels of synthetic estrogen similar to those found downstream of wastewater treatment plant discharges in Canada can cause a population level crash in exposed fish.

In Central Valley stream sampling, up to 38% of male fall-run Chinook salmon showed signs of endocrine disruption in the form of sex reversal (Williamson and May 2002), although this finding may have been an artifact of the test method rather than a true sex reversal of the fish (Williamson and May 2005). Riordan and Adam (2008) found endocrine disruption in male fathead minnows following in-situ exposures below the Sacramento wastewater treatment plant. A high level of incidence (100%) of vitellogenin was found recently in male splittail in Suisun Slough and its tributaries (C. Johnson pers. comm.). Lavado et al. (2009) reported estrogenic activity in the Delta and Carquinez Strait near Benicia. In 2005, a low level (6%) of adult delta smelt males showed evidence of endocrine disruption (Bennett et al. 2008), although the identity and source of the EDCs causing this effect are not known. While population level effects to fish are possible following low level exposures (Kidd et al. 2007), there are few data on ambient levels of EDCs in the Delta. In addition, effects are often observed at levels at or below the detection level for many of the EDCs (Huang and Sedlack 2001). Overall, there is a paucity of data specific to the Delta indicating whether EDCs have adverse effects to covered fish species (see Appendix X, *DRERIP Evaluations*).

There is limited information that EDCs can affect invertebrates (Oetken et al. 2004), such as zooplankton, suggesting that they could indirectly affect covered fish species through food limitation (see Appendix X, *DRERIP Evaluations*). Dussault et al. (2008) found endocrine disruption in amphipods and midges exposed to triclosan and carbamazepine, but not when exposed to atorvastatin and ethinylestradiol. Werner and Moran (2008) found that chronic exposure to cypermethrin causes negative effects on reproductive parameters in mysid shrimp. Conversely, Kidd et al. (2007) found no effects of EDCs to lower trophic levels and food web in whole lake exposures.

Adaptive Management Considerations. If EDCs discharged from local sanitation districts are found to have adverse effects on covered fish species in the Delta, the BDCP Implementing Entity would coordinate with local sanitation districts needing modification to develop adaptive management and monitoring plans for assessing effectiveness of the proposed conservation measures. Adaptive management plans would identify the range of adaptive management responses appropriate to proposed EDC-reduction conservation measures and the process for adaptively adjusting implementation based on monitoring results. This effort would not substitute for any of the requirements prescribed by the CVRWQCB through permits or other regulatory authorities.

OSCM3. Reduce the Load of Methylmercury Entering Delta Waterways. The BDCP Implementing Entity will provide $____ in funding over the term of the BDCP to DWR and the

Central Valley Regional Water Quality Control Board (CVRWQCB) to reduce the load of methylmercury entering the Delta and in-Delta sources in conformance with CVRWQCB's Draft Total Maximum Daily Load (TMDL)[2] . Funding provided under this conservation measure will support staff salaries and/or fund specific actions to reduce these sources (e.g., Cache Creek Settling Basin efficiency improvements). Actions that will be supported, in coordination with DWR and CVRWQCB, include:

1. increasing the mercury-trapping capacity of the Cache Creek settling basin by any one or combination of the following:
    a. expansion of the areal extent of the Cache Creek settling basin to increase residence time of water flows and opportunity for settling of mercury-laden sediment. This expansion was estimated to cost $14.7-17.6 million (2007 dollars) (Wood et al. 2008);
    b. raising the existing weir to improve mercury and sediment trapping efficiency. This action was estimated to cost $2.8-6.0 million (2007 dollars) (Wood et al. 2008); and
    c. annual extraction of 100,000 to 630,000 cubic yards of accumulated sediment to extend the working life of the Cache Creek settling basin. This action was estimated to cost $600,000 to $7.56 million annually (2007 dollars) (Wood et al. 2008).

    The Cache Creek drainage basin is a small portion (~4%) of the area drained by the Sacramento River, but can contribute up to 50% of the total annual mercury load of the Sacramento River (Foe and Croyle 1999 in Domagalski et al. 2004);
2. remediating inorganic mercury sources upstream of the Delta, particularly mercury and gold mines; and
3. working with CVRWQCB to identify and implement most promising management practices for other sources of methylmercury.

In addition, the BDCP Implementing Entity will minimize to the extent practicable any increase in mercury methylation associated with habitat restoration conservation measures through the design and implementation of restoration projects (see Section 3.4.2).

The BDCP Implementing Entity will enter into a Memorandum of Agreement (MOA) or similar binding instrument with DWR, CVRWQCB and/or other third parties as described under Section 3.4.3.1.

Problem Statement. High concentrations of methylmercury in the Delta causes adverse effects to BDCP covered fish and wildlife species. Methylmercury, the bioavailable and toxic form of mercury, bioaccumulates within an individual and biomagnifies up the food chain, causing an increase in the manifested effects. Fish are exposed to methylmercury primarily through consumption, and secondarily through direct exposure to high concentrations in the water column, although the latter is substantially lower than the

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[2] The Central Valley Regional Water Quality Control Board has released a Draft Sacramento-San Joaquin Delta TMDL for Methylmercury (CVRWQCB 2008). The Draft TMDL calls for a 50% reduction of methylmercury entering the Delta, sources of which include tributaries from upstream watersheds and within-Delta sources, municipal and industrial wastewater, agricultural drainage, and urban runoff. The largest sources of methylmercury to the Delta are flux from wetland and open water sediments within the Delta and Yolo Bypass (~35% of total load) and upstream tributaries (~58% of total load). The Draft TMDL recommends total mercury load reductions from the Feather River, Cache Creek, Putah Creek, and American River watersheds.

former (Alpers et al. 2008). Effects of dietary methylmercury on fish include, but are not limited to, endocrine and reproductive problems (Friedmann et al. 2002, Hammerschmidt et al. 2002), liver necrosis (de Oliveira Ribeiro et al. 2002), brain lesions (Berntssen et al. 2003), and altered behavior that can result in an increase risk of predation (Webber and Haines 2003).

There is limited available evidence regarding the extent to which covered species in the Delta are directly affected by acute or chronic exposure to methylmercury, and it is unknown to what extent changes in hydrology (with operation of an isolated conveyance facility) would affect methylation of mercury (see Appendix X, *DRERIP Evaluations*). The reproductive potential in white sturgeon can be limited by exposure to methylmercury (Webb et al. 2006a). Also, Pacific lamprey ammocoetes can absorb methylmercury at high rates relative to other species (Bettaso and Goodman 2008), although effects on the species is unknown. Methylmercury effects have also been demonstrated in other species that reside in the Delta, such as fathead minnows (Devlin and Clary 1998, Hammerschmidt et al. 2002, Devlin 2006, Sandheinrich and Miller 2006,) and golden shiners (Webber and Haines 2003).

Adverse effects of exposure to methylmercury have been observed in species that are closely related to covered species. Hara et al. (1976) found reduced olfactory performance in rainbow trout (*Salmo gairdneri*). Further, Berntssen et al. (2003) found that Atlantic salmon (*Salmo salar*) exposed to several levels of methylmercury had numerous sublethal internal effects, although there were no signs of mortality or reduced growth.

High concentrations of methylmercury also have negative effects on birds and terrestrial wildlife (Wolfe et al. 1998). Deleterious effects on bird species from methylmercury consumption include reproductive impairment and juvenile survival (Heinz 1979, Evers et al. 2004, Albers et al. 2007, Ackerman et al. 2008). Effects on mammals from methylmercury consumption include anorexia, ataxia, and death (Wren et al. 1987, O'Connor and Nielsen 1981).

Another major concern of methylmercury involves human health. An estimated 10,000 to 20,000 fishermen in the Delta and their families are presently eating fish that are at more than ten times the recommended methylmercury reference dose, the US EPA's maximum acceptable oral dose of a toxic substance (see Appendix X, *DRERIP Evaluations*). Effects on humans from methylmercury consumption include loss of coordination, slurred speech, and mental disturbances (Bakir et al. 1973, Marsh 1987). Methylmercury toxicity in developing human fetuses can result in cerebral palsy and/or mental retardation (Harada 1978, Marsh et al. 1980 and 1987, Matsumoto et al. 1964, Snyder 1971). The Office of Environmental Health Hazard Assessment has published health advisories urging limited human consumption of black basses for multiple Delta waterways (see http://www.oehha.ca.gov/).

Hypotheses. The level of inorganic mercury in channel sediment is an important factor in determining methylmercury production, and methylmercury concentrations in the water column (attached to phytoplankton) affect biomagnification of methylmercury up the food chain (Bloom et al. 2003, Heim et al. 2007, Appendix X, *DRERIP Evaluations*). Reducing the load of mercury, and therefore methylmercury, entering Delta waterways is hypothesized to provide benefits to a number of fish species, the Delta ecosystem, and human health. Specifically, this conservation measure is hypothesized to:

- Reduce fish exposure to methylmercury in Delta waterways;
- Reduce deleterious side effects of dietary methylmercury on fish in the Delta waterways;
- Potentially reduce effects of methylmercury exposure on the reproductive potential of white sturgeon; and
- Reduce exposure of BDCP terrestrial covered species to methylmercury.

Adaptive Management Considerations. The BDCP Implementing Entity will coordinate with the CVRWQCB to adjust methylmercury reduction strategies and funding levels through the BDCP adaptive management decision making process as appropriate based on results of effectiveness monitoring and review of CVRWQCB monitoring and other relevant reports. The BDCP Implementing Entity would use results of effectiveness monitoring to determine whether reducing methylmercury loads results in measurable benefits to covered fish species and to identify adjustments to funding levels, control methods, or other related aspects of the program that would improve the biological effectiveness of the program. Such changes would be effected through the BDCP adaptive management process and would be included in the subsequent annual work plans.

If results of monitoring indicate that reducing methylmercury loads does not substantially benefit covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process. If results of monitoring indicate that BDCP habitat restoration activities increase loads of methylmercury in the Delta, this conservation measure will not be terminated and may be amended to include additional activities to mitigate any increase in loads of methylmercury attributable to restoration of BDCP habitats.

OSCM4. Reduce the Load of Agricultural Pesticides and Herbicides Entering Delta Waterways from In-Delta Sources that are Believed to be Toxic to Covered Fish Species and the Food Organisms Upon Which They Depend. The BDCP Implementing Entity will reduce the load of pesticides and herbicides entering Delta waterways from in-Delta sources by implementing two related actions: (1) support efforts by the Central Valley Regional Water Quality Control Board (CVRWQCB) under its Irrigated Lands Regulatory Program to reduce inputs of toxics from agricultural return flows into the Delta, and (2) fund conservation easements, cost-sharing programs, and provide other positive incentives to groups of farmers, large individual farmers, reclamation districts, and irrigation/drainage districts to develop targeted voluntary agricultural chemical management plans or other actions to reduce the amounts of pesticides and herbicides reaching Delta waterways. The estimated cost to implement this measure is $___ annually in 20__ dollars. This conservation measure seeks to work with and through the existing regulatory mechanisms of the CVRWQCB and other authorities and through voluntary cooperative programs in order to achieve the expected benefits for covered species and other water quality benefits.

Action 1: The BDCP Implementing Entity will support efforts by the CVRWQCB under its Irrigated Lands Regulatory Program to reduce inputs of toxics from agricultural return flows into the Delta to levels at which they are not toxic to covered fish species by 20__. The estimated cost to implement this action is $1,000,000 annually in 2009 dollars over the term of the BDCP (K. Larsen, pers. comm.). The Irrigated Lands Regulatory Program regulates dischargers of irrigation water and storm water from irrigated lands under a waiver of waste discharge requirements. Under current regulations, waivers must be conditional, enforceable, and include monitoring to ensure compliance with these conditions. Dischargers must either join an established coalition group or obtain regulatory coverage as an individual discharger. Coalition groups collect fees to monitor and report water quality in discharges and to implement management plans when water quality problems are identified. This conservation measure will support the Irrigated Lands Regulatory Program by enhancing CVRWQCB's compliance, enforcement, and outreach activities under existing regulations and supporting similar efforts conducted by the County Agricultural Commissioners with jurisdiction in the Delta. The purpose of this action is to support the implementation of the Irrigated Lands Regulatory Program by the CVRWQCB.

Action 2: The BDCP Implementing Entity will develop pesticide-reduction plans in coordination with area farmers, coalitions, the CVRWQCB and the Department of Pesticide Regulation. Elements of the plans may include: the funding of conservation easements and cost-sharing programs; and the provision of positive financial incentives to groups of farmers, large individual farmers, reclamation districts, and irrigation/drainage districts to develop voluntary agricultural chemical management actions. The estimated cost is $__ in 20__ dollars over the term of the BDCP to reduce the amounts of pesticides and herbicides reaching Delta waterways. It is anticipated that this funding level will reduce inputs of pesticides that pose risks to covered species or their habitats in discharged water from 548,000 acres of farmland (K. Larsen, pers. comm.). Funded actions could include:

- Changing pesticides and herbicides used to less toxic compounds to aquatic species and provide education on proper use;
- Reducing amounts of pesticides and herbicides used through more direct application methods such as ground-based target-sensing spray systems, or implementation of integrated pest management techniques;
- Supporting partnerships between research universities, the California Farm Bureau Federation, farmer coalitions, the California Department of Pesticide Regulation, and other interested agencies and organizations for exchange of newly acquired information regarding pesticides and other aspects of integrated pest management;
- Reducing concentrations of pesticides and herbicides in return flows to Delta waterways through specific management practices such as development of vegetated buffer strips between agricultural fields and waterways;
- Creating an online database for Delta farmers to use to coordinate applications of pesticides with the goal of reducing the co-occurrence of pesticides in runoff flows to Delta waterways that are known to have additive toxic effects when combined;

- Reducing return flows from agricultural fields to the Delta by using water-efficient technologies (e.g., drip irrigation) (K. Fisher pers. comm.); and
- Reducing wind drift of pesticides and herbicides into Delta waterways through the use of ground-based direct application methods described above and establishment of perennial cover crops between orchard and vineyard rows for dust reduction.

To accomplish Action 1, the BDCP Implementing Entity will enter into a binding Memorandum of Agreement (MOA) or similar instrument with the CVRWQCB as described in Section 3.4.3.1. The BDCP Implementing Entity or another entity as identified in the MOA will be responsible for monitoring the effectiveness of agricultural contaminant reduction activities in reducing loadings and benefiting covered fish species. If the Irrigated Lands Regulatory Program were to be revised in the future by CVRWQCB in such a way that the BDCP Implementing Entity finds that the purposes of this measure will not be met, the BDCP will withdraw financial support and reallocate funds to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

To accomplish Action 2, the BDCP Implementing Entity will enter into binding agreements (e.g., conservation easements, contracts) with participating farmers, irrigation districts, and coalitions that specify specific actions that will be implemented by participants to receive BDCP funding. The BDCP Implementing Entity will coordinate with the Fishery Agencies, the CVRWQCB, and the Department of Pesticide Regulation to identify specific pesticides and herbicides to be targeted for reduction and a menu of measures that could be implemented that will cost-effectively reduce loads of targeted compounds. Elements of participant agreements will include:

- a description of specific BDCP funded activities to be implemented by participants;
- provisions for documenting compliance with the agreements;
- access to conduct BDCP effectiveness monitoring; and
- provisions for modifying or terminating participant agreements.

The BDCP Implementing Entity, in coordination with the Fishery Agencies and the CVRWQCB, will develop a pesticide and herbicide reduction monitoring program to assess the effectiveness of funded activities for reducing pesticide and herbicide loads in Delta waterways and providing benefits for covered fish species.

Problem Statement. Agricultural runoff has been identified as a source of pesticides and other chemical stressors of covered fish species that adversely affect aquatic biota (Werner et al. 2008, Werner and Oram 2008). Many Delta fish species go through early life stages in late winter and spring; a time when runoff from agricultural lands can carry dormant spray pesticides into the waterways, affecting these fish during their most sensitive life stage (see Appendix X, *DRERIP Evaluations*). Pesticides have known lethal and sublethal effects on fish species and direct impacts on invertebrates (Van Wijngaarden et al. 2005), which could serve as prey species for covered fish species. For example, Sacramento splittail larvae exhibited reduced survival and growth after exposure to orchard runoff samples (Teh et al. 2005). Additionally, some combinations of organophosphate pesticides are lethal to Pacific salmon at concentrations observed to be sublethal in single-chemical trials (Laetz et al. 2009). Pyrethroid pesticides are particularly toxic to the aquatic environment (Werner and Oram 2008), and the use of pyrethroid pesticides in the Sacramento-San Joaquin Valley has increased steadily since the early 1990s (Resources Agency 2007). In addition, metals such as copper are used as pesticides in the Delta. Juvenile Chinook salmon susceptibility to infectious hematopoietic necrosis virus (IHNV) is increased by sublethal concentrations of copper (Hetrick et al. 1979).

Hypotheses. Reducing the load of pesticides and herbicides entering Delta waterways is hypothesized to provide benefits to covered fish species through the following mechanisms:

1. Reducing direct mortality of splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races) from pesticides. A 2008 NMFS biological opinion concerning pesticides indicated that re-registration of pesticides containing chlorpyrifos, diazinon, and malathion is likely to jeopardize the continued existence of winter-run and spring-run Chinook salmon and Central Valley steelhead (NMFS 2008). Saiki et al. (1992) found that undiluted agricultural drainwater from the San Joaquin River watershed was acutely toxic to juvenile Chinook salmon.
2. Reducing sublethal effects (behavior, tissue/organ damage, reproduction, growth, and immune) of pesticides on splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races). Zelikoff et al. (1998) found that exposure to the pyrethroid permethrin reduced disease resistance in fish. The susceptibility of juvenile Chinook salmon and rainbow trout to infectious hematopoietic necrosis virus was dramatically increased when exposed to sublethal concentrations of copper (Hetrick et al. 1979) and esfenvalerate (Clifford et al. 2005). Dinoseb, diazinon, and esfenvalerate cause significant metabolic disruption in early life stages of Chinook salmon (Viant et al. 2006). Hecht et al (2007) observed that dissolved copper causes a loss of sensory function in Chinook salmon, steelhead, and other salmonids that is thought to cause disruption in migration and predator detection.
3. Increasing food abundance and quality for splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races) by reducing food web disruption. Although pesticides and herbicides are effective at eliminating weeds and pests on agricultural crops, they are also highly toxic to plants and animals in the aquatic environment, particularly to crustaceans, which are closely related to insects (Weston et al. 2005). Amweg et al. (2006) found pyrethroid concentrations at toxic levels to *Hyallela azteca* in many agriculture-dominated waterbodies in the Central Valley. All these covered fish species consume crustaceans (e.g., copepods, amphipods, mysid shrimp) in the Delta or downstream bays for at least part of their lives. In addition, copper has been shown to reduce algal growth (Stoiber et al. 2007), which could, in turn, limit zooplankton growth.

Adaptive Management Considerations. For Action 1, the Implementing Entity will work closely with and through the CVRWQCB to adjust the Irrigated Lands Regulatory Program contaminant reduction strategies and funding levels through the BDCP adaptive management process as appropriate based on results of performance monitoring and review of CVRWQCB monitoring and other relevant reports. The BDCP Implementing Entity will use results of effectiveness monitoring to determine if reducing pesticide and herbicide loads results in measurable benefits to covered fish species and to identify adjustments to funding levels, control methods, or other related aspects of the program that will improve the biological effectiveness of the program. Such changes, once approved through the adaptive management decision making process, will be effected through subsequent annual work plans. If results of monitoring indicate that reducing pesticide and herbicide loads does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate this conservation measure. If terminated, remaining funding will be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

For Action 2, the Implementing Entity will complete performance monitoring to determine the performance of participating farmers/farmer groups in reducing loads of targeted pesticides and herbicides. Based on effectiveness monitoring results and ongoing reviews of relevant research[3] related to the effects of pesticides and herbicides on covered fish species and food production and abundance, the Implementing Entity may adjust activities for which cost sharing is provided to participating farmers through the BDCP adaptive management process. For example, if results of future research indicates that specific pesticides and herbicides do not measurably adversely affect covered fish species, funding for programs to reduce loads of those pesticides and herbicides will be discontinued and redirected through the BDCP adaptive management process to increase funding for reduction of pesticides and herbicides that are shown to be harmful to covered fish species.

The BDCP Implementing Entity in coordination with the Fishery Agencies may discontinue effectiveness monitoring for both of the actions in future years if monitoring results indicate a strong correlation between reduction in pesticide and herbicide loads entering the Delta and responses of covered fish species.

OSCM5. Reduce the Loads of Toxic Contaminants in Stormwater and Urban Runoff by Working with Existing Efforts in the Delta. The BDCP Implementing Entity will provide $____ (20__ dollars) in funding to the Sacramento Stormwater Quality Partnership, and/or counties and cities whose stormwater contributes to Delta waterways (hereafter "stormwater entities") under National Pollutant Discharge Elimination System (NPDES) MS4 stormwater permits to implement actions from and in addition to their respective stormwater management plans. Actions in addition to those in existing plans/programs will be implemented if they are expected to benefit covered species.

Potential types of actions that could be funded under this measure include, but are not limited to:

3 On July 1, 2009 the EPA made available for comment a proposed Stipulated Injunction that would establish a series of deadlines for the Agency to make ``effects determinations'' and initiate consultation, as appropriate, with the FWS in connection with 74 pesticides and 11 species listed under the ESA as either endangered or threatened (including delta smelt) (http://www.epa.gov/fedrgstr/EPA-PEST/2009/July/Day-01/p15531.htm). By way of background, on May 30, 2007, the Center for Biological Diversity filed a lawsuit in the Federal District Court for the Northern District of California alleging that EPA failed to comply with 16 U.S.C. 1531-1544 in regard to 47 pesticides and 11 species that are listed as endangered or threatened under the ESA (Center for Biological Diversity v. EPA, No. C 07-02794 JCS (N.D. Cal.)); ultimately, 74 pesticides came to be at issue in the case (http://www.epa.gov/fedrgstr/EPA-PEST/2009/July/Day-01/p15531.htm). The Stipulated Injunction would (with some exceptions) enjoin, vacate and set aside EPA's authorization of use of the pesticides in and adjacent to certain habitat features associated with each of the 11 species in specific geographic areas within eight California counties including Alameda, Contra Costa, Marin, Napa, San Mateo, Santa Clara, Solano, and Sonoma (http://www.epa.gov/fedrgstr/EPA-PEST/2009/July/Day-01/p15531.htm).

- construction of retention/irrigation holding ponds for the capture and irrigation use of stormwater;
- design and establishment of vegetated buffer strips to slow runoff velocities and capture sediments and other pollutants;
- design and construction of bioretention systems (grass buffer strips, sand bed, ponding area, mulch layer, planting soil, and plants) to slow runoff velocities and for removal of pollutants from stormwater;
- construction of stormwater curb extensions adjacent to existing commercial businesses that are likely to contribute oil and grease runoff;
- establishment of stormwater media filters to remove particulates and pollutants, such as that located at the American Legion Park Pump Station in Stockton;
- provisioning of funds for moisture monitors to be installed during construction of sprinkler systems at commercial sites that will eliminate watering when unnecessary; and
- providing support for establishment of on-site infiltration systems in lieu of new storm drain connections for new construction, such as pervious pavement in place of asphalt and concrete in parking lots and along roadways, and downspout disconnections to redirect roof water to beds of vegetation or cisterns on existing developed properties, including residential.

The BDCP Implementing Entity will enter into binding Memoranda of Agreement (MOAs) or similar instruments with stormwater entities as described in Section 3.4.3.1. Individual stormwater entities will be responsible for conducting the monitoring necessary to assess the effectiveness of BDCP supported elements of their stormwater management plans. The BDCP Implementing Entity, in coordination with the Fishery Agencies, will be responsible for determining the effectiveness of stormwater pollution load reduction activities in achieving covered fish species benefits.

Problem Statement. Stormwater runoff has been identified as the leading source of water pollution in the United States (Lee et al. 2007) and is thought to be a large contributor to toxic loads present in the Delta (Weston et al. 2005, Amweg et al. 2006, Werner et al. 2008a). Fish kills of threadfin shad have been observed by the California Department of Fish and Game in the San Joaquin River following the first major storm of the season (see Appendix X, *DRERIP Evaluations*). As stormwater runoff returns to the Delta, it accumulates sediment, oil and grease, pesticides, and many other toxic chemicals. Unlike sewage, stormwater is not treated by stormwater agencies before entering the Delta; and despite existing stormwater regulations, many pollutants enter Delta waterways. Of particular concern for fish species is the overuse of pesticides, some of which can have deleterious effects on the aquatic food chain (Weston et al. 2005, Teh et al. 2008, Appendix X, *DRERIP Evaluations*). Regulation of and reductions in stormwater runoff are ongoing (EPA 1993).

All major urban centers in the Delta, including Sacramento, Stockton, and Tracy, and multiple smaller cities are under National Pollutant Discharge Elimination System (NPDES) MS4 permits to develop and implement a Storm Water Management Plan/Program with the goal of reducing the discharge of pollutants to the maximum extent practicable under Section 402(p) of the Clean Water Act. These permits require development and implementation of a Storm Water Management Plan/Program to meet this goal.

Hypotheses. Reducing the amount of pollution in stormwater runoff entering Delta waterways is hypothesized to provide benefits to fish species through the following mechanisms.

1. Reducing direct mortality of splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races) from contaminants. Weston et al. (2009) found that residential runoff is a larger source of pyrethroid pesticides than agricultural runoff. Pyrethroids are known to affect aquatic organisms in the Delta, including covered fish species and their food (Weston et al. 2005, Werner et al. 2008a) (see OSCM4 for more information).
2. Reducing sublethal effects (behavior, tissue/organ damage, reproduction, growth, and immune) of contaminants on splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races). Pyrethroids and other chemicals from urban and stormwater run-off can reduce the health of covered fish species. Suspended sediment in high concentration can impair respiration and reduce the growth rate of fish (e.g., Sutherland and Meyer 2007).
3. Increasing food abundance for splittail, delta and longfin smelt, green and white sturgeon, steelhead, and Chinook salmon (all races). Pesticides and herbicides can be highly toxic to invertebrates and phytoplankton (Amweg et al. 2006, Weston et al. 2005, Stoiber et al. 2007), which form the base of the food web or are important prey species for covered fish species. Further, suspended sediment is the primary attenuator of sunlight in the water column and thus can reduce photosynthesis in phytoplankton and submerged aquatic vegetation and affect fish behavior and health in the Delta (Schoelhammer et al. 2007).

DRERIP analysis results indicate that actions undertaken with this measure to reduce the amount of pollution in stormwater runoff entering Delta waterways will be of high benefit to delta smelt, white sturgeon, steelhead, and Chinook salmon (see Appendix X, *DRERIP Evaluations*).

Adaptive Management Considerations. The Implementing Entity will provide ongoing review of monitoring, progress, and other relevant reports from the stormwater entities related to the effectiveness the Program for reducing contaminant loads in stormwater runoff. The Implementing Entity will coordinate with the stormwater entities to adjust stormwater pollution reduction strategies and funding levels through the BDCP adaptive management process as appropriate based on review of results of effectiveness monitoring and stormwater agency monitoring and other relevant reports.

The BDCP Implementing Entity will use results of effectiveness monitoring to determine if reducing stormwater pollution loads results in measurable benefits to covered fish species and to identify adjustments to funding levels, control methods, or other related aspects of the program that will improve the biological effectiveness of the program. Such changes will be effected through the BDCP adaptive management process and will be included in the subsequent annual work plans.

If results of monitoring indicate that reducing stormwater pollution loads does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding will be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

The BDCP Implementing Entity in coordination with the Fishery Agencies may discontinue effectiveness monitoring for this measure in future years if monitoring results indicate a strong correlation between reduction in stormwater pollution loads entering the Delta and responses of covered fish species.

OSCM7. Maintain Dissolved Oxygen Levels Above Levels that Impair Covered Fish Species in the Stockton Deep Water Ship Channel during Periods when Covered Fish Species are Present. *[**Note to reviewers**: SAIC is currently in discussion with DWR regarding the results of their ongoing oxygen diffuser demonstration project. Due to the recent bond spending freeze, results of this demonstration study are not anticipated to be available in the near future. This conservation measure will be updated as new information becomes available].* The BDCP Implementing Entity will operate and maintain an oxygen diffuser(s) in the Stockton Deep Water Ship Channel to increase dissolved oxygen concentrations between Turner Cut and Stockton to meet Total Maximum Daily Load (TMDL) objectives established by the CVRWQCB (2005) (above 6.0 mg/L from September 1 through November 30 and above 5.0 mg/L at all times). The estimated cost of operations and maintenance for the diffuser is $_____ per year in 20__ dollars. The existing diffuser system will be modified as necessary and additional diffusers and associated infrastructure would be added to optimize oxygen delivery to the river, contingent upon results of an ongoing demonstration project conducted by DWR. Costs for this modification are $___ in 20__ dollars.

The BDCP Implementing Entity will be responsible for developing annual work plans in coordination with Fishery Agencies that specify the extent of dissolved oxygen improvements to be implemented and will be responsible for monitoring the effectiveness of dissolve oxygen enhancement measures in improving dissolved oxygen levels.

Problem Statement. The Stockton Deep Water Ship Channel has been identified as an impaired waterway by the State Water Resources Control Board because of low dissolved oxygen concentrations during late summer and early fall (CVRWQCB 2005). The combination of low flows, high loads of oxygen-demanding substances (algae from upstream, effluent from the City of Stockton Regional Wastewater Control Facility, and other unknown sources), and channel geometry contribute to low oxygen levels in the Stockton Deep Water Ship Channel (CVRWQCB 2005). The Stockton Deep Water Ship Channel often fails to meet water quality objectives established by the Regional Board for dissolved oxygen (CVRWQCB 2007b). The 12 mile low dissolved oxygen area of the ship channel creates a barrier for upstream migration of adult fall-run Chinook salmon and Central Valley steelhead on the mainstem of the San Joaquin River (Hallock et al. 1970). Further, low dissolved oxygen levels can cause physiological stress on and mortality of fish, including Chinook salmon and steelhead (Jassby and Van Nieuwenhuyse 2005), and other aquatic organisms (CVRWQCB 2007b). Once spring-run Chinook salmon are re-established in the San Joaquin River under the San Joaquin

River Litigation Settlement, dissolved oxygen sags in the Deep Water Ship Channel will likely have similar effects on this run if sags were to occur during their adult migration period (expected to be approximately March-September). In addition, juvenile white sturgeon, which rear in the San Joaquin River, exhibit reduced foraging and growth rates at dissolved oxygen saturation levels below 58% (= 5.8 mg/l at 15 °C) (Cech and Crocker 2002).

One potential solution to dissolved oxygen sags in the Stockton Deep Water Ship Channel, a dissolved oxygen aeration system, has been installed and is currently undergoing field testing by DWR. Limited analysis of 2008 results suggests that the diffuser was successful in delivering oxygen to the river. This oxygen aeration project has been funded with Proposition 13 money, which can only be used for demonstration purposes. Long-term funding for operations and maintenance has not yet been secured and there are currently no mandates by the CVRWQCB that require contributors to the cause to fund the project. Under this conservation measure, the BDCP would fund the long term O&M costs associated with the project.

Hypotheses. Increasing dissolved oxygen concentrations in the Stockton Deep Water Ship Channel in accordance with TMDL objectives is hypothesized to result in:

- Reduced delay and inhibition of upstream and downstream migration of fall-run Chinook salmon, steelhead, and, once they are re-established in the San Joaquin River, spring-run Chinook salmon (Hallock et al. 1970); and
- Reduced physical stress and mortality of fall-run Chinook salmon, steelhead, white sturgeon, and, once they are re-established in the San Joaquin River, spring-run Chinook salmon.

Adaptive Management Considerations. Results from monitoring of dissolved oxygen levels at various distances from the diffuser(s) will be used to assess the performance of the oxygen diffuser facilities and operations for achieving the TMDL. The BDCP Implementing Entity will use effectiveness monitoring results to determine whether oxygen diffuser operations result in measurable benefits to covered fish species.

Based on review of performance and effectiveness monitoring results, the BDCP Implementing Entity will adjust funding levels, oxygen diffuser methods, or other related aspects that will improve the performance and/or biological effectiveness of the program through the BDCP adaptive management process as appropriate. Such changes will be effected through the BDCP adaptive management process and would be included in the subsequent annual work plans.

If results indicate that oxygen diffuser facilities do not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding will be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

OSCM8. Improve the Quality of Water Discharged from Managed Seasonal Wetlands into Suisun Bay and Delta Waterways to Prevent Dissolved Oxygen Sags. *[Note to reviewers:*

Funding for the completion of research that will provide significant background information for this conservation measure is not currently available due to the state's bond funding freeze. More specifics will be added to the description of the measure as it becomes available] The BDCP Implementing Entity will coordinate with willing owners/managers of seasonal managed wetlands in the Delta and Suisun Marsh to improve quality of water released from these wetlands by implementing best management practices. The BDCP Implementing Entity will offer incentive funding of $___ over the term of the BDCP to land owners/managers to implement water management measures that are demonstrated through monitoring to reduce adverse effects on covered fish species habitat in adjacent channels. Specifically, the BDCP Implementing Entity will work with willing land owners/managers to:

1. Develop plans for best management practices designed to address discharge water effects on aquatic habitat;
2. Implement best management practices and modifications of drainage systems to allow for wetland management and discharges that minimize adverse effects on covered species; and
3. Acquire and install equipment necessary to implement revised seasonal wetland management and discharge (e.g., gates, siphons).

This conservation measure would allow the BDCP Implementing Entity to coordinate with owners and managers of managed seasonal wetlands to improve the water quality of effluent to benefit covered fish species by implementing best management practices. There are multiple land, water, and vegetation modifying activities that have been identified to reduce dissolved oxygen plumes and loads of biological oxygen demand and methylmercury into receiving waters in Suisun Marsh. These activities include ways to reduce the amount of organic material in and reduce the residence time of ponded water. The activities will be monitored and investigated for efficacy under a grant to Wetland and Water Resources, DWR, and others (C. Enright pers. comm.) once state bond funding is reinstated. This BDCP Implementing Entity will use the results of this study as guidance for formulating best management practices to implement. The estimated cost to implement this measure is $1,000,000 annually in 2009 dollars over the term of the BDCP.

Problem Statement. The Fall flood-up of managed seasonal wetlands typically consists of one or more complete flood and drainage cycles followed by consistent circulation throughout the winter flooded period (Enright & Siegel 2007). High levels of organic matter released from these diked wetlands stimulate microbial activity that consumes dissolved oxygen, resulting in low dissolved oxygen plumes in receiving waters that can kill covered species in Suisun Marsh and Suisun Bay. In addition, elevated concentrations of methylmercury have been associated with effluents from managed seasonal wetlands. Low dissolved oxygen conditions facilitate the methylation of mercury because the two microbial groups that methylate mercury, sulfate-reducing bacteria (Gilmour et al. 1992) and iron-reducing bacteria (Fleming et al. 2006, Kerin et al. 2006), are anaerobes (Alpers et al. 2008).

These areas are important rearing habitat to delta smelt, longfin smelt, splittail, sturgeon, and juvenile salmonids. With the large number of privately managed seasonal wetlands in Suisun Marsh contributing effluent to its channels connected to Suisun Bay, there is the potential for adverse effects on covered fish species.

Hypotheses. Implementing best management practices with willing land owners/managers is predicted to:

- Reduce the effects of methylmercury on covered species (see OSCM3);
- Reduce mortality associated with low dissolved oxygen on delta smelt, splittail, and salmonids that inhabit Suisun Marsh and Suisun Bay.

Adaptive Management Considerations. The BDCP Implementing Entity will monitor the effectiveness of participating diverters/managers in improving water quality and habitat use by covered fish species. The BDCP Implementing Entity will use results of this monitoring to determine whether the reduction of dissolved oxygen and methylmercury from seasonal wetlands results in measurable benefits to covered fish species and to identify adjustments to funding levels, methods, or other related aspects of the program that would improve the biological effectiveness of the program. Such changes, once approved through the adaptive management decision making process, will be effected through subsequent annual work plans. If results of monitoring indicate that this conservation measure does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate the conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

OSCM10. Reduce the Risk for Future Introductions of Non-Native Aquatic Organisms from Recreational Watercraft. The BDCP Implementing Entity will provide $______ in 20__ dollars over the term of the BDCP to support implementation of the following actions to reduce the risk of future introductions of non-native aquatic organisms from recreational watercraft:

1. Provide funding and support to the California Department of Food and Agriculture (CDFA) and DFG to operate __ additional recreational watercraft and trailer inspection stations and cleaning stations (hereafter, "spot check stations") on roads at California borders that currently do not have inspection stations to increase detection of aquatic invasive species. The estimated cost will be $___ in ____ dollars over the term of the BDCP. These spot check locations will assist in "sealing off" California from boats exiting the Colorado River, which is infested with quagga mussels. Spot check stations will be located, in order of priority, at: 1) Needles Highway southbound; 2) Highway 95 southbound at Arrowhead Junction; 3) State Route 95, southbound at Needles Bridge; 4) Havasu Lake Road near the west shore of Lake Havasu; 5) Highway 95 at Vidal Junction; 6) Agnes Wilson Bridge westbound; and 7) Highway 95 southbound north of Blythe (Figure 3.6) CDFA and DFG currently have inspection locations on 16 major roadways into California from Oregon, Nevada, and Arizona at which watercraft are inspected (CDFA 2009). These proposed locations receive equal to or fewer boats than existing permanent stations, although new permanent stations in these locations would not likely be cost-effective or necessary (R. Cline pers. comm.). Instead, semi-permanent inspection stations will be established and operated on busy boat traffic days. Monitoring data indicate that most boat traffic on these roads occurs from Saturday afternoon through Monday at noon, except holiday weekends during which the additional day also has boat traffic (R. Cline, pers. comm.). The start-up cost of each spot check station will be approximately $70,000 in 2009 dollars for a cleaning system, signage, trailers, laptops,

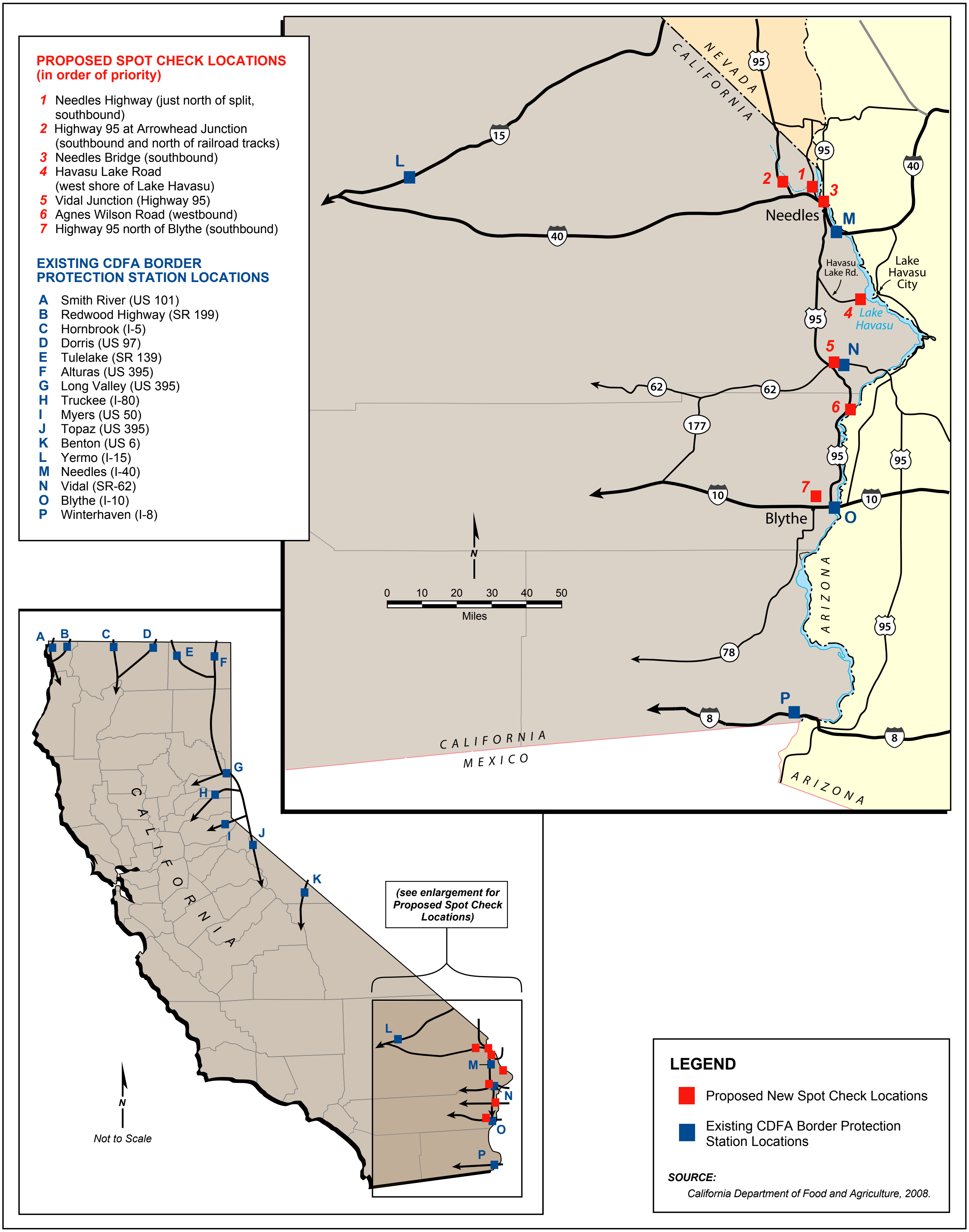

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Figure 3.6
Existing CDFA Border Protection Station Locations and Proposed New Spot Check Locations in California

water tanks, and other related equipment (R. Cline, pers. comm). Daily staffing costs for 24 hour operations will be approximately $1,000 plus monthly operations of $3,400 in 2009 dollars (R. Cline, pers. comm.). Each inspection station will be staffed by CDFA and/or DFG inspectors trained in the inspection of watercraft and trailers for aquatic organisms. Inspection stations will provide wash stations with sufficient abilities to kill aquatic invasive species on watercraft, trailers, and other equipment (see #2 below).

2. Provide wash stations with sufficient cleaning abilities to kill aquatic invasives on watercraft, trailers, and other equipment leaving water bodies within California that are infested with zebra or quagga mussels. The estimate cost will be $___ in ____ dollars over the term of the BDCP. To ensure that aquatic invasive species are killed, the wash station will provide high-pressure, hot water at a temperature of at least 140 °F (60 °C) to apply to the boat's hull, trailer, equipment, bilge, and any other exposed surfaces (DFG 2008). There are currently 19 water bodies infested with quagga mussels throughout Southern California and one water body infested with zebra mussels, San Justo Reservoir in San Benito County (Figure 3.7). Eight of these reservoirs are open to the public – El Capitan, Miramar, Murray, Lower Otay, San Vicente, Jennings, Ramona, and Skinner. Each of these has one boat ramp except Lake Ramona, which has two. The cost of each portable wash station is approximately $40,000-$60,000 in 2009 dollars (D. Norton, pers. comm). The total cost of providing wash stations, staff, and other equipment at all eight water bodies is approximately $600,000/year in 2009 dollars (D. Norton, pers. comm.). Lakes Mead, Havasu, and Mohave in the Colorado River have too many access points along with the Colorado River itself, to be able to provide a comprehensive set of wash stations.

   Wash stations will be strategically placed at boat ramps of each water body and owners will be encouraged to clean their watercraft and trailers upon leaving the water body. If other water bodies in California become infested with zebra or quagga mussels during the term of the BDCP, the BDCP Implementing Entity will provide funding of $___ in 20__ dollars over the term of the BDCP for additional wash stations.

3. Fund the DFG Invasive Species Program to improve Delta-specific outreach and education on the effects, prevention, and control of non-native species in the Delta. Estimated start-up costs will be approximately $___ the first ___ years and $___ per year in subsequent years in 20__ dollars over the term of the BDCP (J. Horenstein, pers. comm.).

   Funding will support the following specific actions:

   a. Add a half time position dedicated to the DFG Invasive Species Program that would: (1) develop and distribute printed material (posters, brochures, and articles) for specific industry sectors and user groups (such as boat charter operators, marinas, angling guides, fishing tournament organizers, bait shops, aquarium stores, and dredging contractors); (2) develop permanent interpretive displays at marinas, boat ramps, boat cleaning stations (see #2 above), and fishing sites; and (3) supervise two teams of one DFG scientific aide and one DFG fish and wildlife technician to educate boaters (see b below);

   b. Fund two teams of one scientific aide and one fish and wildlife technician to rove boat access areas throughout the Delta from March-November each year to educate

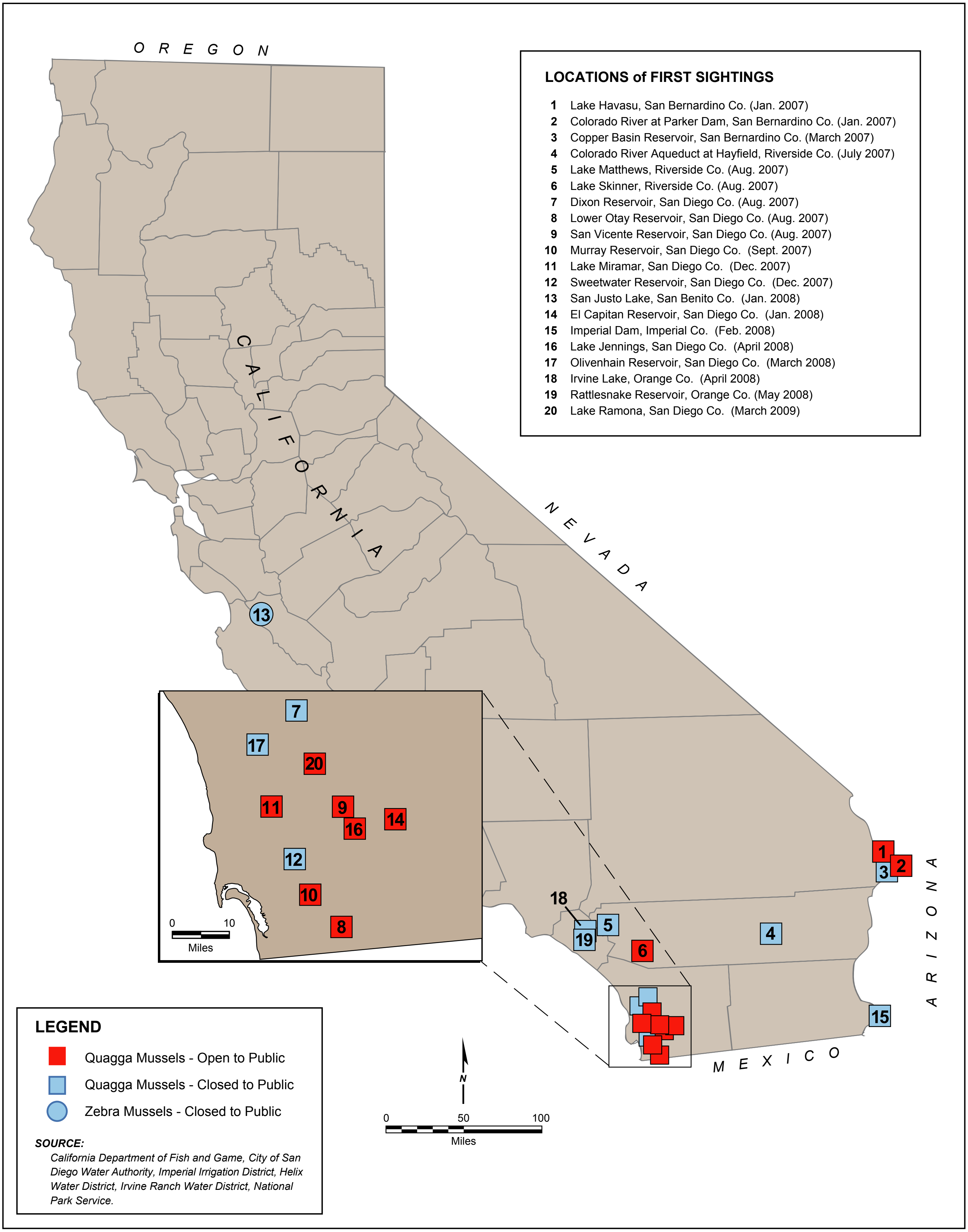

Figure 3.7
Infestations of Zebra and Quagga Mussels as of March 2009

boaters on the effects, prevention, and control of non-native species, inspect boats, demonstrate washing techniques for potentially infested watercraft, and provide information on other spread prevention resources; and

c. Provide two strategically-located portable wash stations in the Delta that teams conducting outreach (see b above) can use when they encounter potentially contaminated boats. Teams will transport wash stations to potentially decontaminated boats to these wash stations and demonstrate how to decontaminate their boat properly.

The BDCP Implementing Entity will enter into binding Memoranda of Agreement (MOAs), contracts, or other instruments as described in Section 3.4.3.1 with DFG, CDFA, and the managers of the water bodies with quagga/zebra mussel infestations to implement this conservation measure. Funded entities will be responsible for implementing the scopes of work and submitting reports as specified in the agreements that demonstrate that work plans are successfully implemented.

Problem Statement. A primary vector of local introductions of aquatic non-native species is recreational watercraft and trailers used to transport them (DFG 2008). Non-native species can become attached to the hulls and engines of watercraft or various parts of trailers or be transported in standing bilge water or live bait tanks. Since the invasion of quagga mussels into Southern California waterways in January 2007, the California Department of Food and Agriculture and DFG boat inspection efforts at California borders. However, many smaller border roads remain unregulated, increasing the risk of transporting aquatic invasive species from other states.

Because many aquatic invasives are already in water bodies within California, additional precautions could be taken to protect the Delta from introduction of aquatic invasives. An inspection program within the Delta is logistically very challenging and expensive due to the large number of watercraft entry points into the Delta (H. Gellerman, pers. comm.). However, reducing the likelihood that watercraft remain vectors of aquatic invasives after exiting one of the 19 infested water bodies in California could be easier to accomplish.

Many individuals do not realize the extent of threat that aquatic invasive species pose and how their own actions could lead to new introductions (CDFG 2008). Educating the public about the effects of non-native species on native species and ecosystems, their own equipment, and water conveyance facilities could reduce future intentional and unintentional introductions into the Delta and reduce the spread of existing non-native species in the Delta (CDFG 2008).

Hypotheses. Increasing inspection efforts of watercraft, trailers, and other equipment by trained experts is hypothesized to increase the identification and subsequent removal of non-natives from watercraft, trailers, and other equipment, thereby reducing the risk of introduction into the Delta

Providing wash stations for watercraft exiting water bodies in California that are infested with non-native species is hypothesized to reduce the number of watercraft carrying non-native aquatic species and, therefore, reduce the risk of future introductions into the Delta.

Funding a position to increase public outreach and education on the risks associated with non-native species and ways to reduce the likelihood that they may unintentionally or intentionally introduce non-native species into the Delta is hypothesized to reduce the risk of future non-native species introductions in the Delta.

As a result of reduced risk of introductions associated with these three actions, the actions are hypothesized to reduce the deleterious effects that non-native species introductions can have on covered species in the Delta. It is not possible to predict the effects of future introductions of non-native species in the Delta, although, if the effects of past introductions are an indication of the effects of future introductions, there will likely be large ecosystem scale effects of non-natives introduced in the Delta in the future. There are several well-documented examples of deleterious effects caused by the introduction of non-native species into the Delta. Two non-native invasive aquatic plants, water hyacinth (*Eichhornia crassipes*) and Brazilian waterweed (*Egeria densa*), have reduced habitat quantity and quality for many native fishes in the Planning Area (NMFS 2004), and likely provide habitat for non-native predatory centrarchids (Brown 2003, Nobriga et al. 2005). The introductions of two clams from Asia, the overbite clam (*Corbula amurensis*) and the Asian clam (*Corbicula fluminea*), have resulted in substantial changes to ecosystem dynamics in the Delta in just 20 years. These clams are considered ecosystem modifiers because of their wide ranging effects on the aquatic ecosystem and specific native species. Both are highly efficient filter feeders that reduce phytoplankton and zooplankton in the water column, which can be food for native fishes, such as delta smelt and juvenile Chinook salmon (Kimmerer and Orsi 1996, NMFS 2004, Center for Biological Diversity 2007). Several introduced invertebrate species that are food for several covered fish species have replaced native species in the low salinity zone, and may have led to lower foraging efficiency, starvation, and reduced growth rates of these fishes (Moyle 2002).

Adaptive Management Considerations. The agencies charged with implementing the actions will be responsible for monitoring the effectiveness of BDCP-funded elements of the program. The BDCP Implementing Entity will review monitoring and other relevant reports prepared by the agencies to assess the effectiveness of the program. The BDCP Implementing Entity will coordinate with the agencies to adjust strategies and funding levels through the BDCP adaptive management process as appropriate, based on review of agency reports.

The BDCP Implementing Entity in coordination with the Fishery Agencies will periodically review the cost effectiveness of this conservation measure in achieving benefits for covered fish species. If it is determined that this conservation measure does not provide a substantial cost-effective benefit for covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management decision making process.

OSCM11. Improve the rapid detection of and rapid response to new non-native species introductions into Delta waterways. The BDCP Implementing Entity will fund the DFG Oil Spill Prevention and Response (OSPR) aquatic species monitoring program and a DFG volunteer invasive early detection network to increase non-native early detection capability in the Bay-Delta, and fund the DFG Invasive Species Program to support their rapid response program. Total funding will be $____ in the initial year and $___ in subsequent years in 20__ dollars. The BDCP Implementing Entity will support the DFG OSPR aquatic species monitoring program. The estimated cost is $200,000 for the initial survey and approximately $150,000 each subsequent year over the term of the BDCP in 2009 dollars (it is assumed that the cost would decrease after the initial survey due to increased efficiency) (S. Foss pers. comm.). The BDCP Implementing Entity will support the DFG Invasive Species Program's establishment and maintenance of a volunteer invasive early detection network. The estimated cost for the volunteer program is approximately $100,000 per year over the term of the BDCP in 2009 dollars (S. Ellis pers. comm.). This network will be administered by the DFG Education and Outreach staff person and would use volunteers that may include dive groups or others already engaged in activities that allow for monitoring activities. The network will not necessarily be scientific or systematic in nature unlike the OSPR monitoring program. The goal of both programs will be to increase the ability to detect new non-native species at an early stage to allow for rapid responses to eradicate the species. The programs will be coordinated to minimize duplicative efforts in monitoring activities.

A 2005 Delta survey completed by the USFWS (USFWS 2007) will serve as the baseline for the OSPR monitoring program and similar protocols and methods used in that survey will be used in future surveys under this measure (S. Foss pers. comm.). Consistent with the USFWS survey, future monitoring will target three main ecological communities: subtidal epifaunal communities, subtidal infaunal communities, and invertebrate species associated with floating plant communities. Sampling will include qualitative and quantitative sampling protocols to survey for the presence of non-native species. Methods employed may include the use of sediment cores and grabs, quadrat clearings, qualitative taxonomic surveys, hand collection of floating plants and their roots, and other techniques deemed necessary by OSPR. Samples will be preserved and individuals will be identified to species if possible and enumerated. The sampling strategy will include multiple depths, substrates, orientations and light exposure conditions to encompass the diversity of potential habitat preferences in larval recruitment and subsequent colonization.

The BDCP Implementing Entity will assist and coordinate with DFG to meet the elements of a successful rapid response program by:

1. Obtaining legal authority to take action;
2. Developing a mechanism or process by which to agree upon species targeted for eradication; and
3. Developing a mechanism or process by which to agree upon control strategies, and clear them of regulatory hurdles.

This conservation measure will also contribute funding to the DFG Invasive Species Program to form a rapid response team specific to the Delta by specifying that these monies fund actions in the Delta or at locations outside the Delta for species with a high likelihood of invading the Delta. The estimated cost will be $250,000 per year in 2009 dollars for dedicated staff to provide the initial response of identifying a newly invaded species, delineating the population, and completing research on suitable habitat (S. Ellis pers. comm.).

The BDCP Implementing Entity will enter into a Memorandum of Agreement (MOA) or similar binding instrument with DFG as described in Section 3.4.3.1.

Problem Statement. The California Aquatic Invasive Species Program includes an action recommending the development of “species- and/or location-specific rapid response plans” (DFG 2008). The Draft Rapid Response Plan states that “the Plan cannot be implemented without adequate, stable and dedicated funding” (DFG 2008). This conservation measure will partially or wholly provide this funding.

Hypotheses. Providing for rapid detection of and response to new introductions of non-native species is hypothesized to increase the identification, immediate response, and eradication of new introductions of non-natives in Delta waterways, reducing the deleterious effects that non-native species introductions and invasions can have on covered species in the Delta. Any delay in response could allow for establishment of a non-native species over an area too large for eradication efforts. By identifying and stopping invading species before they become well established, this measure could prevent substantial adverse effects on covered species as evidenced by past non-native invasions. Threats to the Delta ecosystem that could be associated with future establishment of new non-native species in the Delta are described above in OSCM10.

Adaptive Management Considerations. The BDCP Implementing Entity will review progress reports or other relevant reports prepared by DFG to assess the performance of the Delta-specific rapid detection and rapid response teams in preventing the establishment of new invasive non-native species in the Delta. The BDCP Implementing Entity will coordinate with DFG to adjust rapid detection and response strategies and funding levels through the BDCP adaptive management process as appropriate, based on review of DFG performance monitoring results and other relevant reports.

The BDCP Implementing Entity will use effectiveness monitoring results to determine whether non-native species rapid detection and response results in measurable benefits to covered fish species and to identify adjustments to funding levels, monitoring and response methods, or other related aspects of the program that will improve the biological effectiveness of the program. Such changes will be effected through the BDCP adaptive management process and would be included in the subsequent annual work plans.

If results of review indicate that non-native species rapid detection and response does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding will be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

OSCM13. Remove Non-Native Submerged and Floating Aquatic Vegetation from Delta Waterways. *[**Note to reviewers**: SAIC is in discussions with the Department of Boating and Waterways to refine and provide more detail to this conservation measure. More information will be added as it becomes available]* The BDCP Implementing Entity will fund the removal of Brazilian waterweed (Egeria densa), water hyacinth (Eichhornia crassipes), and other non-native submerged and floating aquatic vegetation (SAV and FAV) from ___ acres of Delta waterways.

To implement this conservation measure, the BDCP will support the California Department of Boating and Waterways (DBW) Egeria densa and Water Hyacinth Control Programs and applicable future non-native aquatic vegetation control programs to reduce the impacts of SAV and FAV on covered fish species. The estimated cost will be $_____ in 20__ dollars over the term of the BDCP[4]. The approximate cost of DBW's current Egeria removal program is approximately $600 per acre.

Unlike the focus of DBW's current programs, which identifies target treatment locations based on impacts to navigability of waterways, SAV/FAV removal using BDCP funds will focus on areas that provide the greatest biological benefits to covered fish species. Prioritization for specific areas for treatment will be according to the following tiers:

1. BDCP restored aquatic habitat (see Figure 3.1);
2. Salmonid migration routes (see Figure 3.8); and
3. Other areas deemed biologically important to covered fish species by the BDCP Implementing Entity.

Annual target acreages for the removal of SAV/FAV will vary according to tier: BDCP restored aquatic habitat-- __ acres, salmonid migration routes-- __ acres, and other biologically important areas-- __ acres.

The BDCP Implementing Entity will enter into a binding Memorandum of Agreement (MOA) or similar instrument with DBW as described in Section 3.4.3.1. The BDCP Implementing Entity will implement this conservation measure if DBW chooses not to participate in its implementation.

Problem Statement. Although the historical extent of native SAV and FAV in the Delta ecosystem is unknown, non-native invasive SAV and FAV species have recently invaded large areas of the Delta (Brown 2003, DFG 2008, Ustin et al. 2008) and the invasion is continuing to expand into a greater proportion of channels and colonize new areas (IEP 2008b). The widest spread non-native FAV species, water hyacinth, was introduced into the Delta over 100 years ago and severe infestations were experienced by the 1980s. The majority of the surface cover of SAV detected through the recent use of airborne hyperspectral imagery is *Egeria densa*, although the SAV vegetation frequently contains a mixture of three invasive non-native species: *Egeria densa*, *Potamogeton crispus* (curlyleaf pond weed), and *Myriophyllum spicatum* (Eurasian watermilfoil) (Ustin et al. 2008). Of the 55,000 acres of the Delta surveyed in 2007, SAV cover has been estimated to be between 5,500 and 10,000 acres (Ustin et al. 2008). Non-native SAV and FAV are thought to cause multiple negative effects on the Delta ecosystem, including providing habitat for non-native predators of covered fish species (Brown 2003, Nobriga et al. 2005), reducing food abundance and feeding ability of covered fish species by reducing light and turbidity (Brown and Michniuk 2007), and blocking rearing habitat for juvenile salmon and splittail (IEP 2008a).

[4] The budget for the combined *Egeria densa* and Water Hyacinth Control Program in fiscal years 2005/2006 and 2007/2008 was $7,000,000 per year with regulatory costs up to 65% of the control costs (DBW 2006, DFG 2008), although regulatory costs are anticipated to be lower in the future once DBW completes preliminary toxicology and monitoring work.

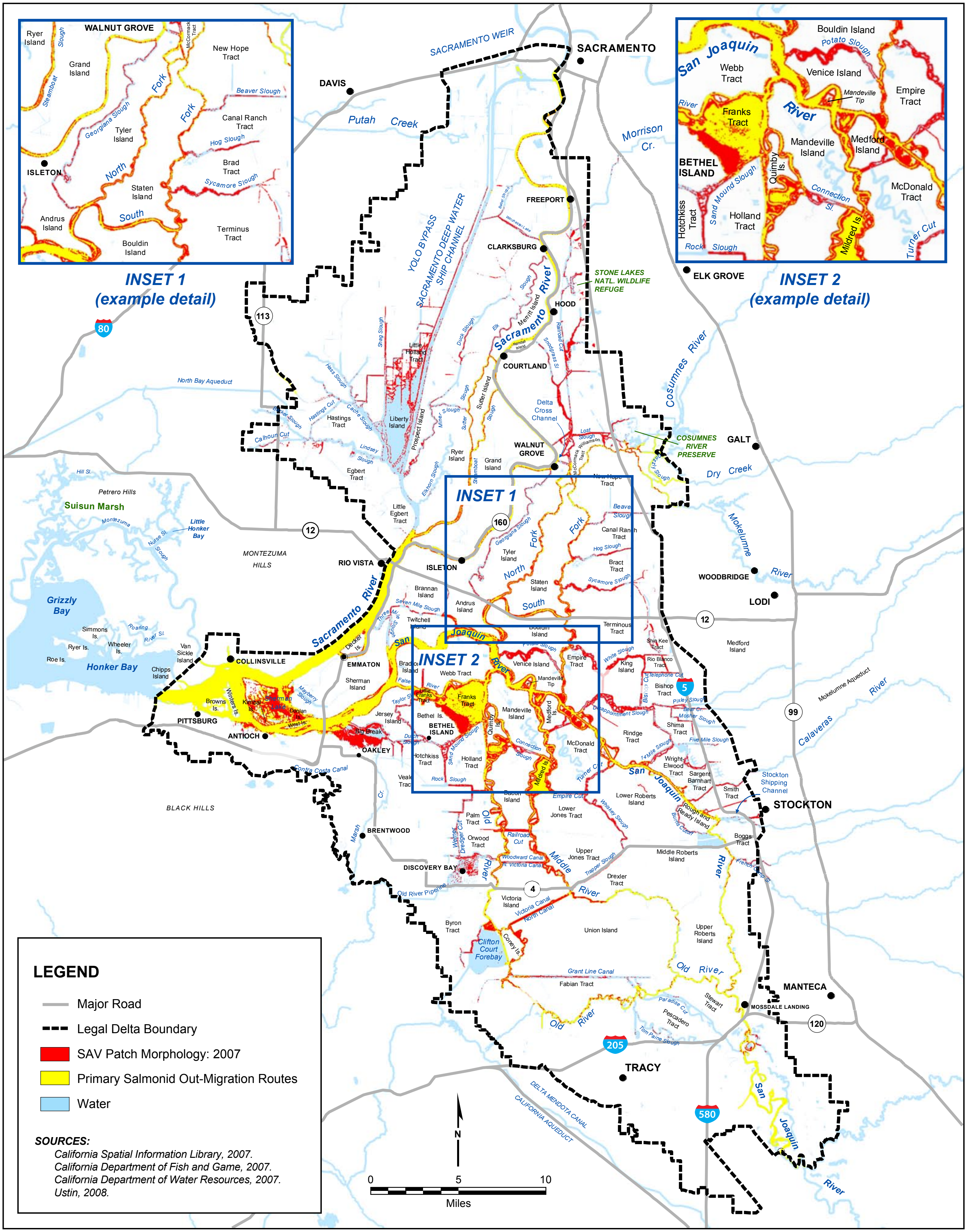

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Figure 3.8
Overlap of SAV 2007 Distribution and Primary Salmonid Outmigration Routes

The DBW's Water Hyacinth Control Program, which began in 1982, has been effective in reducing hyacinth from Delta waterways using chemical and mechanical removal methods. DBW developed and has operated the *Egeria densa* Control Program (EDCP) since 2001 in response to AB 2193, which amended the Harbors and Navigation Code to designate DBW as the lead agency for the control of *Egeria densa* in the Delta (DBW 2006, 2008). Initially, the program focused control efforts in a number of locations where *Egeria* impeded navigation, on a range of mechanical and chemical control techniques, and on an extensive suite of toxicology and water quality tests and sampling that were required by the terms of its National Pollution Discharge Elimination System (NPDES) permit and under biological opinions issued by USFWS and NOAA Fisheries (DBW 2008). In 2006, DBW concluded that its current approach was not effective and proposed expanding the treatment area to sites across most of the legal Delta between 2006-2010 and concentrating on Franks Tract between 2006-2008 (DBW 2006). DBW (2006) stated that they would seek alternative and supplemental resources and funding to support these efforts.

The primary focal areas for removal of both the Egeria densa Control Program and the Water Hyacinth Control Program have been those in which navigation by boats has been blocked.

However, many smaller sloughs and cuts that are not designated as navigable can become filled with non-native SAV and FAV, contributing to their negative effects on covered fish species.

Hypotheses. Removing non-native SAV and FAV from Delta waterways is hypothesized to provide benefits to covered fish species through the following mechanisms.

1. Reducing predation mortality on juvenile salmon, steelhead, and splittail by reducing habitat for non-native predatory fish (see Appendix X, *DRERIP Evaluations*). SAV provides relatively high quality habitat for non-native piscivores and is spread across large portions of the Delta in or adjacent to significant migration corridors and pelagic and subtidal open water habitat for covered species (see Figure 3.8). The interior of SAV stands is good habitat for larval and juvenile centrarchids (Brown and Michniuk 2007), whereas adult striped bass forage immediately outside of the SAV bed and feed on juvenile Chinook salmon, steelhead, splittail, delta smelt, and longfin smelt (Stevens 1966, ODFW 1998, Nobriga and Feyrer 2007, 2008);
2. Reducing predation mortality of delta smelt by increasing turbidity levels (IEP 2008a, Appendix X, *DRERIP Evaluations*). SAV and FAV are thought to reduce local flow rates and cause suspended solids to precipitate out of the water column, resulting in a localized reduction in turbidity levels (Grimaldo and Hymanson 1999). A reduction in turbidity is hypothesized to reduce the predator avoidance abilities in delta and longfin smelt. In addition, reduced turbidity may increase the hunting efficiency of non-native piscivores (Nobriga et al. 2005);
3. Increasing food consumption by delta and longfin smelt by increasing turbidity levels. SAV and FAV are thought to reduce local flow rates and cause suspended particles to precipitate out of the water column, resulting in a localized reduction in turbidity levels (Grimaldo and Hymanson 1999). A reduction in turbidity is hypothesized to reduce the foraging ability of delta and longfin smelt;

4. Increasing rearing habitat for juvenile salmon (all races), steelhead, and splittail (see Appendix X, *DRERIP Evaluations*). Dense patches of SAV and FAV physically obstruct covered fish species access to habitat (IEP 2008a) that would become available with SAV and FAV removal and control; and

5. Increasing food availability for all covered fish species near removal locations by increasing light levels below vegetation. Phytoplankton growth is light limited in the Delta (Cole and Cloern 1984). The further reduction in light levels near non-native SAV and FAV are thought to reduce local growth of phytoplankton, which may drive the local abundance of zooplankton that form the food base for covered fish species near patches of SAV and FAV.

Adaptive Management Considerations. The DBW will be responsible for monitoring the effectiveness of BDCP-funded elements of the non-native aquatic vegetation control programs in successfully controlling SAV and FAV. The BDCP Implementing Entity will review monitoring other relevant reports prepared by the DBW to assess the effectiveness of the program for controlling non-native aquatic vegetation in the Delta. The BDCP Implementing Entity will coordinate with the DBW to adjust inspection strategies and funding levels through the BDCP adaptive management process as appropriate based on review of program reports.

The BDCP Implementing Entity will use results of effectiveness monitoring to determine if reducing controlling SAV and FAV results in measurable benefits to covered fish species and to identify adjustments to funding levels, control methods, or other related aspects of the program that would improve the biological effectiveness of the program. Such changes, once approved through the adaptive management decision making process, will be effected through subsequent annual work plans.

If results of monitoring indicate that removing and controlling SAV and FAV does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

OSCM14. Increase the Harvest of Non-Native Predatory Fish to Decrease their Abundance. The BDCP Implementing Entity will fund development of a pilot program to reduce the size limits and increase the bag limits of recreational harvest of non-native predatory species in two specific locations in the Delta "hot spots." The locations will be identified through coordination with the fish agencies and non-agency scientists familiar with several known predation "hot spots" in the Delta.

The pilot program will be proposed to the California Fish and Game Commission (F&GC) in 2011 and a limited exemption from current size and bag limits will be sought to allow higher removal rates of non-native predators at smaller sizes only in the two identified "hot spots." If approved, the pilot program will be implemented in 2011 and run for three years. The pilot program will include monitoring and assessments of non-native predator populations at the two identified "hot spots" to determine if reduced size and increased bag limits reduce the number of non-native predatory fish at each location and result in improved survival of covered species.

The program plan will be developed in coordination with the Fishery Agencies and reviewed independently, possibly through the CALFED Science Program. The pilot program will include an education component to ensure that recreational fishermen know about the reduced size limits and increased bag limits at the two locations.

At the conclusion of the pilot program, a summary analysis and report will be prepared by the BDCP Implementing Entity in consultation with the DFG that makes findings and reaches conclusions regarding the effectiveness of this effort to reduce non-native predatory fish at the two locations and whether the effort had positive effects on covered species. If results of the pilot program determine that non-native predator populations are reduced to a meaningful level to covered fish species at the two locations, a full-scale program will be designed for additional "hot spots" throughout the Delta or, at the discretion of the F&GC, for the entire Delta.

If, at the two initial study locations, the full-scale program will be proposed to the F&GC for implementation in 2014. The full-scale proposal will include the factual information that supports the conclusions of the pilot program and an estimate of the expected benefits of the full-scale program to covered species based on the conclusions of the pilot program. The F&GC will have the discretion to adopt or reject the full-scale program.

In the event the F&GC decides not to adopt the full-scale program, the funding anticipated for the education component will be shifted to another other stressors program identified through the adaptive management process. In the event the adaptive management program determines that no other stressors conservation measures are available to receive the funding, the funding anticipated for education will be shifted to a habitat restoration conservation measure identified by the adaptive management program.

Problem Statement. Despite the decline of multiple native species in the Delta over the past few years, such as delta smelt (IEP 2008a), longfin smelt (IEP 2008a), and salmon (MacFarlane et al. 2008), the abundance of non-native centrarchids such as large mouth bass have increased in association with increases in Egeria abundance (Brown and Michniuk 2007). Non-native centrarchids, particularly largemouth bass and black crappie, in the Delta consume juvenile salmonids and splittail, although the effect on smelt and sturgeon in the Delta may be minor due to their use of different locations in the water column (M. Nobriga pers. comm.). Striped bass in the Delta are known to consume juvenile salmonids, delta and longfin smelt, and splittail (Stevens 1966, ODFW 1998, Nobriga and Feyrer 2007, 2008). The impact of non-native basses on juvenile sturgeon is likely small in the Delta.

Hypotheses. Relaxation of size and daily bag limits for striped bass and centrarchids is hypothesized to:

- reduce populations of adult and sub-adult striped bass and centrarchids. Humans have been extremely effective historically at harvesting fish species to very low numbers in many parts of the world;
- subsequently reducing the population of fry and juvenile striped bass and centrarchids. Relaxing size limits is expected to allow smaller fish to be harvested, potentially before they have reached a reproductive size, thereby reducing the reproductive capacity of the population;

- reduce predation mortality of Chinook salmon (ODFW 1998, Lindley & Mohr 2003, Nobriga et al. 2003, Nobriga & Feyrer 2007, 2008), steelhead (ODFW 1998), delta smelt (Stevens 1966, Winemiller & Rose 1992, Moyle 2002, Eisermann 2006, Nobriga and Feyrer 2007, 2008), longfin smelt (Nowak et al. 2004, Eisermann 2006), Sacramento splittail (Moyle et al. 2004, Eisermann 2006, Nobriga & Feyrer 2007, 2008), green sturgeon (J. Israel, pers. obs.), and white sturgeon by striped bass and centrarchids; and
- reduce competition for food with delta and longfin smelt by juvenile striped bass (Orsi & Mecum 1996, Kimmerer 2002b, Appendix X, *DRERIP Evaluations*).

Adaptive Management Considerations. Monitoring will consist of assessing the abundance, distribution, and size of centrarchid species before and after implementation of new regulations to determine the effectiveness of regulations. Studies will be conducted to determine size-based predation rates of centrarchids on covered fish species to determine whether relaxation of the regulations has an impact on these species.

If results of fish monitoring indicate that relaxation of regulations have not been sufficient to significantly reduce adverse affects of non-natives on native fish, actions will be modified to be more effective through the adaptive management process.

The BDCP Implementing Entity will review progress reports or other relevant reports to assess the performance of the measure in increasing the harvest of non-native predatory species in hot spots in the Delta. The BDCP Implementing Entity will coordinate with Fishery Agencies to adjust strategies and funding levels through the BDCP adaptive management process as appropriate, based on review of DFG performance monitoring results and other relevant reports.

The BDCP Implementing Entity will use effectiveness monitoring results to determine increasing the harvest of non-native predatory fish results in measurable benefits to covered fish species and to identify adjustments to funding levels, methods, or other related aspects of the program that would improve the biological effectiveness of the program. Such changes will be effected through the BDCP adaptive management process and would be included in the subsequent annual work plans.

If results of review indicate that increasing the harvest of non-native predatory fish does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding will be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

OSCM16. Reduce Illegal Harvest of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and White Sturgeon in the Delta. The BDCP will provide $___ (in 20__ dollars) over the term of the BDCP to increase the enforcement of fishing regulations in the Delta and Bays to reduce illegal harvest of covered salmonids and sturgeon. The BDCP Implementing Entity will provide funds to DFG to support and equip the addition of 17 field wardens and 5 supervisory and administrative staff in support of the field wardens assigned to the Delta-Bay Enhanced Enforcement Program (DBEEP) over the term of the BDCP. The estimated cost will be $9.4 million in 2009 dollars for the first year of implementation and an estimated annual cost of $5.4 million in 2009 dollars in subsequent years without inflation (B. Naslund pers. comm.). The goal of the conservation measure would be to reduce illegal harvest by __ percent from estimated 20__ levels.

The Delta-Bay Enhanced Enforcement Program (DBEEP) is a 10 warden squad that was formed specifically to increase enforcement on poaching of anadromous fish species in Bay-Delta waterways. The program is funded by water contractors through the Delta Fish Agreement. The BDCP would contribute directly to this existing program by expanding its size to improve enforcement on poaching of covered species.

The BDCP Implementing Entity will enter into Memoranda of Agreement (MOAs) or similar binding instruments with DFG as described in Section 3.4.3.1.

Problem Statement. California has the lowest game warden to population ratio in the nation with fewer than 200 field wardens for the entire state. The Delta is a particular hot spot for poaching because of the large number of sport fish, particularly gravid female white sturgeon, whose roe are used for caviar (Lt. L. Schwall, pers. comm.). Illegal harvest is thought to have high impacts on sturgeon populations, particularly white sturgeon (Beamsderfer et al. 2007). Illegal harvest of juvenile and adult Chinook salmon and steelhead in the Delta and Bays is also common (DBEEP 2007).

Hypotheses. It is hypothesized that enhanced enforcement on poaching will reduce mortality, and potentially increase population sizes, of green sturgeon (Beamesderfer et al. 2007, CDFG unpublished, Boreman 1997, D. Tanner pers. comm., DBEEP 2007, Appendix X, *DRERIP Evaluations*); white sturgeon (Bay-Delta Oversight Council 1995, Boreman 1997, Schaffter & Kohlhorst 1999, Beamesderfer et al. 2007, DBEEP 2007, DFG Sturgeon Report Card 2007, M. Gingras pers. comm., Z. Matica pers. comm., CDFG unpubl. data, Appendix X, *DRERIP Evaluations*); Chinook salmon (all races) (Bay-Delta Oversight Council 1995, Williams 2006); and steelhead (DBEEP 2007, DFG Steelhead Report Card 2007, DFG Creel Survey 2007-08, Moyle et al. 2008, Appendix X, *DRERIP Evaluations*).

Magnitudes of population-level benefits of this measure are expected to vary inversely with the population size of each covered species (Bay-Delta Oversight Council 1995, Begon et al. 1996, Futuyma 1998, Moyle et al. 2008).

Adaptive Management Considerations. The BDCP Implementing Entity would coordinate with DFG to adjust enforcement strategies and funding levels through the BDCP adaptive management process as appropriate based on review of Program reports.

OSCM17. Reduce Adverse Effects of Harvest on Sacramento Splittail Abundance. The BDCP Implementing Entity will develop a study of, and draft regulations for limits on recreational and commercial splittail harvest. The study will determine the extent to which current harvest levels reduce the number of splittail in the Delta and will be performed in 2011 and 2012. The study will establish draft regulations for proposal to the California Fish and Game Commission in 2013. The draft regulations may propose a set size and daily bag limits designed to aid in the recovery of splittail. The study will utilize existing monitoring data and DFG creel survey data, which contains considerable information about the number, season, and location of harvested splittail. Working with fish agencies and other fish experts, these data will be compared to life history attributes of splittail (e.g., age at reproduction, growth rates, and spatial and temporal patterns in migration and reproduction) to determine the appropriate size and daily bag limits that would be sufficient to aid in the recovery of the species.

In consultation with CDFG, the study, including a determination of appropriate size and bag limits, will propose appropriate regulations for consideration by the F&GC.

If the F&GC adopts the proposed regulations, the BDCP Implementing Entity will propose the development of a program within DFG to supplement enforcement personnel specifically focused on enforcing the splittail limits and will work with DFG and others to secure the necessary funding to implement the program. The enforcement program will include an education component to ensure that fishermen know about the splittail size and bag limits in advance of active enforcement.

In the event the F&GC decides not to adopt the protective regulations for splittail, the funding anticipated for enforcement will be shifted to another other stressors program conservation measure consistent with the adaptive managing process. In the event the adaptive management program determines that no other stressors conservation measures are available to receive the funding, the funding anticipated for enforcement will be shifted to other conservation measures identified by the adaptive management program.

Problem Statement. There are currently no regulations on the Sacramento splittail fishery. However, the fishery may be considerable despite its poor documentation (Moyle et al. 2004).

Hypotheses. This conservation measure would establish legal limits for splittail based on known abundance and harvest rates. Although harvest is not thought to have significant effects on the population currently, this measure is expected to protect the species if harvest pressure were to increase in the future.

Specifically, this conservation measure is hypothesized to:

- increase the population abundance of Sacramento splittail (Moyle et al. 2004, DFG Creel Data 2007-08, USBR 2008, Appendix X, *DRERIP Evaluations*). By reducing the number of fish being harvested, more fish can survive to reproduce.
- improve the transfer of energy through the foodweb in wetter years. Splittail are highly fecund in wetter years (Sommer et al. 1997, Feyrer et al. 2007b). It is thought that a large number of larval and juvenile splittail during these years are consumed by other organisms, thus contributing to an increase in the transfer of energy through the foodweb (Appendix X, *DRERIP Evaluations*).
- increase predation on Corbula(Appendix X, *DRERIP Evaluations*). Because splittail have been shown to consume Corbula (Feyrer et al. 2003), it is hypothesized that an increase in the splittail population would lead to an increased consumption of Corbula.

Adaptive Management Considerations. *[Note to reviewers: this section is a general summary; more detail will be provided in future iterations.]* DFG would be responsible for monitoring the effectiveness of regulations in conserving Sacramento splittail while providing for a recreational fishery, and for revising regulations as needed to improve their effectiveness. The BDCP Implementing Entity would coordinate with DFG to develop and fund monitoring efforts, and to identify and support needed adjustments in regulations in future years.

OSCM18. Develop and Implement Hatchery and Genetic Management Plans to Minimize the Potential for Genetic and Ecological Impacts of Hatchery Reared Salmonids on Wild Salmonid Stocks. *[**Note to reviewers**: SAIC is in discussion with hatchery coordinators to determine the funding needs for this conservation measure. Additional detail and clarification will be added to this measure as it becomes available]* The BDCP Implementing Entity will minimize potential adverse effects of hatchery reared salmonids on wild salmonid stocks by supporting the accelerated development and implementation of Hatchery and Genetic Management Plans (HGMPs) for all state Chinook salmon and steelhead hatcheries in the Central Valley of California. The estimated cost of this measure will be $______ in 20__ dollars over the term of the BDCP. HGMPs would be implemented to reduce adverse ecological and genetic effects of hatcheries on wild fish and to be consistent with conservation and protection for listed fish species.

The BDCP Implementing Entity will provide funding to:

- Expand and finalize steering groups for each hatchery HGMP process, in part to aid in determining the hatchery's function;
- Support DFG staff and their contractors to prepare HGMPs under departmental and NOAA direction;
- Staff a DFG HGMP Coordinator, a position dedicated to coordinating HGMPs from beginning through implementation. HGMP implementation and adaptive management will be an ongoing task for the life of the hatchery;
- Staff hatcheries sufficiently to carry out changes necessary to meet ESA requirements including providing regional support for fishery biologists at each hatchery;
- Improve efforts to minimize several categories of hatchery impacts including trucking, interbasin egg transfers, genetic stock management, monitoring (especially hatchery natural proportions and impacts of hatcheries on natural stocks), and conservation hatcheries; and
- Provide support for staffing and analysis associated with a genetic parental-based tagging system.

The BDCP Implementing Entity will enter into binding Memoranda of Agreement (MOAs) or similar instruments with DFG as described in Section 3.4.3.1.

Problem Statement. Hatchery-reared Chinook salmon and steelhead are believed to have negative effects on wild Chinook salmon and steelhead, including competition for space and food as juveniles and for spawning habitat as adults. Fish reared in hatcheries can be selected for traits that are different from those in nature, such as those that allow them to survive in an artificial, contained environment (e.g., fast growth, large size). This could result in reduced genetic isolation of hatchery fish from wild fish. It is thought that these hatchery fish outcompete their smaller wild-reared conspecifics for food and space in natural waterways (Williams 2006). Also, as adults, straying by hatchery reared salmon into natural spawning grounds may lead to genetic introgression, where offspring of wild salmon are “genetically polluted” with hatchery-selected genes, thereby reducing the fitness of wild population (ISAB 2003, Goodman 2005, Hey et al. 2005).

To address these concerns, hatcheries have begun reforming their management practices to minimize the effects that hatchery fish may have on wild fish. HGMPs serve as the foundation of hatchery management and reform to minimize genetic and ecological impacts to wild fish. HGMPs are developed to devise and evaluate practices of a hatchery to ensure the hatchery contributes to the conservation and recovery of listed salmonids.

Although required, the development of HGMPs in Central Valley hatcheries has been slow to date. The following provides a summary of the status of the progress made toward completion of HGMPs at Central Valley hatcheries (M. Lacy pers. comm.):

- **Nimbus Hatchery** - Draft HGMPs for both fall Chinook salmon and winter steelhead have been completed. Updates and minor revisions were made during 2008 to initial drafts. Reclamation and DFG staff are currently reviewing subsequent drafts.
- **Feather River Hatchery** - Draft HGMPs for spring and fall Chinook salmon and Central Valley steelhead were competed by in late 2008. DWR is reviewing the spring Chinook salmon draft HGMP; fall Chinook salmon and steelhead HGMPs are both still in-house Cramer Fish Sciences review. Updates and DWR comments are being incorporated into all drafts as appropriate.
- **Mokelumne River Hatchery** - A revised draft HGMP for the steelhead program was completed at the end of 2008 and has been reviewed by hatchery staff. A draft HGMP for the fall Chinook salmon is 50% complete.
- **Merced River Hatchery** - There has been no progress towards beginning work on this HGMP.
- **Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery** - All of the necessary HGMP information for Coleman and Livingston Stone NFHs are contained in the 2001 Biological Assessment (plus a subsequent addendum for Section 10 coverage for winter Chinook and amendments to respond to operational changes at Coleman NFH) submitted to NMFS. The Biological Opinion, including updates to the BA, is in process.

Hypotheses. Accelerating the development and implementation of HGMPs at Central Valley hatcheries is hypothesized to:

- improve the genetics and fitness of wild salmonids (ISAB 2003, Goodman 2005, Hey et al. 2005); and
- reduce competition for rearing and spawning habitat and food with hatchery reared salmonids (Flagg et al. 2000, Goodman 2005).

Adaptive Management Considerations. The BDCP Implementing Entity will review annual reports or other relevant reports to assess the performance of the HGMP teams in the accelerated development and implementation of HGMPs. The BDCP Implementing Entity will coordinate with the individual hatcheries to adjust HGMP strategies and funding levels through the BDCP adaptive management process as appropriate, based on review of performance monitoring results and other relevant reports.

The BDCP Implementing Entity will use effectiveness monitoring results to determine whether HGMP development and implementation results in measurable benefits to covered fish species and to identify adjustments to funding levels or other related aspects of the program that would improve the biological effectiveness of the program. Such changes will be effected through the BDCP adaptive management process and will be included in the subsequent annual work plans.

If results of review indicate that HGMP development and implementation does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding will be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

OSCM19. Reduce Losses of Wild Stocks of Chinook Salmon to Commercial Fishing and Recreational Fishing through a Mark-Select Fishery. To reduce harvest of wild stocks of Chinook salmon, the BDCP Implementing Entity will produce a proposal by July 2011 for a full-scale mark-select fishery program that may be implemented by the California Department of Fish and Game (DFG) and the Pacific Fishery Management Council (PFMC). The proposal will be developed using lessons learned from implementation of mark-select fisheries in Washington and Oregon and marking technologies currently in existence. The full-scale programs will include all Chinook salmon hatchery fish from both the Sacramento and San Joaquin River systems. The program will not be submitted to DFG or PFMC until it has been peer reviewed by hatchery experts holding positive and negative views of mark-select programs.

If DFG and PFMC choose to adopt the full-scale program, it will be funded by the BDCP at $___ (in 20__ dollars), which is sufficient to allow its full implementation for six successive years (2012 to 2017). Implementing the program over six years will allow time for four separate broods to return upstream. During 2017, a summary report will be produced describing the program's implementation, its degree of success or failure based on monitoring results, and recommendations to improve the program regardless of its outcome.

The program will include a proposal for integrating differences between historical data sets using fractional marking and future data sets derived from mass marking. The purpose of this element of the proposal is to ensure that, in the event that a full-scale mark-select program is implemented but is not successful in improving wild salmon stocks, the mark-select program can be terminated and its data modified to conform to the historical fractional marking data. The data integration will also be capable of converting past data from fractional marking into data sets than can be used in conjunction with data from the mark-select program if DFG and PFMC decide to continue the program at the conclusion of the sixth year.

In the event that DFG and PFMC decide not to continue the mark-select program, the funding anticipated to support a continuation of the program will be shifted to another Other Stressors conservation measure consistent with the BDCP adaptive managing process. In the event the adaptive management program determines that no other stressors conservation measures are available to receive the funding, the funding to support continuation of the program will be shifted to the habitat restoration conservation measure identified by the adaptive management program.

Problem Statement. Commercial ocean harvest has been identified as an important stressor to wild Chinook salmon populations (Williams 2006, NMFS 2009). In addition, hatchery-produced Chinook salmon and steelhead are thought to have negative effects on wild fish via competition for resources and genetic effects that can reduce the fitness of wild fish if interbreeding occurs (see ISAB 2002 for review). As a result, reducing pressure from harvest and competition and genetic introgression from hatchery salmon are hypothesized to improve conditions for wild salmonids.

Hypotheses. Although the greatest benefits of this conservation measure would be realized if a mark-selective fishery were implemented, it is expected that there would be major benefits to wild stocks of Chinook salmon of mass marking hatchery fish. Specifically, marking 100% of hatchery reared fish is hypothesized to:

- increase the knowledge base regarding Central Valley Chinook salmon (population sizes, harvest rates, success of restoration and river management programs, and other key biological parameters) for improved management (it is unknown whether current management programs primarily benefit wild fish, hatchery fish, or both, and in what proportion) (Hankin 1982, JHRC 2001, ISAB 2003, PSC-SFEC 2005, 2008a, AFS Position Paper 2009, Mohr 2009);
- increase the ability for hatcheries to track and manage the composition of wild versus hatchery origin fish in breeding programs, detect and quantify straying rates of hatchery fish, and improve broodstock management (with tagging, much improved) (ISAB 2003, AFS Position Paper 2009); and
- streamline, simplify, and reduce costs for coded wire tag, scale, otolith, and genetics sampling programs that specifically target wild or hatchery fish. Targeted fish would be easily identifiable with a visual mark leading to more efficient collection of targeted fish and reduced "bycatch" of non-targeted fish.

If the F&GC and PFMC decide to implement a mark-selective fishery, it is hypothesized that benefits would include:

- Reduce harvest-related mortality of wild Chinook salmon, thus contributing to the recovery of all covered Chinook salmon races (Cramer et al. in press, Appendix X, *DRERIP Evaluations*); and
- reduce competition and genetic introgression from hatchery fish with natural fish on spawning grounds due to increased harvest of hatchery fish and the ability for managers to visually segregate hatchery reared fish from wild fish (Hankin 1982, Flagg et al. 2000, Goodman 2005, Weber & Fausch 2005, Araki et al. 2006, AFS Position Paper 2009, Mohr 2009, Appendix X, *DRERIP Evaluations*);

DFG has marked and tagged a constant fraction (25%) of hatchery reared fall-run fish since 2007, which has been proposed to be sufficient to gain information about life history parameters (Newman et al. 2004). However, additional potential benefits associated with harvest reductions of wild fish and increased harvest of hatchery fish are predicted to be greatly increased with 100% marking of hatchery fish compared to 25% (Cramer et al. in press.).

Adaptive Management Considerations. The BDCP Implementing Entity will review results of annual reports or other relevant reports to assess the performance of the mark-select fishery on wild stocks. The BDCP Implementing Entity will coordinate with fishery agencies to adjust strategies and funding levels through the BDCP adaptive management process as appropriate, based on review of performance monitoring results and other relevant reports.

The BDCP Implementing Entity will use effectiveness monitoring results to determine whether the mark-select fishery results in measurable benefits to wild salmon stocks and to identify adjustments to funding levels or other related aspects of the program that would improve the biological effectiveness of the program. Such changes will be effected through the BDCP adaptive management process and will be included in the subsequent annual work plans.

OSCM20. Establish New and Expand Existing Conservation Propagation Programs for Delta and Longfin Smelt. The BDCP Implementing Entity will support: (1) the development of a delta and longfin smelt conservation hatchery by the USFWS to house a delta smelt refugial population and provide a source of delta and longfin smelt for supplementation or reintroduction, if deemed necessary by Fishery Agencies, and (2) the expansion of the refugial population of delta smelt and establishment of a refugial population of longfin smelt at the University of California, Davis Fish Conservation and Culture Laboratory to serve as a population safeguard in case of a catastrophic event in the wild.

The new facility proposed by the USFWS will house genetically-managed refugial populations of delta and longfin smelt (Clarke 2008). Further, the facility will provide fish to supplement the wild population and provide fish stocks for reintroduction, as necessary and appropriate. State-of-the-art genetic management practices will be implemented to avoid hatchery produced fish becoming genetically different from wild fish. The facility will be designed with the ability to add other species if necessary in the future. Construction and start-up costs are estimated to be $19.5 million in 2008 dollars (Clarke 2008). Annual operating costs are estimated to be $1.5-2.0 million in 2008 dollars (Clarke 2008). Specific rules will be established to discontinue housing refugial populations of delta and longfin smelt at the hatchery if and when populations of these species are considered recovered by the Fishery Agencies.

In addition, the UC Davis Fish Conservation and Culture Laboratory (FCCL) is in need of additional space and funds to expand the refugial population of delta smelt and establish a refugial population of longfin smelt. The FCCL and the Genomic Variation Laboratory (GVL) at UC Davis are and will be, the primary entities developing and implementing genetic management of the delta smelt refugial population over the period 2009-2015 or longer and may then play a secondary role in keeping a back-up population(s). UC Davis cost estimates include a one time expansion cost of $2.56 million for physical expansion of the existing site, but substantially more funds may be required to pay for existing building (and more than double this figure if a new site is required), and an estimated $1.2 million for annual operating costs (FCCL - $1M and GVL - $200K) in 2009 dollars (J. Lindberg pers. comm.). UC Davis and the GVL have not developed cost estimates for developing and implementing genetic management for a longfin smelt conservation hatchery at this time.

At both facilities, genetic management practices will be implemented to maintain wild genetic diversity, minimize genetic adaptation to captivity, minimize mean kinship, and equalize family contributions. Furthermore, genetic monitoring of wild populations will proceed to minimize risks such as: genetic swamping from the hatchery population, reduction in effective population size, and changes in the census population-to-breeder population ratio over time.

The BDCP Implementing Entity will enter into binding Memoranda of Agreement (MOAs) or similar instruments with the USFWS and University of California, Davis similar to that described in Section 3.4.3.1. In addition, if and when populations of these species are considered recovered by the Fishery Agencies, the BDCP Implementing Entity will terminate funding for the propagation of the species and either fund propagation of an additional BDCP covered fish species if necessary and feasible or deobligate funds to this conservation measure and reallocate them to augment funding other conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

Problem Statement. Populations of both delta and longfin smelt have dramatically declined recently (IEP 2008). Although a variety of stressors are suspected, there is not a clear understanding of why these populations have declined (IEP 2008). There is evidence that delta smelt continue to decline and that very low population size could result in an Allee effect causing an even more rapid decline of the species (Mueller-Solger 2007). As a result, the risk of extinction of delta smelt is hypothesized to be increasing. Longfin smelt abundance has followed a similar trend to delta smelt (IEP 2008).

Hypotheses. Artificial propagation and maintenance of refugial populations of delta and longfin smelt are hypothesized to:

- provide a safeguard against the possible extinction of delta and/or longfin smelt by maintaining a captive population that is genetically similar to the wild population (Carolsfeld 1997, Kowalski et al. 2006, Sorensen 1998, Sveinsson & Hara 1995, Turner & Osborne 2008, USFWS 1998, 2003, Hedgecock et al. 2000, Hedrick et al. 1995, Nobriga 2008, B. Clarke, pers. comm., Turner et al. 2007, Lande 1988, (Appendix X, *DRERIP Evaluations*);
- improve the knowledge base regarding threats to and management of delta and longfin smelt by increasing the ability to study the effects of various stressors on these species using hatchery-reared specimens (Appendix X, *DRERIP Evaluations*); and
- increase population sizes of delta smelt (Purchase et al. 2007, Deblois & Leggett 1991, Lande 1988, Flagg et al. 2000, Carolsfeld 1997, Kowalski et al. 2006, Sorensen 1998, Sveinsson & Hara 1995, USFWS 1998, 2003, Richards et al. 2004, Nobriga 2008, B. Clarke, pers. comm.) and longfin smelt (Flagg et al. 2000, Carolsfeld 1997, Kowalski et al. 2006, Sorensen 1998, Sveinsson & Hara 1995, USFWS 1998, 2003, Richards et al. 2004, Nobriga 2008) to self-sustaining levels in the wild.

Adaptive Management Considerations. Based on review of performance and effectiveness monitoring results in USFWS and UC Davis reports, the BDCP Implementing Entity in coordination with Fishery Agencies and UC Davis will adjust funding levels, hatchery operations, or other related aspects that will improve the performance and/or biological effectiveness of the program through the BDCP adaptive management process as appropriate. Such changes will be effected through the BDCP adaptive management process and would be included in the subsequent annual work plans.

If results indicate that oxygen diffuser facilities do not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding will be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

OSCM21. Screen, Remove, Relocate, Consolidate, Modify and/or Alter Timing of Non-Project Diversions to Reduce Entrainment of Covered Fish Species in the Delta. The BDCP Implementing Entity will provide funding to reduce entrainment at non-project diversions. The estimated cost will be $___ over the term of the BDCP in 20__ dollars. To implement this conservation measure, the BDCP Implementing Entity will take two actions:

1. Support the U.S. Bureau of Reclamation's Anadromous Fish Screen Program and DFG's Fish Screen and Passage Program to screen non-project diversions, thereby reducing entrainment risk of covered fish species at non-project diversions. The estimated cost will be $____ in 20__ dollars over the term of the BDCP[5]. Decisions regarding which diversions to prioritize in this element will rely on existing criteria established by these programs; and
2. In cooperation with voluntary non-project diverters, share costs for removing, relocating, consolidating, modifying design, and altering operations of individual non-project diversions, as appropriate, to reduce the risk of entrainment of covered fish species. The estimated cost will be $____ in 20__ dollars over the term of the BDCP. Relocation and consolidation will involve moving diversions from high quality habitat for covered fish species to lower quality habitat.

   Decisions regarding which diversions to prioritize in this second action will rely in part on existing criteria established by the Anadromous Fish Screen Program and the Fish Screen and Passage Program. In addition, DFG is expected to conduct a comprehensive study to determine the distribution of fish in the Delta relative to non-project diversions and to determine entrainment rates of at least 27 diversions throughout the Delta (C. Armor pers. comm.). If DFG monitoring is not funded, the BDCP Implementing Entity will fund a similar study to gain this information to inform prioritization.

This conservation measure could employ either of two strategies. The first would focus on the largest diversions (greater than 250 cfs) under the assumption that larger diversions entrain fish at a disproportionately larger rate than smaller diversions. The second strategy would be to focus

[5] With limited funds and the high cost of screening, both programs have been forced to prioritize diversions on which to install screens. The Bureau's program prioritizes based on size, location, number of species impacted, and cost, whereas DFG's program prioritizes screening of diversions based on the likelihood and level of impact on federal and state listed endangered species. To date, most screens have been installed on the largest diversions upstream of the Delta under the assumption that larger diversions entrain a disproportionately higher number of fish than smaller diversions, although there is some uncertainty regarding this assumption. Both programs have relied on internal and CALFED ERP funds and regularly partner with the Family Water Alliance, a non-profit organization that has acted as the program manager of the Sacramento River Small Diversion Fish Screen Program since 1996.

on the many smaller diversions, which are cheaper to screen per unit capacity. The relative benefit of these two approaches for covered species will be evaluated based on the results of the DFG study described above.

For the first element of this conservation measure, the BDCP Implementing Entity will enter into Memoranda of Agreements (MOAs) or similar binding instrument with the Bureau of Reclamation and DFG as described in Section 3.4.3.1.

For the second element of this conservation measure, the BDCP Implementing Entity will enter into contracts or similar binding instruments with non-project diverters that would describe respective roles and obligations for expenditure of BDCP funding. Elements of the contracts will include a description of specific actions that would be funded by BDCP, preparation and approval of project designs, BDCP funding levels, provisions for documenting work performed, access to conduct effectiveness monitoring, and provisions for modifying or terminating the contracts.

The conservation measure could include, but is not limited to, any of the following methods:

- Removal of individual diversions with large impacts on covered fish species,
- Consolidation of multiple diversions to a single or fewer diversions placed in lower quality habitat would reduce entrainment of covered fish species,
- Relocation of diversions with large effects on covered species from high quality to lower quality habitat[6],
- Relocation of diversions to areas of lower habitat quality,
- Reconfiguration of individual diversions in high quality habitat to take advantage of small scale distribution patterns and behavior of covered fish species relative to the location of individual diversions in the channel[7], and
- Voluntary alteration of the daily and seasonal timing of irrigation. The practicability of this approach is dependent on the crop being grown, the season when irrigation is needed relative to season fish distribution patterns, and the diel activity patterns of the covered fish species in the area of the diversion[8].

Problem Statement. There are approximately 2,200 water diversions within the Delta (Figure 3.9) and an additional 1,000 in place along the Sacramento and San Joaquin Rivers and their tributaries outside of the Delta and the Suisun Marsh (Herren and Kawasaki 2001). A coarse estimate of 22,000 cfs has been calculated as the total

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[6] High quality habitat includes potential spawning areas, important migration pathways, or known centers of distribution. Low quality habitat includes back channels with limited connectivity to main Delta channels or areas that are close to other sources of stress.

[7] For example, if the diversion were located in an area with high abundance of sturgeon, the diversion should be off the bottom. If the diversion is located in an area of high Chinook salmon or splittail abundance, the diversion should be off shallow slopes. Other aspects that could be modified include proximity to non-native predator habitat and orientation, shape, and design of the distal end, or movement of the intake to a groundwater well location adjacent to the channel.

[8] The agricultural irrigation period in the Delta is generally between April and August, depending on the crop. The early part of this season coincides with the presence of juveniles of all nine covered fish species in the Delta. Combined with a comprehensive monitoring plan determining the spatio-temporal patterns on a real-time basis, diversion operations could be altered when covered species are in the vicinity of a diversion. Many covered fish species appear to exhibit diel patterns of activity (Grimaldo 2006, Webb et al. 2006b, Wilder and Ingram 2006) that could be used to determine diel timing of diversion operations. The goal would be to divert when covered fish species are not near in-channel location of the diversion.

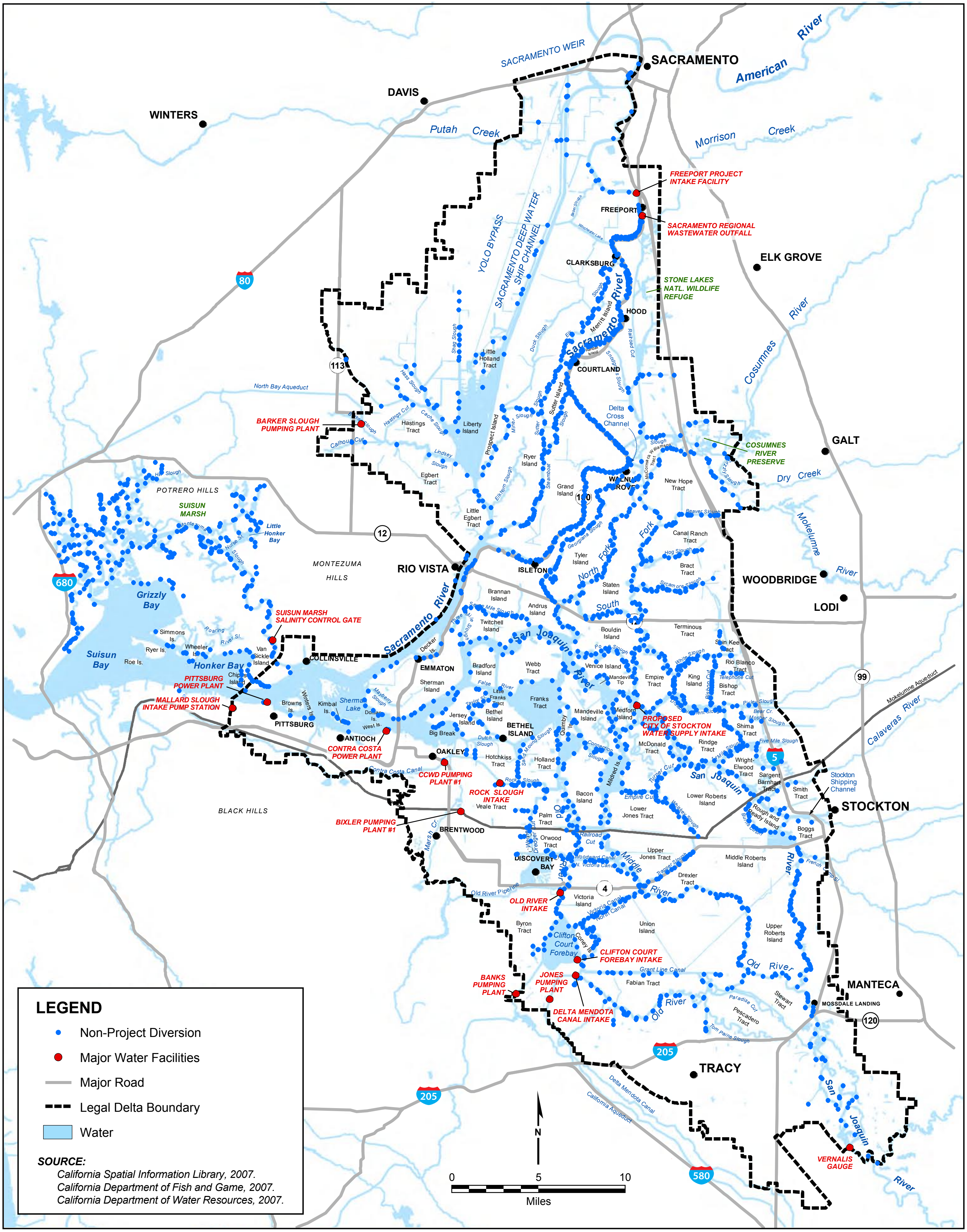

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Figure 3.9
Locations of Non-Project Diversions in the BDCP Planning Area and Suisun Marsh

capacity of these diversions. The majority divert water to agricultural fields between April-August, depending on the crop. This diversion timing partially overlaps with the presence of many covered species in the Delta (generally January-July). Over 95% of these water diversions are not screened to reduce fish entrainment (Herren and Kawasaki 2001). Given this information, the potential for significant entrainment of fish is high (Hallock and Van Woert 1959 as cited Moyle and White 2002). Limited studies indicate that screens over such diversions have been at least 99% effective in reducing fish entrainment into them, even for larval fish <25 mm (Nobriga et al. 2004).

Hypotheses. The screening, removal, relocation, consolidation, modification and/or alteration in the timing of non-project diversions is hypothesized to:

- reduce entrainment mortality by non-project diversions of covered fish species, including larval and juvenile delta and longfin smelt (Cook and Buffaloe 1998, Nobriga et al. 2004), juvenile green (Cook and Buffaloe 1998, CDFG 2002, Nobriga et al. 2004) and white sturgeon (Cook and Buffaloe 1998, Nobriga et al. 2004, R. Garz, CDFG pers. comm.), juvenile splittail (Young and Cech 1996, Sommer et al. 1997, 2007, Cook and Buffaloe 1998, Moyle et al. 2004, Nobriga et al. 2004, Matica and Nobriga 2005), and fry and juvenile Chinook salmon (all races) and steelhead (Cook and Buffaloe 1998, Nobriga et al. 2004); and
- increase food availability for delta and longfin smelt (Lund et al. 2007, 2008), green sturgeon (Nilo et al. 2006, Wanner et al. 2007), white sturgeon (Brannon et al. 1984, Buddington and Christofferson 1985, Muir et al. 2000), splittail, Chinook salmon (all races), and steelhead through reduced entrainment of phytoplankton and zooplankton from the Delta.

Adaptive Management Considerations. The BDCP Implementing Entity may adjust its strategies for selecting diversions to be relocated or consolidated, modify intake designs, or adjust funding levels through the BDCP adaptive management process based on monitoring results and other relevant information (e.g., monitoring and research conducted by others). If results of monitoring indicate that screening of non-project diversions does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity in coordination with Fishery Agencies may terminate this conservation measure. If terminated, remaining funding would be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

OSCM24. Reduce the effects of predators on covered fish species by conducting localized predator control of high predator density locations. The BDCP Implementing Entity will reduce the effects of predators on covered fish species by conducting localized predator control using a variety of methods in locations in the Delta that are known to have high densities of predators ("predator hot spots"). The estimated cost would be $___ in 20__ dollars over the term of the BDCP. The BDCP Implementing Entity will examine existing bathymetry data, fish monitoring data, and radio and acoustic tagging study results to determine the locations and causes of predator hot spots throughout the Delta. Locations of hot spots likely include areas with physical parameters that favor predators, such as deep holes, shaded areas around docks and marinas, abrupt depth changes, and release sites for salvaged fish from CVP/SWP facilities The BDCP Implementing Entity will use a variety of methods to control predator populations in hot spots, including modification of channel geometry, targeted removal of predators, and/or other focused methods as dictated by site-specific conditions and intended outcome/goal. Preference for which hot spots to remove will be given to areas of high overlap with covered fish species, such as major migratory routes or spawning and rearing habitats. Site specific control plans will be developed in consultation with the Fishery Agencies, which include expected benefits, methods, and a monitoring design that will provide information necessary to determine the effectiveness of the action.

Problem Statement. Although a natural part of the estuarine ecosystem, predation in the Delta has been identified as a stressor to BDCP covered fish species (DRERIP models). Habitat for fish predators generally consists of a specific suite of attributes that allow them to forage more efficiently, such as dark locations adjacent to light locations or deep pools that allow the predator to hide and ambush their prey. There are multiple locations in the Delta that contain these physical attributes and attract predatory fish that prey upon covered fish species.

Hypotheses. Conducting localized predator control at hot spots using in the Delta a variety of control methods is expected to reduce local predator abundance, thus reducing predation mortality of Chinook salmon (ODFW 1998, Lindley and Mohr 2003), steelhead (ODFW 1998), Sacramento splittail (Moyle et al. 2004), and delta smelt (Stevens 1966, Moyle 2002), and possibly longfin smelt (Nowak et al. 2004), green sturgeon (J. Israel pers. obs.), and white sturgeon.

Adaptive Management Considerations. Monitoring will consist of assessing the abundance, distribution, and size of predator species before and after implementation of predator control in hot spots to determine the performance of the action. In addition, survivorship of covered species will be monitored using acoustic tagging studies or similar techniques.

The BDCP Implementing Entity in consultation with the Fishery Agencies will use results of effectiveness monitoring to determine whether the action result in measurable benefits to covered fish species and to identify adjustments to funding levels, methods, or other related aspects of the program that would improve its biological effectiveness. Such changes, once approved through the adaptive management decision making process, will be effected through subsequent annual work plans. If results of monitoring indicate that the action does not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate this conservation measure. If terminated, remaining funding will be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

OSCM25. Improve the survival of outmigrating juvenile salmonids by using non-physical barriers to re-direct them away from channels in which survival is lower. The BDCP Implementing Entity will install __ non-physical barriers at the junction of channels with low survival of outmigrating juvenile salmonids to deter fish from entering these channels. Potential locations may include the Head of Old River, the Delta Cross Channel, Georgiana Slough, Turner Cut, Columbia Cut, the Delta Mendota Canal intake, and Clifton Court Forebay (Figure 3.10). For each barriers, the estimated total cost would be $____ in 20__ dollars for the first year

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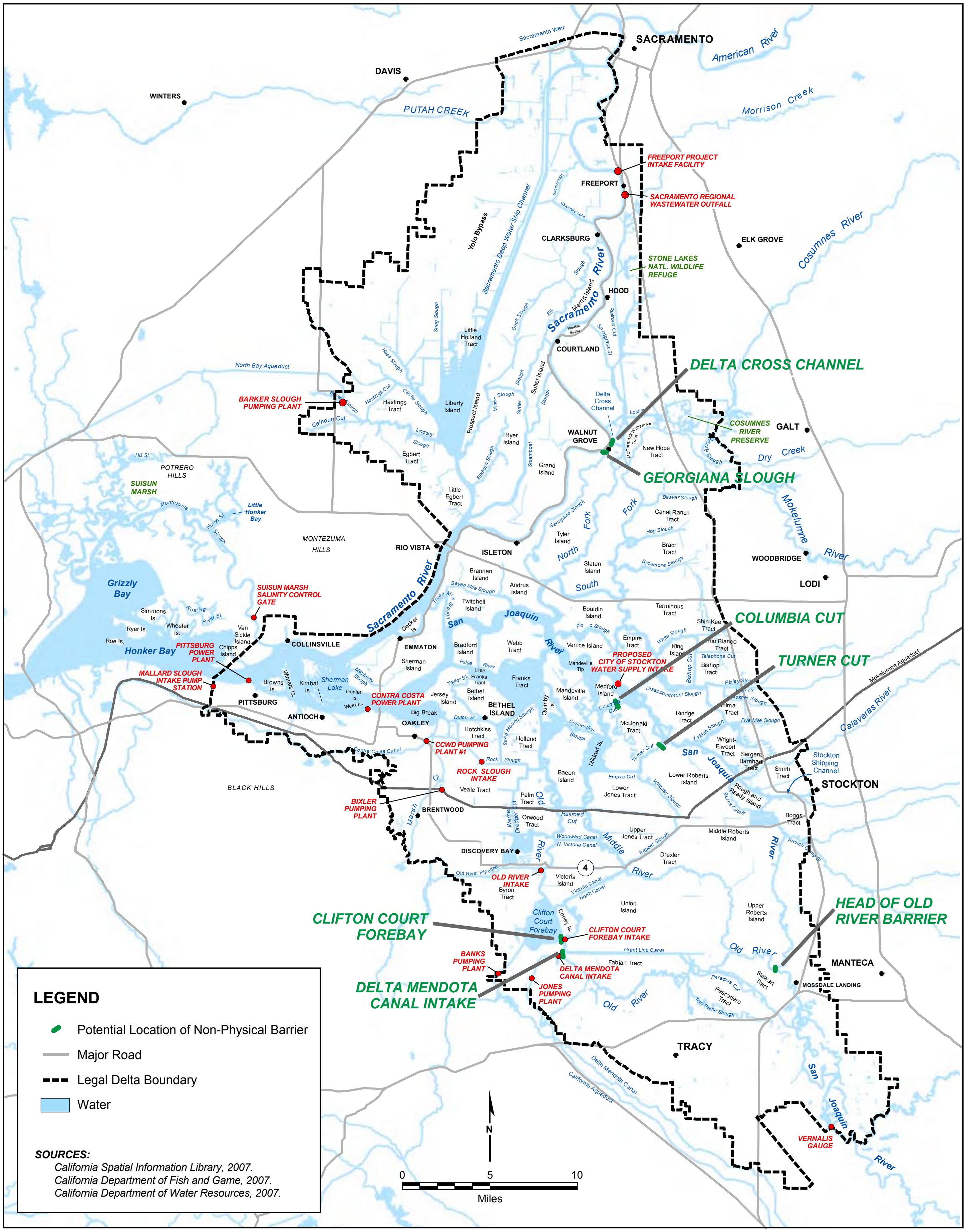

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Figure 3.10
Potential Locations of Non-Physical Barriers

and $____ in 20__ dollars for annual operations and maintenance costs after the first year. Non-physical barriers will include a combination of sound, light, and bubbles similar to the three-component barrier used in the 2009 DWR Head of Old River Non-Physical Barrier Test Project (M. Holderman pers. comm.). Barriers will be installed and operated during October-June or when Fishery Agencies monitoring determines that salmonid smolts are present in the Delta. Other locations may be considered in the future by the BDCP Implementing Entity if, for example, future research demonstrates differential rates of survival in Sutter and Steamboat Sloughs relative to the mainstem Sacramento River or in the Yolo Bypass relative to the mainstem Sacramento River. Previous evidence suggests that, under a barrier configuration that was effective in deterring salmon smolts, the barrier was not effective in deterring delta smelt (Bowen et al. 2008). It is currently not known whether this was a result of the configuration (e.g., sound frequency) of the barrier or the poor swimming ability of delta smelt that was swamped by high flows (Bowen et al. 2008). If demonstrated to be effective in deterring delta smelt and longfin smelt and deemed necessary by the Fishery Agencies, non-physical barriers could also be installed at the mouths of Old and Middle Rivers and in Three Mile Slough (if salinity manipulation is not needed) to deter these species from moving into these channels.

Problem Statement. Juvenile salmonids experience low survival rates while migrating through the Delta towards the ocean. Survival rates vary among routes taken through the Delta (Brandes & McLain 2001, Perry and Skalski 2008), likely as a result of differential exposure to predation, entrainment mortality at state and federal water export facilities and small agricultural diversions, and other factors (J. Burau pers. comm.).

Physical barriers have been used in the Delta, such as the Delta Cross Channel gates and the rock barrier at the Head of Old River, to prohibit the entry of fish into channels where survival rates are low. Physical barriers are effective at prohibiting entry of salmonids into channels, but also alter flow dynamics in these channels, likely affecting tidal flows, sediment loads, bathymetry, water supply reliability, potential for noxious algal blooms, toxic concentrations, and other water quality parameters. However, operation of non-physical barriers is predicted to cause smaller changes in the physical configuration of the channel, thus reducing flow-related effects, while improving survival of salmonids by deterring them from entering channels with a higher risk of mortality.

Hypotheses. Installation and seasonal operation of non-physical barriers is hypothesized to improve survival of juvenile salmonids migrating downstream (Welton et al. 2002). The three component non-physical barrier has shown promising results in laboratory experiments on Chinook salmon that emulated the Sacramento River/Georgiana Slough flow split (Bowen et al. 2008) and a field experiment on Atlantic salmon (*Salmo salar*) smolts in the River Frome, UK (Welton et al. 2002). In addition, preliminary evidence suggests that the barrier was effective in deterring acoustically-tagged Chinook salmon juveniles from entering the head of Old River during a 2009 pilot study (M. Holderman pers. comm.). Sound is known to affect the behavior of salmonids (Vanderwalker 1967, Knudsen et al. 1992, 1994). By keeping juvenile salmonids out of channels that are known to have lower salmonid survival, fish can avoid the sources of lower survival observed in these channels.

Adaptive Management Considerations. The BDCP Implementing Entity will conduct and review monitoring to assess the effectiveness of using non-physical barriers. The BDCP Implementing Entity will use results of effectiveness monitoring to determine whether operations of non-physical barriers result in measurable benefits to juvenile salmonids and to identify adjustments to funding levels, methods, or other related aspects of the program that would improve the biological effectiveness of the program. Such changes, once approved through the adaptive management decision making process, will be effected through subsequent annual work plans. If results of monitoring indicate that operations of non-physical barriers do not substantially and cost-effectively benefit covered fish species, the BDCP Implementing Entity, in coordination with Fishery Agencies, may terminate this conservation measure. If terminated, remaining funding will be deobligated from this conservation measure and reallocated to augment funding for other more effective conservation measures identified in coordination with the Fishery Agencies through the BDCP adaptive management process.

3.4.4 Avoidance and Minimization Measures for Covered Wildlife and Plant Species

[***Note to Reviewers:*** *The avoidance and minimization measures are under development by the BDCP Terrestrial Resources Subgroup and will be presented to the Steering Committee in subsequent versions of Chapter 3.]*

3.5 Monitoring and Research Program

[***Note to Reviewers***: *The text of this section of Chapter 3, including the approaches to monitoring and research described, is subject to change and revision as the BDCP planning process progresses. This section, however, has been drafted and formatted to appear as it may in a draft HCP/NCCP. Although this section includes declarative statements (e.g., the Implementing Entity will…), it is nonetheless a "working draft" that will undergo further modification based on input from the BDCP Steering Committee, state and federal agencies, and the public.*]

This section describes the elements of the BDCP monitoring and research program. The monitoring and research program has been designed to provide a means by which information necessary to implement the BDCP over time will be collected and compiled, and the adaptive management decision making process informed by the best available science. The monitoring program is consistent with the guidance provided by the U.S. Fish and Wildlife Service's Five-Point Policy for HCPs (65 FR 106, June 1, 2000) and provisions of the Natural Community Conservation Planning Act (NCCPA) (Fish and Game Code Sections 2810(a)(7)). As described in the Five-Point Policy, the monitoring program of a conservation plan should generate information sufficient to guide plan implementation, particularly with respect to the following matters (65 FR 106, June 1, 2000; 35254):

> "(1) assess the implementation and effectiveness of the HCP terms and conditions (e.g., financial responsibilities and obligations, management responsibilities, and other aspects of the incidental take permit, HCP, and the IA, if applicable); (2) determine the level of incidental take of the covered species; (3) determine the biological conditions resulting from the operating conservation program (e.g., change in the species' status or a change in the habitat conditions); and (4) provide any information needed to implement an adaptive management strategy, if utilized. An effective monitoring program is flexible enough to allow modifications, if necessary, to obtain the appropriate information."

The BDCP research program will be implemented to address specific scientific questions regarding covered species, natural communities, and ecosystem processes to increase the base of knowledge about these resources such that conservation measures can be adaptively implemented to advance biological goals and objectives. While HCPs and NCCPs are not specifically required to include research programs, the ecological complexity of the Delta and the high level of uncertainty regarding the level of anticipated beneficial outcomes for covered species resulting from some of the conservation measures highlight the need for focused research to better inform BDCP implementation. Existing research programs (particularly those funded under the Interagency Ecological Program and CALFED Science Program) have produced a broad range of valuable research results and conclusions. The BDCP research program may provide funding for research on specific hypotheses important to more effective implementation of the Conservation Strategy. Many of these hypotheses are stated within the BDCP conservation measures in section 3.4 *Conservation Measures*.

Consistent with regulations and policies, the BDCP monitoring and research program will be conducted primarily to:

- document compliance with terms and conditions of BDCP permits, including limits set by the permits on the incidental take of covered species;
- increase and refine scientific understanding of the effects of the covered activities (described in Chapter 4, *Covered Activities*) on covered species and natural communities;
- collect data necessary to effectively implement conservation measures;
- document and evaluate the progress toward meeting specifically identified targets established for conservation measures;
- document and evaluate the effectiveness of conservation measures in achieving BDCP biological goals and objectives;
- determine the sufficiency of the scientific hypotheses on which the assessment of effects and effectiveness are based; and
- assess progress towards achieving the biological goals and objectives both specific to conservation actions and Delta-wide.

3.5.1 Responsibility for the Monitoring and Research Program

The BDCP Implementing Entity is responsible for implementing the BDCP monitoring and research program. However, program components will likely be conducted by multiple parties, including staff of the Implementing Entity or, with the oversight of the Implementing Entity, other BDCP participants (e.g., DWR, Reclamation, Fishery Agencies), other entities implementing conservation actions ("supporting entities" such as those tasked to implement some of the other stressor conservation measures), academic institutions, consulting firms, or other qualified entities. As described under Section 3.5.4, monitoring conducted under existing programs implemented by other entities (e.g., CALFED Science Program, Interagency Ecological Program, Central Valley Regional Water Quality Control Board) may also be used by the BDCP Implementing Entity to assess the effectiveness of BDCP conservation measures in achieving biological goals and objectives. The BDCP Implementing Entity, however, is responsible for ensuring that monitoring and research efforts undertaken by others on behalf of the BDCP are sufficient for the purposes of BDCP implementation requirements.

3.5.2 General Requirements for Various Types of Monitoring

The Implementing Entity will conduct several types of monitoring to ensure the success of the Conservation Strategy. The general types of monitoring required are described in this section.

Preconstruction Surveys

As specified in Section 3.4.4 *Avoidance and Minimization Measures*, preconstruction surveys are required for specifically identified covered species, prior to the implementation of certain covered activities and conservation measures (e.g., tidal habitat restoration actions that would remove existing terrestrial habitat) that may affect covered species or their habitats. The potentially affected area will be surveyed to determine if covered species are present and likely to be affected by the activity. Survey results will be used by the Implementing Entity to determine the need to implement measures described in Section 3.4.4 to avoid and minimize impacts on covered species and natural communities related to the covered activity or conservation measure.

Construction Monitoring

Monitoring of construction activities will be conducted during the construction of various proposed facilities (both covered activities and conservation measures), including habitat restoration projects. Construction monitoring is required to ensure that avoidance and minimization measures are properly carried out where specific sensitive occurrences covered species (e.g., an active nesting site for a covered bird species or a population of a highly restricted covered plant species) have been identified at or adjacent to a construction site. The Implementing Entity will: (1) monitor implementation of covered activities to ensure that any applicable avoidance and/or minimization measure is properly and effectively implemented, and (2) ensure that conservation measures are implemented in accordance with specifications and plans.

Compliance Monitoring

The purpose of compliance monitoring is to: (1) track progress of BDCP implementation in accordance with established timetables, and (2) ensure compliance with terms and conditions of the BDCP and its associated permits. Compliance monitoring will be undertaken for all conservation measures, whether implemented directly by the BDCP Implementing Entity or by other supporting entities through contracts, memoranda of agreement, or other agreements with the BDCP Implementing Entity. Compliance monitoring will be conducted to ensure that conservation measures are meeting specified permit terms. These permit terms are characterized as specific values for metrics assessed in compliance monitoring (permit terms for conservation measures are identified in Table 3.13).

The Implementing Entity will conduct monitoring for: (1) water operations conservation measures to assess compliance with permit terms for flow and salinity conditions and screen performance, (2) physical habitat restoration conservation measures to assess progress toward meeting plan requirements (e.g., vegetation composition and structure, ecological functions), and (3) for other stressors conservation measures to assess the success in meeting permit terms for the particular metrics used to addressing the stressor (e.g., effectiveness of submerged and floating aquatic vegetation control methods in reducing the extent of submerged and floating aquatic vegetation in specified locations). Results of compliance monitoring will also be used by the Implementing Entity to evaluate the relative success of different implementation methods to improve the effectiveness of future conservation actions.

Results of compliance monitoring would be used by the Implementing Entity to determine if BDCP implementation should be adjusted under the BDCP adaptive management program (see Section 3.6, *Adaptive Management Program*) to ensure that compliance with permit terms is achieved.

The BDCP Implementing Entity will also establish quantifiable thresholds to serve as adaptive management triggers for some conservation measures (see Table 3.13). These adaptive management triggers would serve to signal the need to improve the performance of conservation measures and allow for adjustments to be made through the adaptive management program. Adaptive management triggers, and other indicators and targets, may be modified during the course of plan implementation through the adaptive management process described in Section 3.6, *Adaptive Management Program*, as new information becomes available.

Effectiveness Monitoring

Effectiveness monitoring assesses ecosystem and covered species responses to the implementation of conservation measures and monitor progress made toward achieving biological goals and objectives (metrics and targets for biological goals are identified in Table 3.12). This effectiveness monitoring will be undertaken for water operations, physical habitat restoration, and other stressors conservation measures implemented by the BDCP Implementing Entity and for conservation measures that may be implemented by supporting entities. Results of effectiveness monitoring will inform the Implementing Entity as it considers adjustments to implementation through the adaptive management program (see Section 3.6, *Adaptive Management Program*). For some conservation measures specific adaptive management triggers are included that identify conditions under which targets are not likely to be achieved and adaptive changes must be considered (see Table 3.13). The effectiveness monitoring requirements for specific conservation measures are designed to collect information necessary to improve their effectiveness over time and to resolve the uncertainties and address the potential risks identified through the DRERIP evaluation of draft conservation measures (see Appendix X, *DRERIP Evaluations*).

BDCP covered species will be monitored to assess individual and population responses to conservation measures that have been implemented. Specific attributes of the aquatic ecosystem that are necessary for the survival and recovery of covered fish species will also be monitored to determine if conservation measures are effectively improving critical physical and biological conditions of the Delta and Suisun Bay. Effectiveness monitoring will also be used to determine whether any undesirable consequences may be associated with the implementation of specific conservation measures.

Effectiveness monitoring will be closely coordinated with the BDCP research program and adaptive management program. It is anticipated that the extent of effectiveness monitoring will be reduced over time as causal relationships between the implementation of conservation measures and the responses of covered species and ecosystems to those measures are better understood (as a result of knowledge gained under the BDCP monitoring and research program and other research programs). For example, if relationships between restoration of tidal marsh and zooplankton production are established through monitoring and research on initially restored tidal marshes, then effectiveness monitoring for assessing the production of zooplankton associated with subsequent restoration of tidal marsh may be reduced or no longer required.

System Monitoring

System monitoring is conducted to assess the overall status, trends, and distribution of selected covered species populations; the responses of aquatic ecosystem processes that support covered fish species; and the status of covered natural communities, including the ecological functions they provide covered species over the term of the BDCP. System monitoring will also be conducted to assess the status and trends of important aquatic ecosystem functions that support covered species and natural communities. System monitoring is important to provide context for interpretation of results of effectiveness monitoring and other monitoring and research. It also provides the BDCP Implementing Entity with information necessary to make implementation adjustments through the BDCP adaptive management process in advance of large-scale changes that appear forthcoming.

Covered Fish Species. The status and distribution of, and trends related to, covered fish species will be monitored within the BDCP Planning Area and Suisun Marsh over the term of the BDCP. System monitoring for covered fish species will provide the BDCP Implementing Entity with information sufficient to track long-term changes attributable to any of a number of factors (e.g., covered activities, climate change, activities of others) that may affect the status, trends, and distribution of covered fish species. The results of these monitoring efforts will also provide documentation of the contribution of the BDCP toward the conservation of covered fish species and inform system-level assessments of status, trends, and distribution.

As part of system monitoring, the BDCP Implementing Entity will review relevant scientific data collected for covered fish species whose range and life stage distribution extends beyond the BDCP Planning Area as it becomes available. Review of information gathered outside of the BDCP Planning Area will be sought to further inform assessments of the status and trends relating to covered fish species within the BDCP Planning Area and for making adjustments to BDCP implementation through the adaptive management process.

Initially, system monitoring will be conducted annually during periods associated with the life stages of covered species. If populations of covered species reach levels established by the BDCP biological goals and objectives, and strong relationships between the response of covered fish species and conservation measures have been established, the frequency of system monitoring for those covered fish species may be modified by the BDCP Implementing Entity. System monitoring for covered fish species, however, will be conducted at intervals of no less than every __ years over the term of the BDCP. It is anticipated that most system monitoring for covered fish species will be conducted through ongoing monitoring programs implemented by other entities (see Section 3.5.4).

Covered Wildlife and Plant Species. [To come.]

Covered Natural Communities. The BDCP Implementing Entity will monitor the range and distribution of natural communities within the BDCP Planning Area at __-year intervals over the term of the BDCP. System monitoring of covered natural communities will provide the BDCP Implementing Entity with information sufficient to track long-term changes in the distribution and extent of covered natural communities attributable to any of a number of factors that may affect the communities (e.g., covered activities, climate change, activities of others). The results of these monitoring efforts will also provide documentation of the contribution of the BDCP towards maintaining and improving the extent, distribution, and continuity of covered natural communities. The baseline conditions from which changes in the range and distribution of natural communities will be assessed are the conditions described in Chapter 2, *Existing Ecological Conditions*.

Aquatic Ecosystem Functions and Attributes. Within the BDCP Planning Area, the Implementing Entity will monitor functions and attributes of the aquatic ecosystem that are important to the viability of covered fish species and aquatic natural communities. System monitoring of aquatic ecosystem conditions will provide the BDCP Implementing Entity with information necessary to track long-term changes in important functions and attributes of the aquatic ecosystem attributable to all factors affecting the aquatic ecosystem (e.g., covered activities, climate change, activities of others) and to document the contribution of the BDCP toward maintaining and improving aquatic ecosystem functions in support of the covered fish species.

The BDCP Implementing Entity will use the best available information and data regarding the Delta aquatic ecosystem to establish markers from which to assess future changes in ecosystem functions and attributes. Depending on the type and extent of data gaps, the BDCP Implementing Entity may, at the outset of plan implementation, collect additional information to better understand existing conditions. Initially, system monitoring will be conducted annually to detect responses in the aquatic ecosystem as covered activities and conservation measures are implemented. If strong relationships between the response of specific ecosystem functions and attributes and conservation measures are established, the frequency of system monitoring for those monitoring elements of the plan may be modified by the BDCP Implementing Entity in future years through the adaptive management process. System monitoring for aquatic ecosystem functions and attributes, however, will be conducted at intervals of no less than __ years. It is anticipated that most aquatic ecosystem system monitoring will be conducted through ongoing monitoring programs implemented by other entities (see Section 3.5.4).

3.5.3 Development of Specific Monitoring Plans

The BDCP Implementing Entity will prepare detailed monitoring plans tailored to specific conservation measures and based on the monitoring requirements, metrics, and targets identified in Table 3.13. These monitoring plans will be developed prior to implementation of the applicable conservation measures. The plans will include survey protocols for monitoring efforts related to preconstruction, construction, compliance, and effectiveness. In most instances, existing and generally accepted monitoring protocols (e.g., USFWS survey protocols for listed species, protocols for monitoring status and trends in abundance and distribution of covered fish species) will be adopted by the BDCP Implementing Entity, as appropriate. In some cases, however, the Implementing Entity will need to develop specific monitoring protocols to assess a conservation measures.

The specific contents of each specific monitoring plan may vary depending on its purpose. The monitoring plans, however, will generally include the following types of information:

- description of the purpose and objectives of the monitoring (e.g., assessing progress towards achieving a biological objective);
- description of monitoring protocols, including sampling design and justification supporting the validity of monitoring methods and sampling design;
- analytical methods for assessing monitoring results;
- procedures for validating monitoring data and methods;
- monitoring schedule, duration, and rationale;
- content requirements and submission schedule for monitoring reports;
- monitoring data storage procedures;
- analytical methods for the assessment data and presentation of results
- references, including printed references and personal communications;
- provisions for documenting subsequent revisions to the monitoring plan; and
- other information pertinent to specific monitoring plans.

Because monitoring results are a primary source of information to allow for adaptations to occur over the course of plan implementation and to measure progress toward achieving the BDCP biological goals and objectives, monitoring plans must be based on the best available information and subject to rigorous standards, including statistically sound sampling designs. To ensure defensibility of the BDCP monitoring plans, protocols, and sampling designs, the Implementing Entity will provide for internal science-based review of these monitoring elements as a routine matter, and provide for external science review, as necessary and appropriate.

3.5.4 Integration of Monitoring and Research with Other Programs

Monitoring of covered species and ecosystem conditions that are relevant to BDCP implementation is currently undertaken by a number of entities, including DFG, DWR, USFWS, Reclamation, and UC Davis (see Table 3.11). These monitoring efforts are being implemented either as conditions of existing regulatory authorizations or as part of programs to study and analyze the Bay-Delta ecosystem and fisheries (e.g., Interagency Ecological Program, CALFED Science Program). The Implementing Entity will coordinate with entities implementing these monitoring programs and will use data collected through these programs, as appropriate, to evaluate the effectiveness of the BDCP Conservation Strategy in achieving biological goals and objectives and to assess the long-term status and trends of covered fish species populations and ecosystem conditions (see Section 3.5.5.4, *System Monitoring* below).

[***Note to Reviewers:*** *this table is incomplete and will be expanded in subsequent document versions.*]

Table 3.11. Existing Bay Delta Monitoring Programs Anticipated to Provide Data in Support of the BDCP Monitoring Program

Monitoring Program	*Agency*	*Primary Purpose*	*Available data for BDCP*
Spring Kodiak trawl	DFG	Monitors spawning adult delta smelt distribution, relative abundance, and reproductive status, January-May, 2002-present	Spawning abundance index, distribution, sex ratios, reproductive status (e.g., pre-spawn, mature, or spent)
20 mm townet survey	DFG	Monitors post larval-juvenile delta smelt distribution and relative abundance, March-June, 1995-present	Post larval and juvenile abundance index, distribution, length frequency
Summer townet survey	DFG	Monitors striped bass and delta smelt abundance indices, July-August, 1959-present	Delta smelt: juvenile delta smelt abundance index, distribution, and length frequency. Longfin smelt: post larval juvenile longfin smelt abundance index, distribution, and length frequency. Sacramento splittail: YOY splittail, distribution, and length frequency
Fall midwater trawl	DFG	Monitors striped bass and delta smelt abundance indices, September-December, 1967-present	Delta smelt: Pre-adult delta smelt abundance index. Longfin smelt: Pre-adult longfin smelt abundance index. Sacramento splittail: Abundance of all size classes
Smelt larval study	DFG	Monitors longfin smelt larvae distribution and relative abundance, January 2009-present	Larval abundance index and distribution

Table 3.11. Existing Bay Delta Monitoring Programs Anticipated to Provide Data in Support of the BDCP Monitoring Program

Monitoring Program	Agency	Primary Purpose	Available data for BDCP
Bay Study	DFG	Monitors abundance indices for a variety of species in South San Francisco and Suisun Bays, Year-round, 1980-present	Delta smelt: Juveniles-adult delta smelt abundance index. Longfin smelt: Juveniles-adult longfin smelt abundance index. Sacramento splittail: Young of year and older splittail abundance
Suisun Marsh fisheries monitoring program	UC Davis	Monitors abundance of all fish species in Suisun Marsh, Year-round, 1979-present	Delta smelt: Juveniles-adult delta smelt abundance, distribution within Suisun Marsh. Longfin smelt: Juveniles-adult longfin smelt abundance, distribution within Suisun Marsh. Sacramento splittail: Abundance of all size classes, distribution within Suisun Marsh.
Fish salvage monitoring	DWR, DFG, USBR	Monitors entrainment and salvage of all fish species, Year-round, 1979-present	Delta and longfin smelt: 20 mm post larvae-adult smelt abundance. Sacramento splittail: Abundance of all size classes >20 mm and length frequency. Salmonids: >20 mm larvae-adults abundance. Sturgeon: >20 mm juvenile sturgeon abundance.
Chipps Island, Mossdale, and Sacramento trawls	USFWS	Monitors fish abundance and distribution in mid-channel at surface at Chipps Island, Mossdale (RM 54), and Sacramento (RM 55), and survival through the Delta, targets Chinook salmon, Year-round, 1976-present	Salmonids: juvenile abundance, distribution, length frequency, survival indices (of hatchery tagged fish) to Chipps Island Delta smelt: >25 mm abundance, distribution, and length frequency. Longfin smelt: >25 mm abundance and distribution, and length frequency. Sacramento splittail: >25 mm abundance and distribution, and length frequency.
Beach seines	USFWS	Monitors fish abundance and distribution throughout the Delta, upstream Sacramento River, northern San Francisco and San Pablo Bays, targets Chinook salmon, Year-round, 1976-present	Sacramento splittail: >25 mm young of year splittail abundance, distribution, and size frequency. Salmonids: juvenile salmonids, abundance, distribution, and size frequency.
Chinook salmon escapement estimates (Grandtab database)	DFG, DWR	Grandtab collects all races of Chinook salmon escapement	Salmonids: adult returns to spawning grounds by race and location
Suisun March otter trawl	UC Davis	Monitors abundance of all fish species in Suisun Marsh, Year-round, 1979-present	Chinook salmon: juvenile abundance and distribution within Suisun Marsh
Adult sturgeon tagging study	DFG	Tag-recapture (via creel surveys) of green (prior to being listed) and white sturgeon for abundance and population dynamics	White and green sturgeon: abundance, distribution, population dynamics, length frequency, annual harvest rates, and migration rates.

3.5.5 Specific Monitoring Requirements, Metrics, and Targets

[***Note to Reviewers:*** *Compliance and effectiveness monitoring metrics, targets, methods, and adaptive management responses and triggers, and specific target values for the metrics that constitute achievement of biological objectives are under development.*]

Monitoring Metrics and Targets for Biological Objectives

Each BDCP biological objectives was developed to be measurable using one or more metrics. Monitoring metrics and targets for each BDCP biological objective are provided in Table 3.12.

Table 3.12. Monitoring Requirements, Metrics, and Targets for BDCP Biological Objectives

[***Note to Reviewers:*** *Table 3.12 will contain a description of specific monitoring metrics and targets for each BDCP biological objective. This table is under development and will contain a substantial amount of information. The Steering Committee has approved the formation of a group of technical experts to advise on the development of these metrics and targets and this effort will get underway the week of July 20, 2009.*]

Monitoring Metric	***Description of Monitoring Requirements, Metrics, and Targets.***

Monitoring Requirements, Metrics, and Targets for Conservation Measures

Each BDCP conservation measure will be monitored using the various types of monitoring described in section 3.5.2, *General Requirements for Various Types of Monitoring*. Table 3.13 provides details of the compliance and effectiveness monitoring requirements, metrics, targets, and adaptive management triggers for each BDCP conservation measure.

Table 3.13. Monitoring Requirements, Metrics, Targets, and Adaptive Management Triggers for BDCP Conservation Measures.

[***Note to Reviewers:*** *Table 3.13 will contain a description of specific compliance and effectiveness monitoring requirements, metrics, targets, and adaptive triggers for each conservation measure. This table will contain a substantial amount of information. The Steering Committee has approved the formation of a group of technical experts to advise on the development of these metrics and targets and this effort will get underway the week of July 20, 2009.*]

Monitoring Metric	***Description of Monitoring Requirements, Metrics, Targets, and Adaptive Management Triggers***

3.5.6 Analysis of Compliance, Effectiveness, and System Monitoring Data

The BDCP Implementing Entity will ensure quality control of all monitoring data, and will adopt procedures to maintain the highest standards of quality. Steps will be instituted to maintain the accuracy and functionality of gages, meters, and other devices, and protocols will be established to govern the collection, transcription, and storage of data. All monitoring data will be entered into database software (see Section 3.5.8, *Database Development and Maintenance*) and will be made readily available online once quality control analyses have been conducted.

The BDCP Implementing Entity will document all standardized analytical procedures and update procedures as necessary. Particular analyses would be specific to individual monitoring parameters and would consist of classical parametric or non-parametric hypothesis testing and statistical models (e.g., t-tests, ANOVAs, correlations, regressions, etc.) to the extent practicable. If advanced statistical methods are necessary (e.g., multivariate ANOVAs, principle components analysis, Bayesian statistics, etc.), the BDCP Implementing Entity would consult with experts to ensure proper analyses are being conducted. For many parameters, due to high environmental variability, time series analyses will be necessary to assess with confidence whether a trend in a parameter depicts a change that has occurred as a result of a BDCP action. Results of the analysis of monitoring data will feed back into the BDCP adaptive management process to modify and refine conservation measures to maximize benefits to and minimize unanticipated adverse effects on covered species and other components of the aquatic community.

3.5.7 Research and Analytical Tools Development

[***Note to Reviewers:*** *Areas for potential research and analytical tools development are under development and will be revised and expanded as conservation measures are further developed.*]

BDCP Implementing Entity may undertake or contract focused research to develop information necessary to better inform BDCP implementation. The types of research that may be conducted include those related to resolving BDCP-specific uncertainties related to:

- technologies and methods for effectively implementing conservation measures;
- appropriate indicators, targets, and adaptive management triggers;
- the ecological requirements of covered species as they relate to effective implementation of conservation measures; and
- the likely response of covered species to conservation measures.

Results of research would also be used to help direct and prioritize subsequent implementation of conservation measures.

The BDCP Implementing Entity may develop or participate in the development of models and other analytical tools to help inform BDCP implementation. These analytical tools include development of relevant deterministic, statistical, and conceptual models and correlations. To develop these tools, the BDCP Implementing Entity may conduct studies to collect information necessary for their development. Additionally, it is anticipated that the BDCP Implementing Entity will also participate in revising existing tools (e.g., hydrodynamic models) as new information becomes available over the term of the BDCP to improve their utility.

3.5.8 Database Development and Maintenance

The BDCP Implementing Entity will develop and maintain a comprehensive spatially-linked database to track implementation of all aspects of the BDCP. The database would be structured to be "user friendly" and to allow for future expansion and integration with external databases (e.g., linkage to CALFED and Fishery Agency databases). The database would be structured to support the following services:

- data documentation such that future users can determine why, how, and where data were collected (i.e., metadata);
- quality assurance and control of the data and data entry;
- access and use the most current information for analysis and decision making; and
- evaluation of data by all users, as appropriate, and incorporation of corrections and improvements in the data.

Major types of information expected to be maintained within the database include:

- monitoring, research, and adaptive management experiment data and results;
- BDCP funding and expenditures;
- status of covered activities, including implementation and impacts;
- implementation status of conservation measures;
- implementation status of research and adaptive management experiments;
- adopted changes to BDCP implementation through the adaptive management process; and
- all reports and documents generated by the Implementing Entity and relevant data and reports generated by other entities.

The BDCP Implementing Entity may choose to develop a web-linked database to facilitate controlled transference of information into and out of the database by other entities. If the BDCP Implementing Entity chooses to allow access to the database by others, the database will incorporate strict controls and monitoring to ensure the integrity of the database is maintained.

3.5.9 Monitoring and Research Schedule

The general schedule for implementing monitoring is presented in Table 3.14 [*to come*]. Following authorization of the BDCP, the Implementing Entity will develop detailed monitoring schedules for compliance, effectiveness, and system monitoring. In addition, site-specific monitoring schedules will be developed for each BDCP habitat area as they are restored.

Table 3.14. Schedule for Implementing Monitoring

[*to come*]

3.5.10 Reporting

The BDCP Implementing Entity will prepare annual implementation reports that describe survey, monitoring, research, and adaptive management experiment activities and results over the term of the BDCP. Annual implementation reports will summarize the previous calendar year's activities and results and will be completed within an established time frame the following year. Reports will be submitted to the BDCP permitting agencies, permit applicants, and participants. The process for distributing implementation reports is described in Chapter 7, *Implementing Structure*. The BDCP Implementing Entity may also distribute reports as appropriate to other cooperating entities and entities engaged in Delta ecosystem management and research that could benefit from sharing information. The BDCP Implementing Entity will use results of compliance, effectiveness, and system monitoring, and adaptive management experiments to assess BDCP progress towards achieving the biological goals and objectives and to inform adaptive management decision making over the term of the BDCP.

Annual implementation reports, as appropriate to BDCP activities undertaken during the reporting year, should include descriptions of:

- implemented covered activities;
- implemented conservation measures;
- implemented avoidance, minimization, and mitigation measures to address impacts of covered activities and conservation measures on covered species and natural communities;
- effects monitoring activities and results;
- compliance monitoring activities, monitoring results, and a description of implemented remedial actions, if any;
- effectiveness monitoring activities and monitoring results; and
- research activities and results.

Implementation reports will also include year-to-date summaries of the extent to which conservation measures have been implemented and impacts of covered activities and conservation measures on covered species and natural communities.

3.6 Adaptive Management Program

[***Note to Reviewers***: *The text of this section of Chapter 3, including the approach to adaptive management described, is subject to change and revision as the BDCP planning process progresses. This section, however, has been drafted and formatted to appear as it may in a draft HCP/NCCP. Although this section includes declarative statements (e.g., the Implementing Entity will…), it is nonetheless a "working draft" that will undergo further modification based on input from the BDCP Steering Committee, State and federal agencies, and the public.*]

This section describes the BDCP adaptive management program, which will establish a process to ensure that the implementation of the BDCP Conservation Strategy becomes increasingly more effective over time and responsive to changing ecological conditions in the Delta.

Adaptive management is premised on the concept that, as new information and insight is gained during the implementation of a conservation plan. Adjustments will be made to the implementation of the conservation strategies to further advance the goals and objectives of the conservation plan. The NCCPA recognizes this function, defining adaptive management as "the use the results of new information gathered through the monitoring program of the plan and from other sources to adjust management strategies and practices to assist in providing for the conservation of covered species." (Fish and Game Code Sections 2800-2835). Similarly, the U.S. Fish and Wildlife Service and National Marine Fisheries Service describe adaptive management as a "method for examining alternative strategies for meeting measurable biological goals and objectives, and then if necessary, adjusting future conservation management actions according to what is learned." (see Five-Point Policy for HCPs, 65 FR 106, June 1, 2000)

Consistent with these definitions, the BDCP adaptive management program will: (1) identify uncertainties and the questions that will need to be addressed to resolve uncertainties; (2) devise alternative approaches and determine which approaches to implement; (3) integrate with a monitoring and research program to produce information sufficient to evaluate the efficacy of new approaches; and (4) incorporate feedback loops that link implementation and monitoring to a decision-making process that allows for timely and responsive changes in management. Outcomes of the adaptive management decision making process could include revisions to biological objective metrics and targets, conservation measures, monitoring program and monitoring metrics and targets, and analytical tools as warranted by new information (e.g., monitoring data, results of research) within the limits of authorizing permits. The BDCP adaptive management program will be administered by the BDCP Implementing Entity. The roles and responsibilities of the Implementing Entity, the Fishery Agencies, and BDCP permit holders and participants with respect to the implementation of the adaptive management program are described in Chapter 7, *Implementation Structure*.

The conservation measures described in Section 3.4, *Conservation Measures*, have been designed to achieve the BDCP biological goals and objectives and are based on the best scientific and commercial information and data available. Over the term of the BDCP, however, new data and information will be developed and knowledge gained that will further inform the Implementing Entity regarding the efficacy of conservation measures and provide insight into the potential for substantial changes to occur in Delta conditions as a result of climate change (e.g., sea level rise, hydrology in the Delta watershed, and increased water temperatures), seismic events, potential large scale changes in land use, and other factors. As more is understood about the Delta ecosystem, modifications to the implementation of the BDCP conservation measures may be necessary. The adaptive management process will afford the Implementing Entity the flexibility to make these adjustments to address existing and future uncertainties, including modifications, removal, and additions to conservation measures and changes to the monitoring program as indicated by new scientific information (i.e., results of relevant monitoring and research). Should strong cause and effect relationships be established, the adaptive management program will provide the mechanism to concentrate efforts on the implementation of conservation measures that have been demonstrated to be effective and to deemphasize or discontinue implementation of conservation measures that have proven to be less effective at achieving desired outcomes. For example, if removal of submerged aquatic vegetation is shown to provide little benefit to covered fish species and actions to reduce levels of a specific contaminant yield substantial benefits to fish, then efforts to remove submerged aquatic vegetation may be reduced or discontinued and resources diverted to support additional contaminant reduction actions. Similarly, conservation measures related to water operations may be modified to the benefit of water supply if information and analysis suggests that resources would be better directed toward other conservation measures to accomplish certain biological goals and objectives.

To meet the challenge of uncertainty regarding Delta ecological processes and species biology, to provide for flexibility in the Conservation Strategy through time as ecological knowledge expands, and to ensure that the BDCP becomes increasingly more effective over time and responsive to changing ecological conditions in the Delta, the BDCP adaptive management program has been developed with the following elements:

- Process Framework – the process by which the BDCP adaptive management program will be implemented, including gathering data through monitoring and research, analyzing data, assimilating new knowledge, and making adjustments to the strategy (Section 3.6.1);
- Decision Making – a decision making process specifically focused on efficient adaptive management that allows for sufficient input from various participants (Section 3.6.2) under the governance structure of the BDCP (see Chapter 7, Implementation Structure);
- Adaptive Ranges – specifically stated upper and lower limits to changes to some conservation measures that would be encompassed within the BDCP permit authorizations and that provide for future adjustments in performance criteria in instances where BDCP objectives are not being met or are being substantially exceeded (Section 3.6.3);
- Adaptive Triggers – identified levels of performance at which adaptive management adjustments must be evaluated and undertaken;
- Adaptive Experiments – adaptive management experiments and pilot studies specifically to test the hypotheses underlying conservation measures to rapidly gain knowledge that could improve performance;
- Status Reviews – required periodic reviews of the monitoring program, overall conservation strategy performance, achievement of goals and objectives, and status of covered species.

This adaptive program of knowledge expansion and implementation flexibility is central to the BDCP Conservation Strategy and the achievement of the BDCP biological goals and objectives.

3.6.1 Adaptive Management Process Framework

To ensure development of a high quality, scientifically based BDCP adaptive management program, independent science advisors were engaged to provide expert input on best approaches to adaptive management. The efforts of these advisors resulted in the *BDCP Independent Science Advisors Report on Adaptive Management, February 2009* (Appendix X). That report included the following principles for effective adaptive management:

1. The scope and degree of reversibility of each proposed action (i.e., conservation measure) determines the form of adaptive management that can be applied (e.g., "active" or experimental adaptive management versus "passive" adaptive management)[1].
2. The knowledge base about the ecosystem is key to decisions about what to do and what to monitor, and includes all relevant information, not just that derived from monitoring and analysis within the context of BDCP.
3. Program goals should relate directly to the problems being addressed and provide the intent behind the conservation measures; objectives should correspond to measurable, predicted outcomes.
4. Models should be used to formalize the knowledge base, develop expectations of future conditions and conservation outcomes that can be tested by monitoring and analysis, assess the likelihood of various outcomes, and identify tradeoffs among conservation measures.
5. Monitoring should be targeted at specific mechanisms thought to underlie the conservation measures, and must be integrated with an explicitly funded program for assessing the resulting data.
6. Prioritization and sequencing of conservation measures should be assessed at multiple steps in the adaptive management cycle.
7. Specifically targeted institutional arrangements are required to establish effective feedback mechanisms to inform decisions about whether to retain, modify, or replace conservation measures.
8. A dedicated, highly skilled agent (person, team, office) is essential to assimilate knowledge from monitoring and technical studies and make recommendations to senior decision makers regarding programmatic changes.

The advisors report included an adaptive management process framework. The BDCP adaptive management process is depicted in the flow diagram in Figure 3.11. This process follows the recommendations provided in the independent science advisors report.

Plan Objectives and the Knowledge Base

The starting point for the adaptive management process is the problem statements and hypotheses that underlie the biological goals and objectives and the conservation measures. These hypotheses are a reflection of the existing "knowledge base" - the totality of current

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[1] Active adaptive management is experimental, involving manipulations intended to achieve conservation goals but also to improve knowledge. Passive adaptive management is not experimental, but is nevertheless approached from a scientific perspective to improve knowledge and adapt strategies during project implementation.

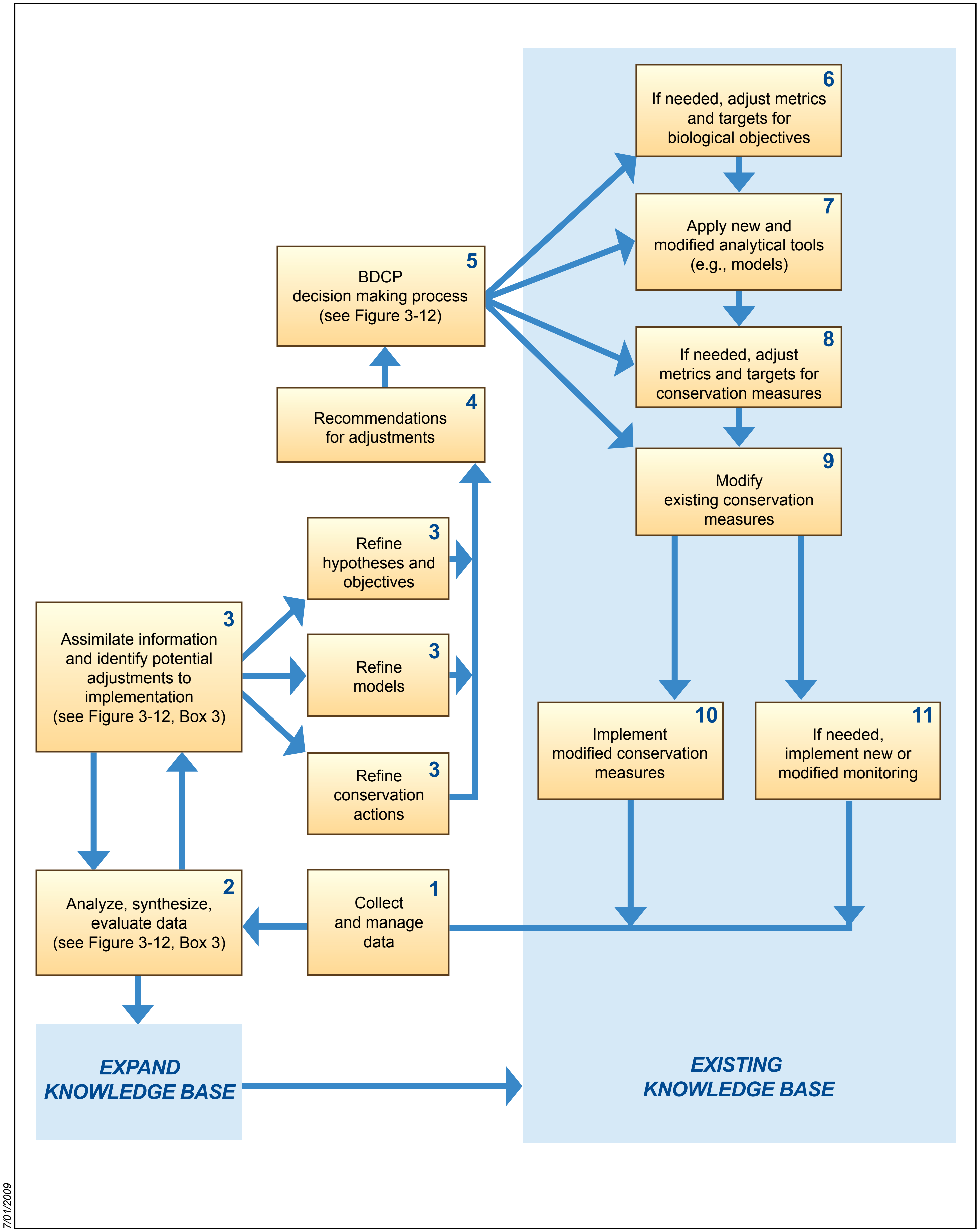

Figure 3.11
BDCP Adaptive Management Process Framework

scientific understanding of the ecological and biological conditions of the Delta (see large shaded box underlying the right side of Figure 3.11). The existing knowledge base supported the development of the BDCP Conservation Strategy, including the biological goals and objectives, conservation measures, conservation metrics and targets, and monitoring actions. Information and analysis derived from the BDCP monitoring and research program and from other sources will supplement and expand the knowledge base over the term of BDCP implementation.

Collect and Manage Data

Critical to the adaptive management process is the collection and management of existing and new data (see Figure 3.11, Box 1) to assess conservation measure performance and the achievement of biological goals and objectives. Data collection and management will be conducted through the BDCP monitoring and research program (see Section 3.5, *Monitoring and Research Program*) following the initial implementation of conservation measures. Monitoring requirements, metrics and targets for BDCP conservation measures are provided in Table 3.13 and monitoring metrics and targets to assess progress toward achieving biological objectives are provide in Table 3.12. In addition, results of research conducted as part of the BDCP research program or by other entities will contribute to the knowledge base to support understanding of ecological cause and effect relationships. Monitoring data and research results will provide the BDCP Implementing Entity with information to help determine the effectiveness of conservation measures in providing benefits to species and habitats, the effectiveness of different approaches and methods of implementing conservation measures, the effectiveness of combinations of measures to achieve desired objectives, and the effectiveness of adjusting or modifying approaches to the implementation of the measures. Because new data provide the foundation for making effective adjustments to plan implementation over time through the adaptive management process, collected data will undergo quality assurance reviews. Decisions by the Implementing Entity to modify implementation of conservation measures will be guided by information gathered through the monitoring and research program and other research sources. The BDCP monitoring and research program is designed to establish cause and effect relationships between implementation of specific conservation measures and the type and magnitude of species responses to those measures, as well as species responses to the implementation of combinations of conservation measures.

Analyze Data, Assimilate Information, and Develop and Recommend Adjustments to Implementation.

The science advisors report on adaptive management (Appendix X) pointed out that the weakest aspect of most adaptive management plans is in the sequence of steps required to link the knowledge gained from implementation and other sources to decisions about whether to continue, modify, or stop actions, refine objectives, or alter monitoring. Responsibility for this step would be assigned to a highly skilled agent (person or team) within the BDCP Implementing Entity having the right mix of policy and technical expertise (such individuals are referred to as "polymaths[2]"). This investment is critical to making adaptive management effectively support the BDCP. See the discussion of internal and external science review in the 3.6.2, *Adaptive Management Decision Making*. Collected data will be analyzed, synthesized, and evaluated to inform the BDCP Implementing Entity of the cause and effect relationships between conservation measures and ecological processes, covered species, and natural communities; the status of ecosystem conditions

[2] See Chapter 7, Implementing Structure, for a further elaboration of these roles and functions.

and covered species; and the effectiveness of the conservation measures and the monitoring program (Figure 3.11, Box 2). Information gained through this process may indicate the need to redefine hypotheses underlying biological objectives and conservation measures; refine, discontinue, or expand conservation measures; or develop and implement new conservation measures within limits set by the plan and its associated regulatory authorizations.

The science advisors also emphasized the need to integrate the evaluation of the efficacy of conservation measures across suites of measures that are inter-related, and to use and expand upon the existing (and new) modeling capabilities to assist in that integrated evaluation. New data will therefore also be used to update models (e.g., conceptual, statistical, and process models) and other analytical tools that are useful in assessing the performance of both individual conservation measures and suites of interrelated measures in helping to achieve the goals and objectives of the plan. New data and modeling work will also help predict the magnitude and trajectory of ecosystem and covered species responses to conservation measures, and identifying the need for new models and tools (Figure 3.11, Box 3 which corresponds to Box 2 of decision making process illustrated in Figure 3.12). Ecological models (either conceptual or mathematical) are extremely valuable for formalizing the link between objectives and proposed conservation measures to clarify how and why each conservation measure is expected to contribute to objectives and are a key element of adaptive management. Models will be used to formalize knowledge about the system and to predict the outcomes of and design modifications to conservation measures.

Based on assimilation of new information, the BDCP Implementing Entity will formulate new approaches for BDCP implementation to improve its effectiveness in achieving the biological objectives (see Figure 3.11, Box 4). These new approaches would then be routed through the BDCP adaptive management decision making process (illustrated in Figure 3.12; see Box 3 in this figure).

Follow a Decision Making Process

The Implementing Entity will follow a defined decision making process before making significant adaptive management changes (Figure 3.11, Box 5). This adaptive management decision making process is described in Section 3.6.2, *Adaptive Management Decision Making*.

Implement Modified Conservation Measures, Tools, Metrics, and Targets

BDCP Implementing Entity through the adaptive management program with the limits set by authorizing permits would implement adaptive changes to conservation measures, monitoring program, analytical tools, metrics, and targets:

- Adjustments to metrics and targets for biological objectives (Figure 3.11, Box 6) – Metrics and targets for BDCP biological objectives were developed based on the existing knowledge base. New information developed during the BDCP implementation could result in the need to revise metrics and targets for these objectives (as allowable under the authorizing permits).
- The development and application of new analytical tools (Figure 3.11, Box 7) – As knowledge grows over time, new analytical tools are expected to be developed including monitoring technologies and techniques, physical and biological models, statistical relationships, etc. These new tools would be incorporated into implementation of the BDCP Conservation Strategy as they become available.

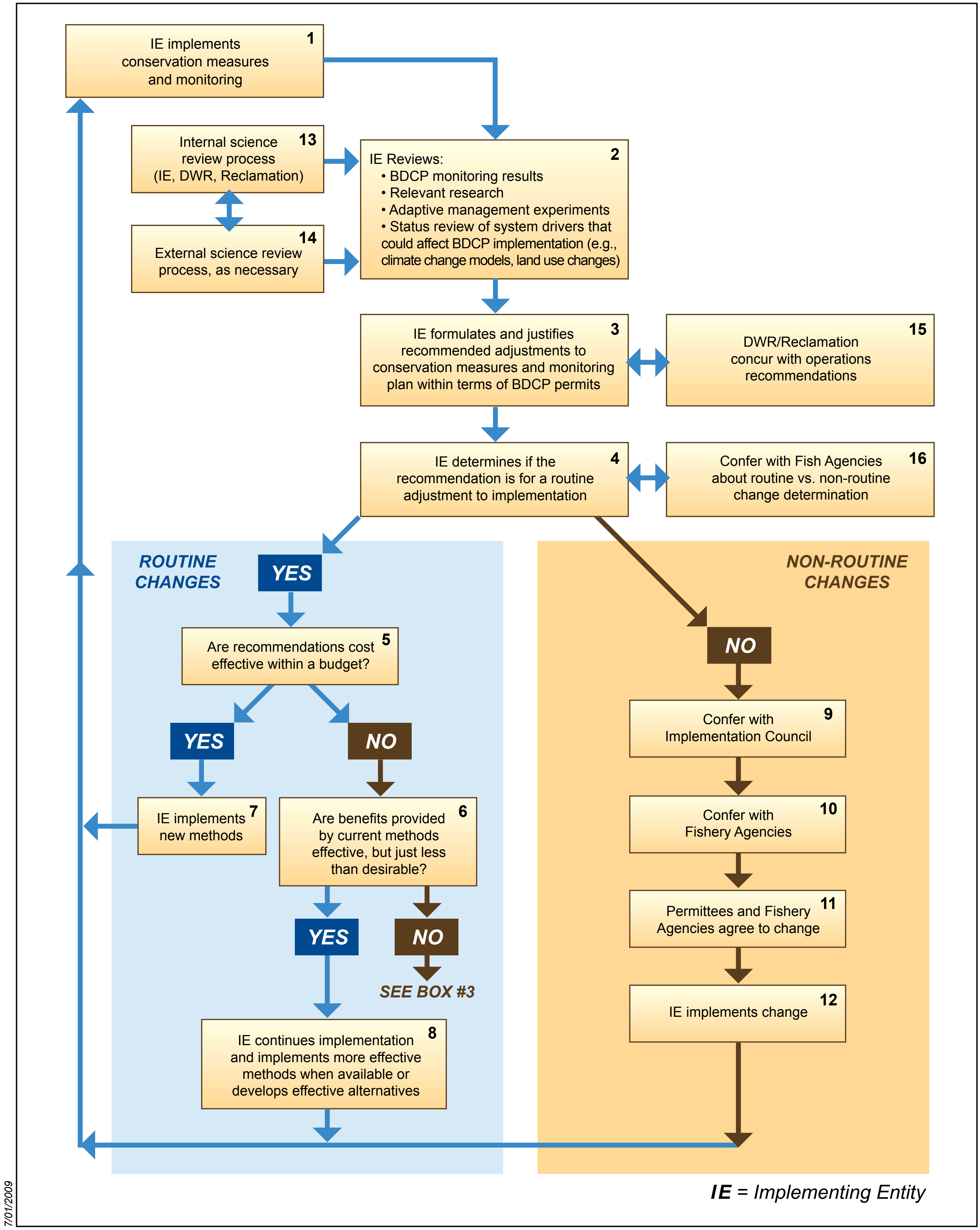

Figure 3.12
BDCP Adaptive Management Decision Making Process

- Adjustments to metrics and targets for conservation measures (Figure 3.11, Box 8) – Specific metrics and targets have been identified for BDCP conservation measures based on existing knowledge. As understanding of the Delta ecosystem improves, revisions would be made to these metrics and targets to reflect this new knowledge.
- Development and implementation of modified conservation measures (Figure 3.11, Boxes 9 and 10) – The adaptive management program guides the modification of BDCP conservation measures to improve effectiveness in meeting goals. The adaptive management program will also set priorities and timetables for implementing conservation measures and may modify adaptive management triggers based on new knowledge.
- Discontinuance of ineffective conservation measures – The adaptive management program allows for the elimination of unsuccessful conservation measures. The funds allocated to these measures may be reallocated to expand successful measures.
- Implementation of new or modified monitoring methods (Figure 3.11, Box 11) – The adaptive management program will inform and guide the subjects of monitoring, monitoring metrics, and the duration and scope of monitoring. Monitoring technology and techniques improve through time and as new methods are developed they will be incorporated into the BDCP monitoring program. The adaptive management program would also identify and implement modifications to the research program and adaptive management experiments.

3.6.2 Adaptive Management Decision Making

This section describes the process by which decisions will be made to change the implementation of components of the BDCP Conservation Strategy under the adaptive management program, including adjustments to biological objective metrics and targets, conservation measures, the monitoring program and monitoring metrics and targets, and analytical tools, as warranted by new information. The BDCP contemplates changes in implementation actions over time to address uncertainties and provide for improvements to the effectiveness of conservation measures in achieving biological goals and objectives as new scientific information is developed. The adaptive management decision making process described in this section and illustrated in Figure 3.12 is intended to provide for such changes without requiring amendments to the BDCP.

The decision making process describes how the BDCP Implementing Entity will coordinate with the multiple state and federal agencies that will be participating in the implementation of the BDCP, including DWR, the Bureau of Reclamation, and the federal and state fish and wildlife agencies (Figure 3.12, Boxes 2, 3, 4, 15, 16). A key decision point is the determination if an adaptive management response is routine or non-routine.

Routine and Non-routine Adaptive Management Responses

Potential changes to conservation measures made through the adaptive management program are characterized as either “routine” and “non-routine” (Figure 3.12, Box 4). These terms are not found in the statutes or regulations underlying NCCPs or HCPs, but were developed for the BDCP in an effort to establish levels of coordination between the Implementing Entity, the Fishery Agencies, and Implementing Council (see Chapter 7, *Implementation Structure*, for a description of the Implementing Council) on matters relating to adaptive management changes.

The concepts of routine and non-routine adaptive management responses do not lend themselves to precise definition or measurement; rather they must be viewed in the context of their purpose. The distinction reflects the view of the Plan Participants that the Implementing Entity ought to confer with the fish and wildlife agencies and the Implementing Council on major, substantive adaptive management decisions, particularly during the initial period of plan implementation. The level of coordination, however, is to be weighed against the need for the Implementing Entity to have sufficient discretion to make day-to-day decisions regarding plan implementation, which will, to some extent, require interpretation of and minor adaptations to conservation measures.

Existing environmental conditions and the status of several covered species are such that few adaptive management responses will initially be considered routine. As the BDCP evolves and the status of covered species improves, however, the actions of the Implementing Entity will likely be increasingly viewed as routine. The primary factors that will determine whether a response is deemed to be routine include the level of potential risk that the action poses to the species, the degree of complexity and uncertainty associated with it, and the perceived need for coordination between the Implementing Entity, the Fishery Agencies, and the Implementation Council. To maintain flexibility in these characterizations, the BDCP allows the Implementing Entity and Fishery Agencies to reassess, on an ongoing basis, these distinctions throughout the implementation of the plan.

Adaptive management responses that are likely to be considered routine at the outset of the plan include, for example, small adjustments to techniques used to restore habitat and to remove invasive species. All adaptive management responses that are not categorized as routine at the beginning of the plan will be considered non-routine. Adaptive management responses expected to be considered non-routine at the outset include any change in criteria governing water conveyance operations or the discontinuation, expansion, or addition of a conservation measure.

With respect to routine actions, the Implementing Entity may modify conservation measures without the need for coordination with the Implementation Council or the Fishery Agencies. Routine adaptive management responses would be accounted for in the annual report or other periodic reports, providing an opportunity for review and input regarding those responses through the BDCP reporting process.

Both routine and non-routine changes to the plan would be subject to the parameters and sideboards established for adaptive management, including funding caps established to implement the BDCP Conservation Strategy. Some non-routine changes may reflect decisions to reallocate available funding or resources away from ineffective conservation measures and toward more promising ones.

Once a management response is determined to be routine, a specified decision process will be followed (see Figure 3.12, Boxes 5, 6, 7, and 8) and if the management response is found to be non-routine a different decision process will be followed (see Figure 3.12, Boxes 9, 10, 11, and 12).

Internal Scientific Review and Implementation of Changes

The Implementing Entity will establish an internal process of review by technical experts (e.g., biologists, restoration ecologists, physical scientists, habitat managers, engineers) to assess, on a regular basis, the adaptive management program, including the results of effectiveness and performance monitoring, selection of research and adaptive management experiments, and relevance of new scientific information developed by others (e.g., universities, CALFED Bay-Delta Program, Interagency Ecological Program) to determine whether changes in the implementation of the conservation measures and the monitoring program would be desirable to improve effectiveness of the BDCP in achieving biological goals and objectives (see Figure 3.12, Boxes 13).

Based on the results of these reviews, the technical experts will provide recommendations regarding potential adjustments to the implementation of conservation measures and modifications to the monitoring program. The Implementing Entity may also request the assistance of the Fishery Agencies and knowledgeable outside scientists and experts in the review process and seek additional recommendations related to the adaptive management program (see Figure 3.12, Boxes 14).

Recommendations made by scientists through the internal science review process will be memorialized in a standardized format and will include a description of the recommended change in implementation; a description of the justification for the recommended change; an assessment of effects the change may have on other elements of BDCP implementation, if any; and any other relevant information in support of the recommendation. The Implementing Entity will review these recommendations and determine if the recommendations would involve routine or non-routine changes. Any recommendations adopted by the Implementing Entity will be described in the BDCP annual implementation work plan, The Implementing Entity will document the rationale for rejection of adaptive management recommendations made by the internal science review process.

Unforeseen circumstances (those changes in ecological conditions related to covered species that could not be foreseen during plan development) would not be addressed through the adaptive management process. Rather, they would be dealt with through the processes described in Chapter 6, *Plan Implementation*.

External Independent Scientific Review

The Implementing Entity will from time to time seek additional science input on specific adaptive management-related issues. The Implementing Entity may convene, at its discretion, experts in selected topic that are not affiliated with the Implementing Entity, permit holders, or Fishery Agencies (see Figure 3.12, Boxes 14). The Implementing Entity would consult with the Implementation Council, the Permittees, and Fishery Agencies regarding the selection of scientists to provide advice on specific matters.

3.6.3 Concept of a "Defined Adaptive Range"

The targets and criteria that define the BDCP conservation measures reflect judgments based on the best available science (see section 3.4, *Conservation Measures*, and Tables 3.12 and 3.13). As the BDCP is implemented, however, new information may indicate that some of these targets or criteria are less effective at producing desired outcomes than initially anticipated, while others may be more effective. To allow for flexible and responsive implementation of the BDCP, many conservation measures include a defined adaptive range, which establishes the parameters within which a conservation measure may be adjusted to improve its effectiveness or respond to changing biological conditions. For some conservation measures, a decision to expand or contract the measure within a defined adaptive range will be governed by the Implementing Entity in collaboration with the Fishery Agencies and the Implementation Council through the process for non-routine changes.[3]

Defined adaptive ranges will be included in the BDCP Conservation Strategy for a number of measures related to water operations (see Section 3.4.1, *Water Operations Conservation Measures*). For example, initial operational criteria (to be implemented once new facilities become operational) will be established for Sacramento River bypass flows at the north Delta diversion, along with a defined adaptive range that includes allowance for increasing the bypass criteria should a targeted flow prove to be less effective than expected (as defined by the plan; *e.g.*, target levels or standards established for the transport of fish). Similarly, a lower limit to the defined adaptive management range may include allowance for narrowing the bypass criteria (allowing increased diversions) should flows or other conservation measures prove more effective in meeting objectives than predicted, as defined by a standard or measure set out in the biological objectives and monitoring program. Such changes are considered non-routine and would require decision making through the non-routine decision process (see Figure 3.12).

3.6.4 Adaptive Management Triggers

Adaptive management triggers are quantified thresholds established for some conservation measures that, if exceeded, would require a management response by the Implementing Entity to improve results through a mandatory adaptive management process review. Adaptive management triggers related to performance and effectiveness targets identify specific conditions in which targets are not likely to be achieved and therefore adaptive changes must be considered and undertaken. Adaptive management triggers for applicable conservation measures are described in Section 3.5, *Monitoring and Research Program*, and presented in Tables 3.12 and 3.13.

3.6.5 Adaptive Management Experiments

[*Text to Come.*]

[***Note to Reviewers**: This section will describe how adaptive management experiments will be conducted and the relationship of these experiments to the BDCP research program. Such experiments fall under the "active adaptive management" approach. Active adaptive management is experimental, involving manipulations intended to achieve conservation goals but also to improve knowledge. Passive adaptive management is not experimental, but is nevertheless approached from a scientific perspective to improve knowledge and adapt strategies during project implementation.*]

3.6.6 Program Status Reviews

[*Text to Come.*]

[***Note to Reviewers:** This section will describe program status reviews that may be conducted by the Implementing Entity. Status reviews would focus on review of technical elements of BDCP implementation procedures (e.g., administrative reviews of the effectiveness of Implementing Entity processes and procedures, agreements with other parties, need for updates to guidance*

[3] To harmonize adaptive management with No Surprises assurances, the federal fish and wildlife agencies require that "[w]henever an adaptive management strategy is used, the approved HCP must outline the agreed-upon future changes to the operating conservation program." *Id.*

documents [e.g., monitoring protocols and plans], implementation infrastructure [e.g., data bases, computer systems].) and species status reviews. Technical reviews provide for ongoing improvement in the Implementing Entity's effectiveness by providing for periodic critical and methodical review of its implementation procedures. Periodic reviews of the status of covered species would be conducted to determine if changes in BDCP implementation may be warranted based on regional population trends and new information related to species needs. Changes in BDCP implementation resulting from program status reviews would be implemented through the adaptive management decision making process.]